

2026

Green Demand Policy Playbook

Stimulating Demand For Low and Near-Zero Carbon Materials,
Fuels and Chemicals Through Government Policies



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Executive Summary

- **Heavy industry and transport account for almost 30% of global energy** - and process-related emissions. Mission Possible Partnership's Global Project Tracker (June 2026) counts nearly 1000 clean industrial projects worldwide across heavy industry (aluminium, cement/concrete, chemicals, steel) and heavy transport fuels (for aviation and shipping), worth close to \$5tn in investment potential when underpinning energy assets are included. Only 161 of these projects have reached final investment decision (FID) – the point at which construction can commence.
- **The obstacle is not technology or finance** – it is demand. Early projects moved forward on the back of generous subsidies, voluntary premium buyers and management willing to accept lower returns to prove what was possible. Those advantages are fading for the projects that follow. Deeply decarbonised materials, chemicals and fuels are still early in their commercialisation, and so cost more than their emissions-intensive equivalents – making it hard for buyers to sign the long-term purchase agreements lenders need before financing a project. Corporate voluntary commitments have helped build early demand, but on their own they are not enough at scale.
- **This is a solvable problem, and one with precedent.** Blending mandates have driven over a decade of biofuel uptake; purchase incentives scaled the electric vehicle market; obligations are now taking shape for sustainable aviation fuel (SAF). Of these sectors, SAF is scaling fastest; materials need the same policy push. Progress is visible: the EU's Industrial Accelerator Act, for example, is building demand for low-carbon materials by targeting uptake in key lead markets like automotive and construction; India's SECI auctions are establishing early contracts for green ammonia use in fertilisers. But only a handful of such measures have been put in place.
- **Building demand means a heavy bill for consumers.** Costs are highest early in the production chain, but by the time a product reaches the shopper, clean inputs add little to the price – clean steel adds around one per cent to the cost of a car, and clean fuels a similarly small share to shipping a pair of shoes. This impact will shrink further as more of the market switches to clean supply – all the more reason to start building demand now, so premiums fall sooner.
- **The ITA Green Demand Policy Playbook, prepared by the Industrial Transition Accelerator (ITA)** secretariat with more than 100 organisations, sets out how governments can close this gap across aviation, shipping, aluminium, cement, chemicals and steel. It groups nine demand-stimulation policies into four types – government procurement, mandatory regulations, market-based mechanisms and non-financial incentives – and shows how they reinforce one another. For example, construction, automotive and packaging alone drive over half of demand for aluminium, cement and steel, so action in three end-use sectors can shift production across three material sectors at once. None of this works without robust standards to define what counts as clean and give buyers confidence in what they are buying; closing the remaining gaps, and aligning standards across regions, is now a priority. For each policy, the playbook explains how it works, where it has the biggest impact, and includes sector deep-dives with real-world implementation examples and case studies.
- **The next few years will decide which countries lead.** Governments that move first on demand, finance and infrastructure will secure industrial leadership and reduce their exposure to volatile fossil markets; those that wait risk being locked out.

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Introduction

Motivation and use

- This Green Demand Policy Playbook is intended to provide:

A A set of government policy options prioritised by sector, highlighting particularly impactful measures that can be used by regional, national and subnational governments to stimulate demand for low and near-zero emissions goods and services across six sectors: heavy industry - aluminium, cement & concrete, chemicals (specifically hydrogen and its derivatives), iron & steel, and transportation – aviation and shipping.

B A compilation of key examples of implementation to date from diverse economies across the world

C Deep dives and implementation guidance on the most impactful measures, showcasing examples where governments are, or are in the process of, implementing these policies, drawing out key implementation considerations, and pointing to more detailed studies and organisations that can assist in implementation of key policies.

- **Comprehensive green industrial policy frameworks** should encompass research and development, supply-side and market-enabling policies, as well as demand stimulation policies. This work focuses on the need for governments to accelerate the introduction of demand stimulation policies to unlock the next wave of investments in commercial-scale industrial projects. This is because these have received less attention from governments in recent years and have been identified by project developers as essential to strengthen the investment case for the production of low and near-zero carbon commodities.
- The guidance is intended to inform and support domestic policymaking processes. This report should be used as an **introduction and signposting to key policies**. As with any government policy, the exact mix of measures and their specific design, will need to be tailored to the local context, considering social, economic, and environmental circumstances and detailed impact assessments. All government policies should also be underpinned by deep stakeholder consultation, paying particular attention to ensuring a just transition that protects vulnerable communities.

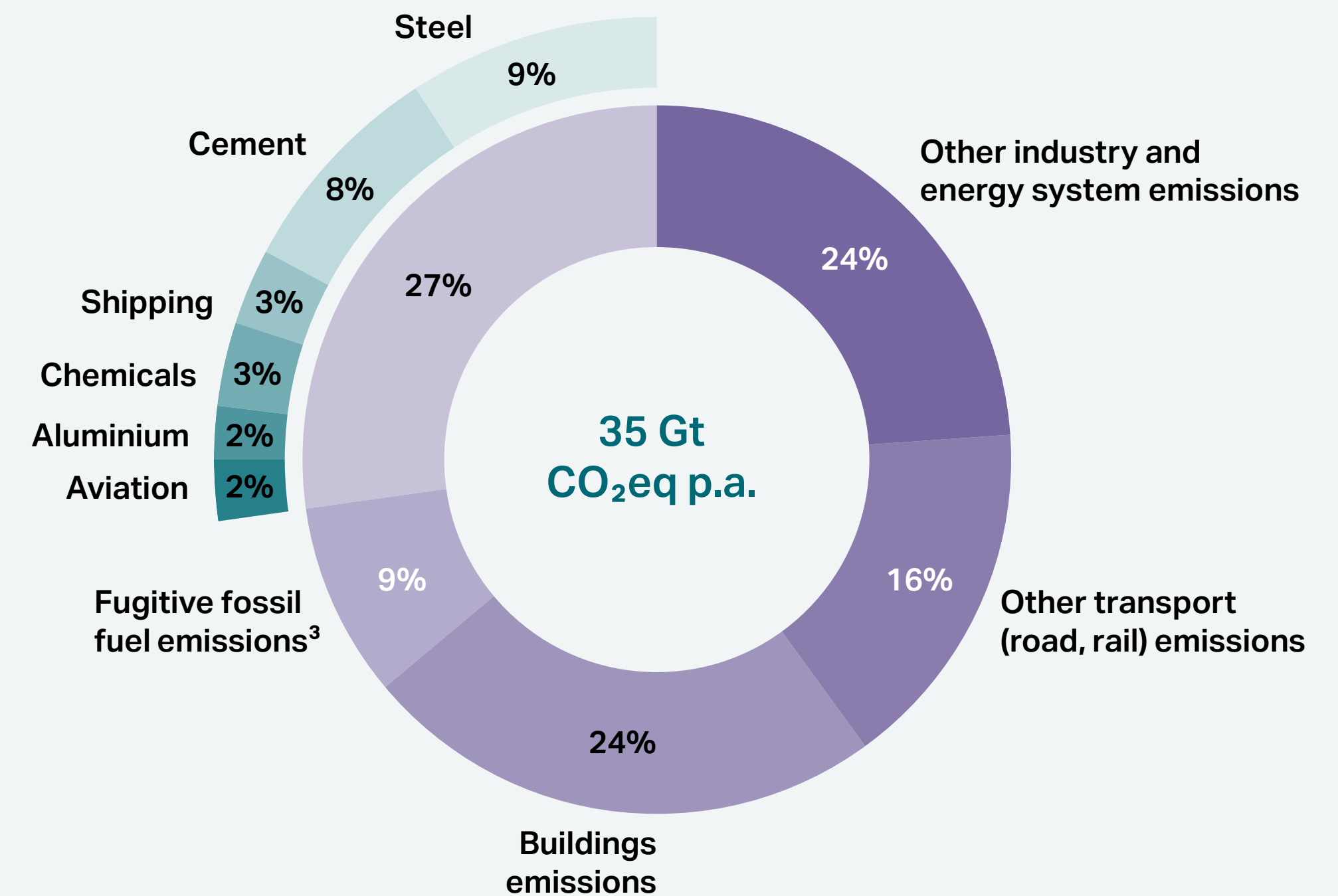
- Where possible, we have highlighted organisations, resources and initiatives that can support implementation. The [ITA secretariat](#) looks forward to engaging with government interlocutors interested in discussing the policy options outlined in this playbook.
- In early 2025, we plan to launch an online version of the playbook. This will allow us to make live updates as more examples of relevant policies emerge. Please get in touch if we have missed anything.

There is an urgent need to transform heavy industry and transport quickly to win the war against climate breakdown

- Heavy industry and transport sectors are responsible for nearly 30% of global CO₂e emissions² and make up a significant portion of scope 3 emissions for other sectors.
- In a world where scope 3 emissions are under scrutiny and need to be addressed, hard-to-abate sectors are facing increasing pressure to decarbonise.

Scope 1 and 2 greenhouse gas emissions¹

Allocated to energy and industrial sectors in 2020



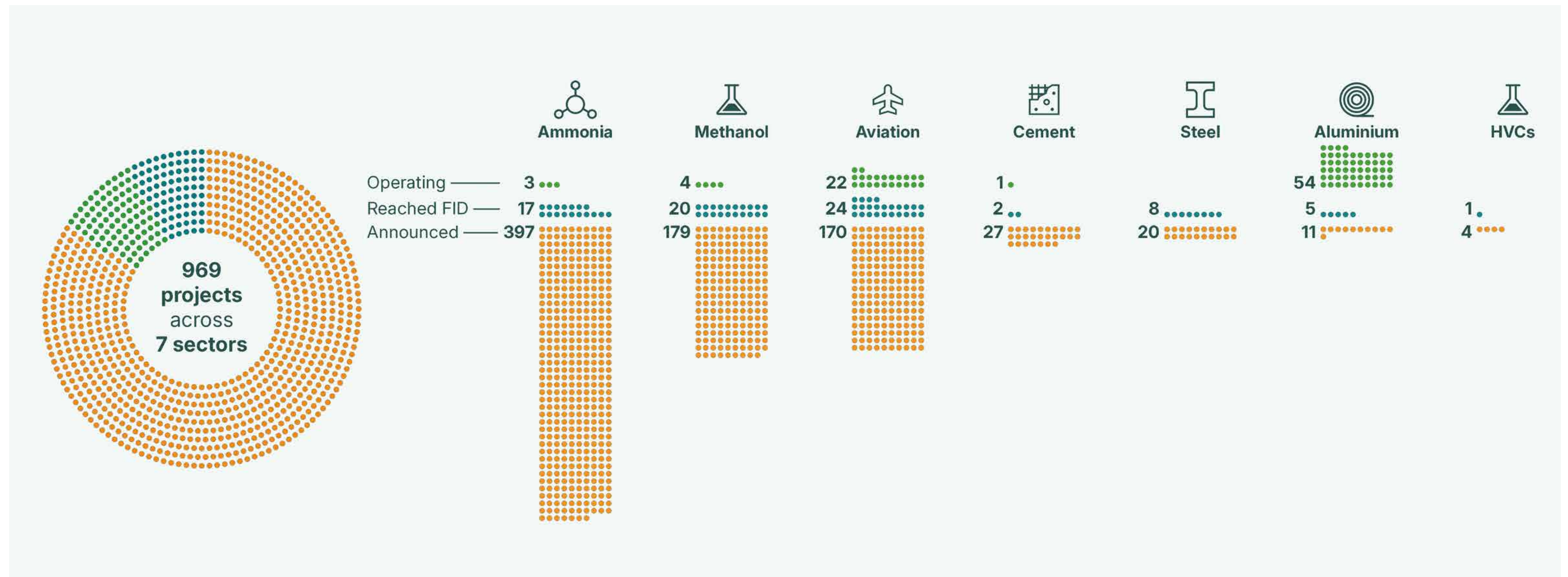
1: global scope 1 and 2 emissions shown with GWP 100 used for non-CO₂ emissions

2: excludes agriculture, forestry and land use emissions

3: Fugitive emissions are greenhouse gas emissions that arise from leaks and other irregular releases, usually associated with industry and fossil fuel extraction.

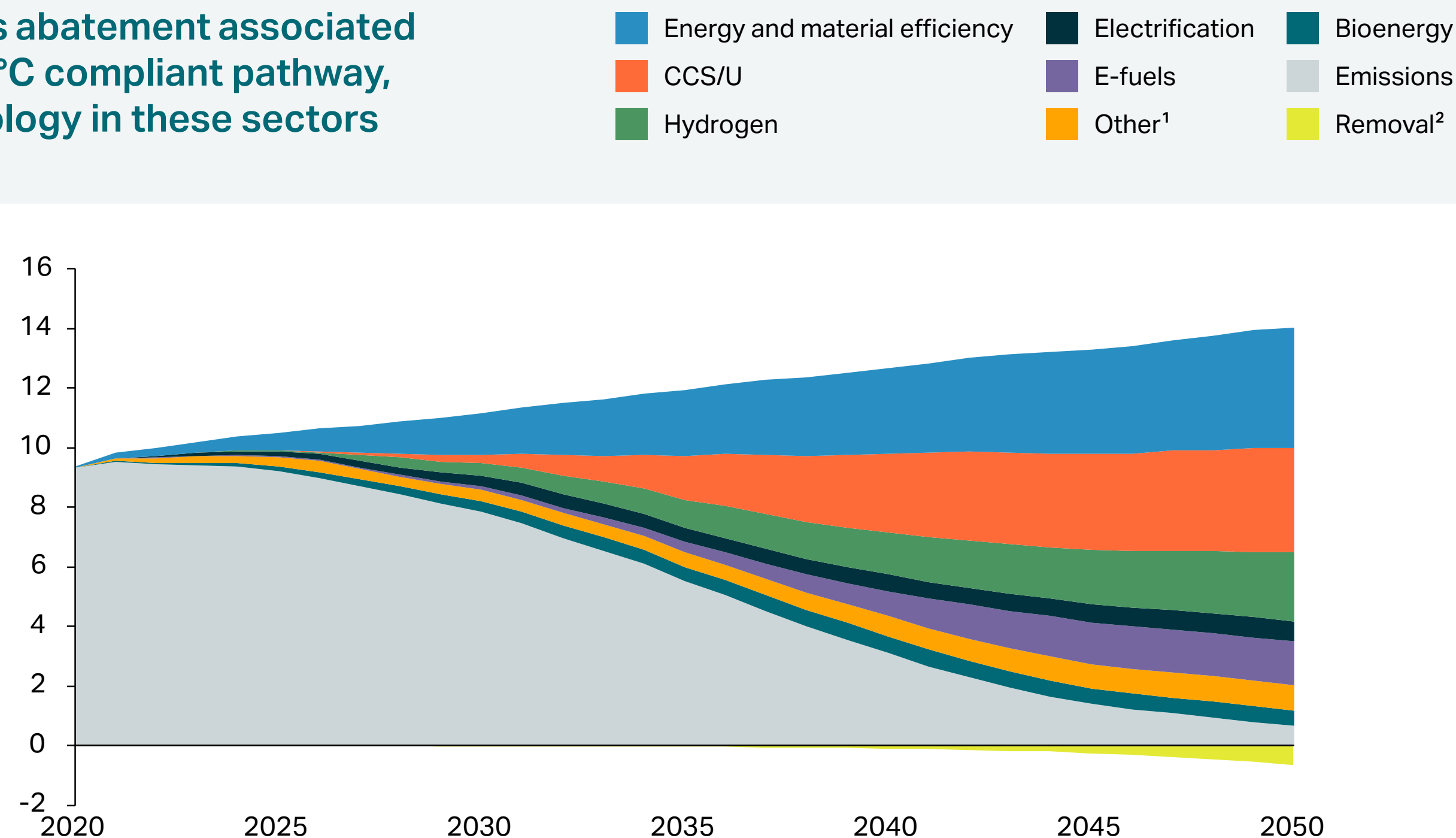
Sources: IEA (2022), [GHG Emissions from Energy](#); Mission Possible Partnership (MPP) (2020), [European Environment Agency](#)

Transformation is happening but progress is vastly insufficient. Although over 800 commercial scale deep decarbonisation projects have been announced, only 161 have passed FID.

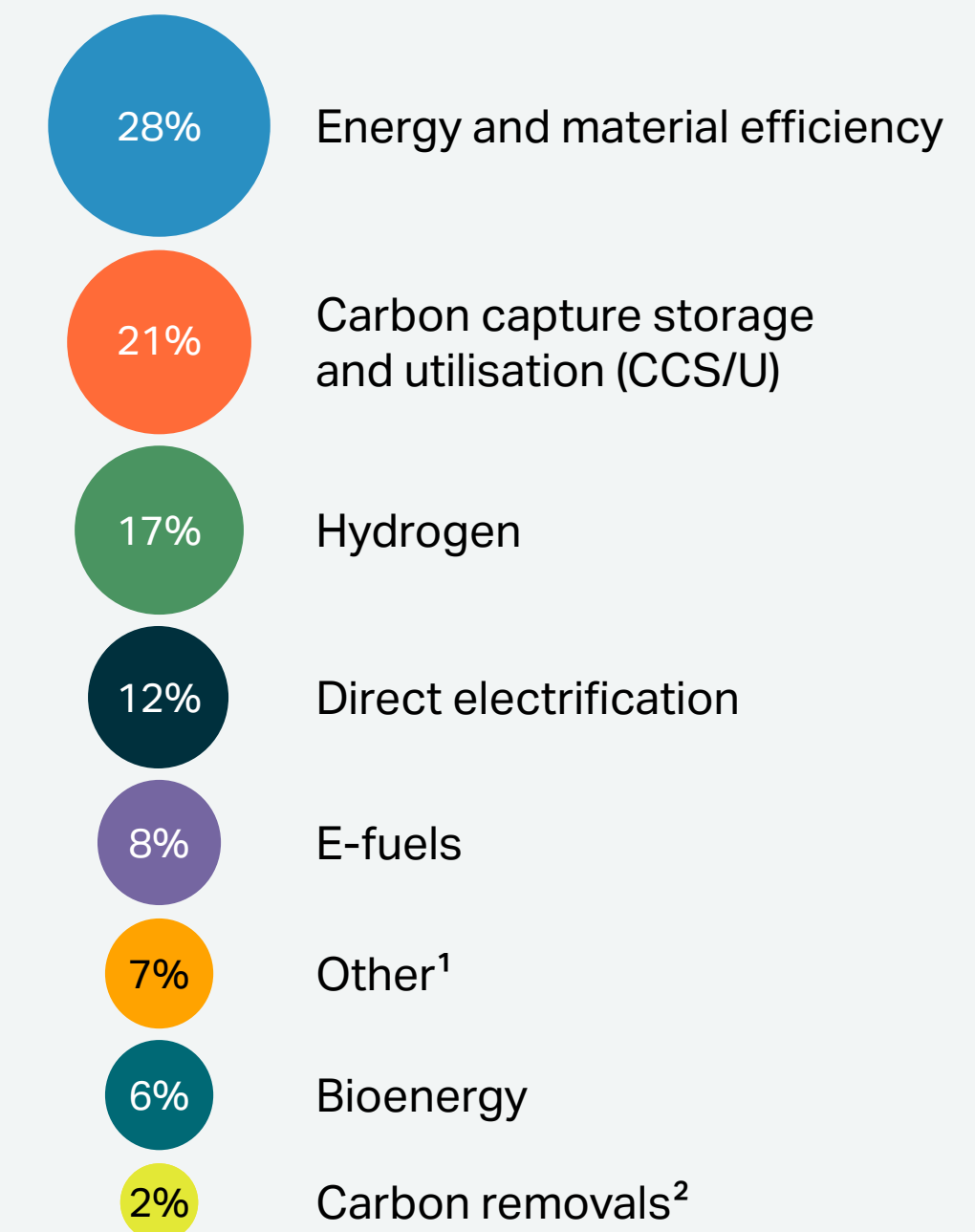


In addition, other decarbonisation levers, such as increased energy and material efficiency, including greater circularity, will also be needed

Emissions abatement associated with a 1.5°C compliant pathway, by technology in these sectors
Gt CO₂ p.a.



% of cumulative emissions saved, 2020-50



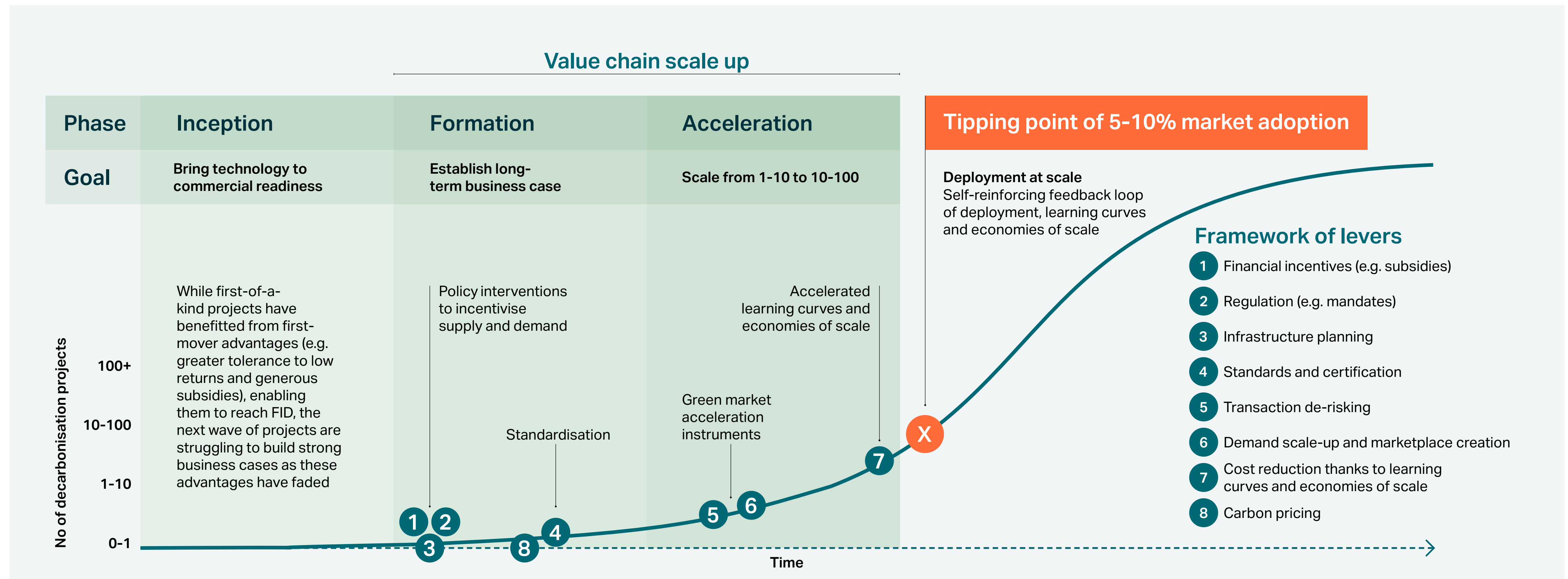
Notes: emissions calculated for hard-to-abate sectors in scope (i.e. aluminium, concrete, steel, maritime, aviation and chemicals)

1: other includes transitional technologies, fuel switching and sector specific technologies (e.g. inert anodes in aluminium)

2: carbon dioxide removals are used in roadmaps to reach net zero by 2050 i.e. counter-balancing residual emissions in 2050. In the figure shown, a potential ramp-up of these carbon dioxide removals are included

Source: MPP analysis, based on MPP's sector transition strategies

First-of-a-kind projects have benefited from first-mover advantages, but these have faded for the next wave of projects: a framework of levers is needed to unlock supply



A comprehensive policy framework is required to drive heavy industry and transport decarbonisation: green demand stimulation is a critical but underleveraged dimension

Today, many initiatives and policies have been geared towards research and development and supply stimulation. Critically, **green demand stimulation** needs to be addressed to stay in line with the desired growth in low-carbon production.

Framework of government policies – examples of policies

Research and Development

Examples

- Funding early-stage trials and demonstration projects to advance new technologies towards commercial deployments

Status:

- Many demonstration projects are underway for key technologies.

Critical enablers

Examples

- Robust certifications and standards for low and near-zero emission products
- Scaling up underpinning energy infrastructure (e.g. clean electricity supply and hydrogen transportation)

Status:

- Certifications are a work in progress¹
- Strategic infrastructure planning ongoing in many geographies, but its construction is lagging behind.



Focus of the playbook

Demand stimulation

Examples

- Creating differentiated markets for green products (e.g. via mandatory measures and green public procurement)
- Providing financial incentives to use green fuels and materials (e.g. via carbon taxes and subsidies)

Status:

- Promising examples across multiple geographies, but not widely adopted yet.

Supply stimulation

Examples

- Providing financial support and low interest loans to scale up supply capacity
- Expediting planning and permitting for energy supply and green industrial projects
- Prioritising use of sustainable bio-energy feedstocks for heavy industry and transport

Status:

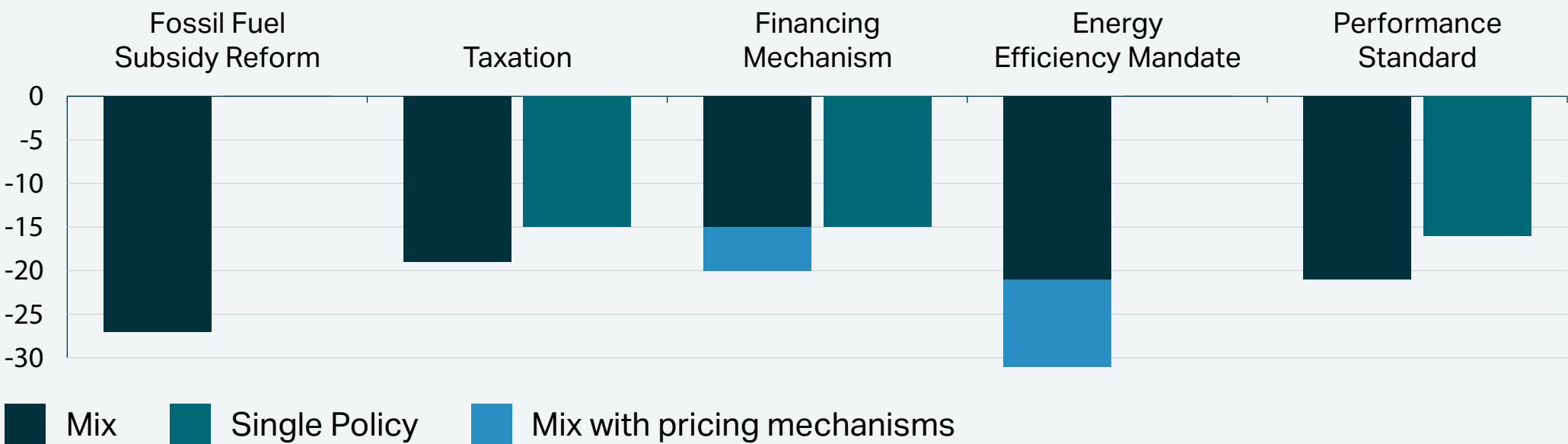
- Supply-side packages developed in many advanced and emerging economies.

1: see the [ITA Standards Map](#) for more details

Combinations of policies, e.g. carbon pricing and/ or complementary subsidies and regulations, have proven to be effective emission reduction strategies

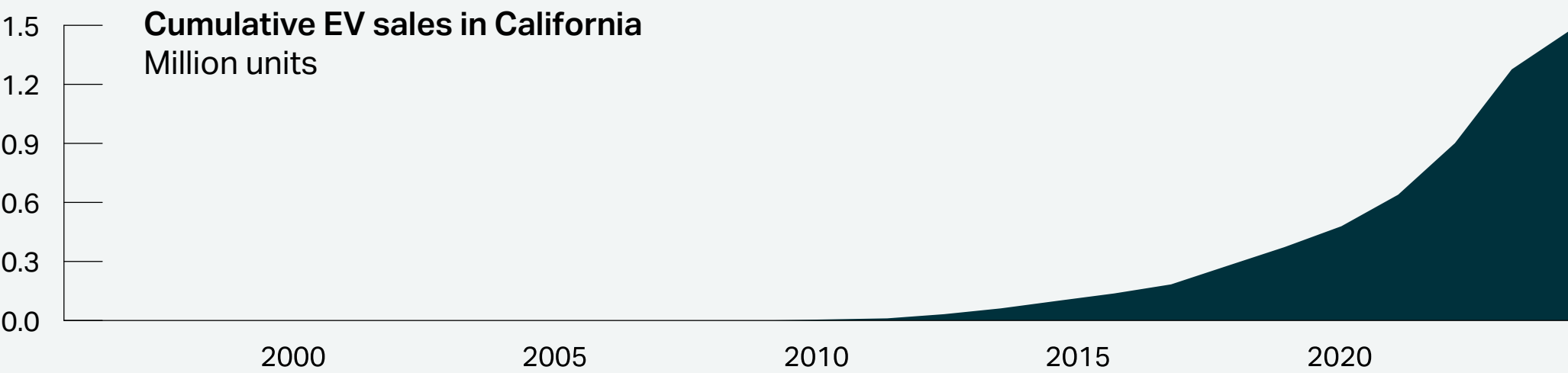
- Based on a [systematic study](#) of climate policies from the past 20 years, using a mix of policies can lead to greater emissions reductions.
- All policy instruments studied, except financing mechanisms/subsidies, had a larger effect on emissions reductions when combined with other policies, than when implemented alone.
- Furthermore, a larger impact was achieved when combining non-pricing and pricing mechanisms (namely taxation or reduced fossil fuel subsidies)
- Using a mix of policies has proven to be successful in other sectors, e.g. with zero emission vehicle adoption in California, US.

Average effect size (%)¹ on emissions reductions for single policy vs in a mix of policies in the Industry sector



Case study: Zero Emission Vehicles (ZEV) Adoption in California

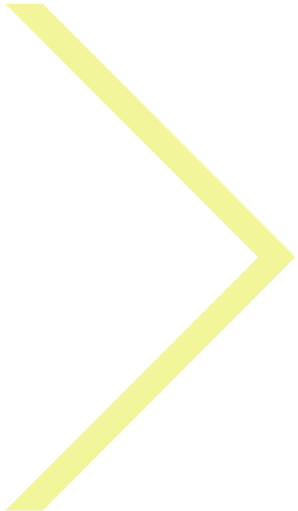
- In 1990, California pioneered a mandate for ZEVs, requiring manufacturers to annually surrender tradable credits gained by selling ZEVs. Manufacturers who generate more credits than needed can sell them to those with a deficit. The overall percentage of ZEV (and in practice hybrids) out of total vehicles sold progressively increased from 4.5% in 2018 to 22% in 2025. Since the mandated share of credits started low, this had only a small knock-on cost impact on conventional vehicles.
- Accompanying mandates were state funded [rebates](#), offered to subsidise EV purchases. Under the [California Clean Vehicle Rebate Project](#), rebates range from \$1000 to \$7,500 for buying or leasing eligible ZEV. Adoption was the highest in Los Angeles and Santa Clara counties in 2015, where many rebates were issued. In [2015-2016, \\$128m in rebate funds were distributed](#) in the state.
- The mandate, coupled with demand-side subsidies, enabled early movers to enter the market and create an additional revenue stream. Between 2012 - 2017, almost all ZEV credits traded were generated by [Tesla and Nissan](#). Analysis suggests the programme contributed to Tesla's survival until it became structurally profitable from 2020. By then, Tesla had become the world's most valuable [car manufacturer](#), subsequently overtaken by Chinese manufacturer BYD (similar policies were adopted under China's New Energy Vehicle programme).



1: effect size is a statistical indicator on the strength of a relationship between the policy and significant emission reductions
Sources: Stechemesser A, Koch N, Mark E, Dilger E, Klösel P, Menicacci L, Nachtigall D, Pretis F, Ritte, N, Schwarz M, Vossen H & Wenzel A. (2024) [Climate policies that achieved major emission reductions: global evidence from two decades](#). Meckling, Jonas & Sterner, Thomas & Wagner, Gernot (2017). [Policy sequencing toward decarbonisation](#), [Columbia Center on Global Energy Policy \(2024: Triggering Investment in First of a kind and early near zero emissions industrial facilities](#); [California Clean Vehicle Rebate Project](#);

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Although it is high at the industrial product level, the green premium in most of these sectors gets diluted throughout the value chain and is manageable at end product or service level

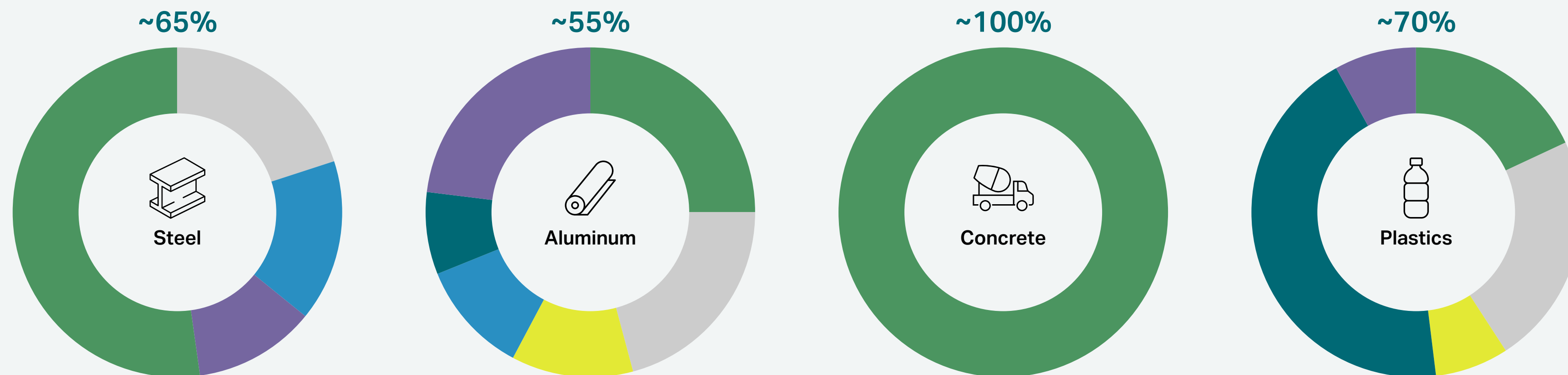
		Green upstream cost increase in 2030		End product	End-product price increase in 2030	
					100% substitution	10% substitution
Materials		Aluminium +20%		 Average passenger car	+1.4%	+<1%
		Plastics +25%		 Average washing machine	+1.5%	+<1%
		Steel +40%		 New 2000sq. ft house	+5%	+<1%
		Concrete +40%				
Fuels and Chemicals		Shipping +480% fuel costs		 Imported pair of shoes	+<1%	+<1%
		Ammonia fertilizers +100% ammonia costs		 Loaf of bread	+1%	+<1%
		Aviation +200 – 300% fuel costs for HEFA		 Flight fares	+75 – 120%	+7.5 – 12%

Notes on materials: premiums are based on estimates of levelised costs of the relevant commodity per production technology without carbon pricing, weighted by the market share of green versus. fossil-based technologies in 2030 to reach net zero by 2050. Upstream premiums are approximations rounded to the nearest 5%. An average car is assumed to weigh 1860kg and to contain approximately 900kg steel, 180kg aluminium and 180kg plastic. An average washing machine is assumed to weigh 70kg and to contain approximately 30kg steel, 3kg aluminium, 4kg plastic and 25kg concrete. A 2000sq ft house is assumed to weigh 124,000kg and to contain 8,000kg steel and require 40,000kg of cement. Notes on fuels and chemicals: SAF assumes fuel makes up 25-30% of a ticket price. Costs are indicative and based on literature estimates. Sources: World Steel Association , MPP analysis

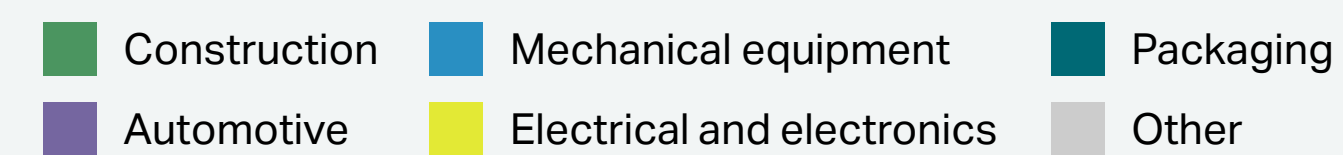
Triggering demand in a subset of downstream sectors (incl. construction, automotive & packaging) can drive decarbonisation for multiple upstream sectors

Global market share of end-user industries per material

Combined demand from construction, automotive and packaging sectors:



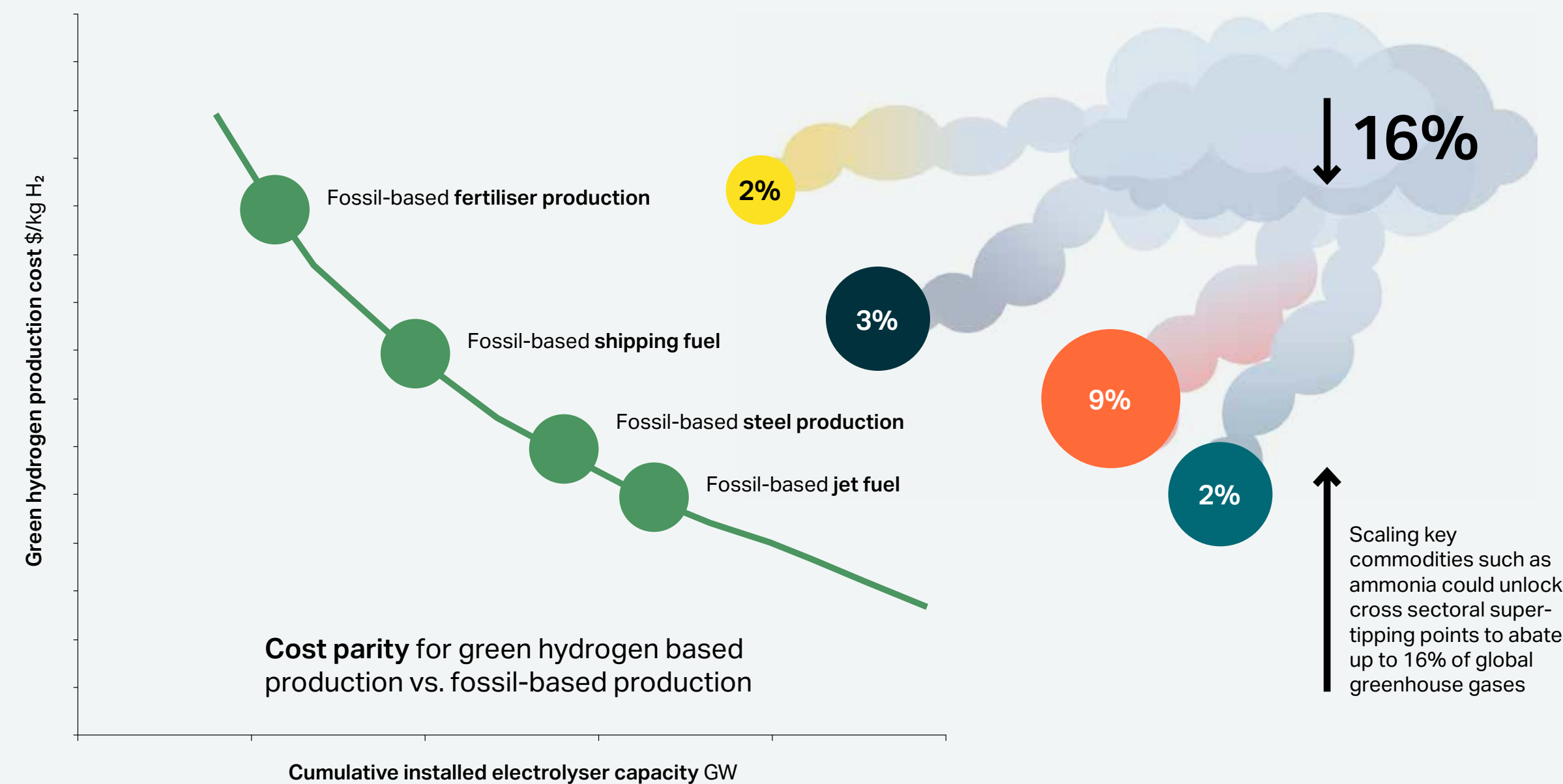
Stimulating demand in downstream sectors, e.g. construction, will simultaneously drive the production of green materials upstream across several hard-to-abate sectors (steel, aluminum, plastics and concrete) and reduce the market share of grey materials, thereby triggering decarbonisation



Similarly, driving demand for green fertilisers can lead to lower production costs, benefitting other sectors and further stimulating demand

Indicative cost reduction benefits in several sectors, driven by lower green H₂ costs

— Indicative green hydrogen price curve in future exporting regions (e.g. Brazil, Namibia)¹



- Driving foothold demand for green ammonia for fertilisers can help scale production and achieve economies of scale for green hydrogen, reducing production costs of other green commodities.
- The cost reduction benefits could therefore trigger a cascade of tipping points in other sectors for green products, e.g. shipping fuel, steel derived via hydrogen-based direct reduced ironmaking (H₂ DRI).
- Additional policy measures – including carbon pricing, financial support, or regulations - will also be needed to achieve cost parity and scale-up demand in these different sectors.

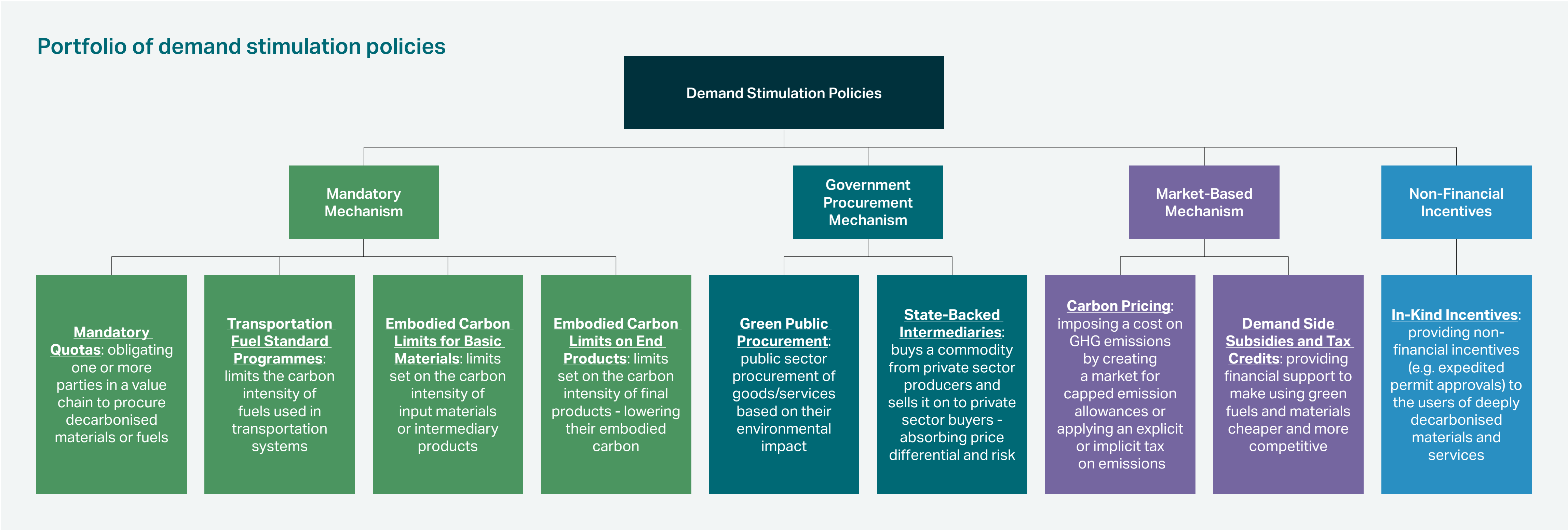
1: the presented costs correspond to favourable locations with very good solar/wind resource, assuming continued falls in the cost of clean electricity and 18% learning rate for electrolyser cost decline. Other cost projections put green hydrogen costs at scale at significantly higher levels (e.g. above \$2/kg). Sources: Indicative curve based on [The Breakthrough Effect](#), Systemiq (2023)

2

Overview of Green Demand Stimulation Policies

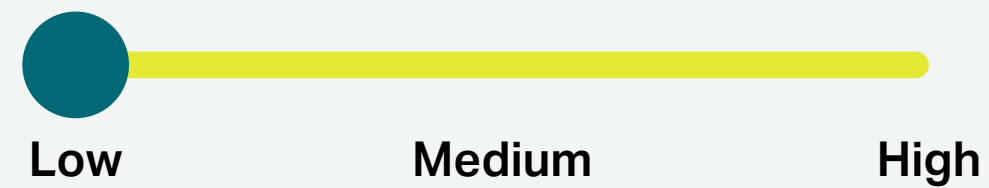
A portfolio of green demand stimulation policies can be leveraged by governments based on their specific objectives and local context

- There are **nine green demand stimulation policies** explored in detail in this playbook, spanning across four types of mechanisms. These policies are considered as if they were implemented as a standalone policy, as opposed to being implemented in combination with another. Policymakers can consider these for domestic application at the regional, national or sub-national level.
- As with any government policy, the exact mix of measures, and their specific design will need to be tailored to the local context, considering social, economic, and environmental circumstances and detailed impact assessments. All government policies should also be underpinned by deep stakeholder consultation, paying particular attention to ensuring a just transition that protects vulnerable communities.



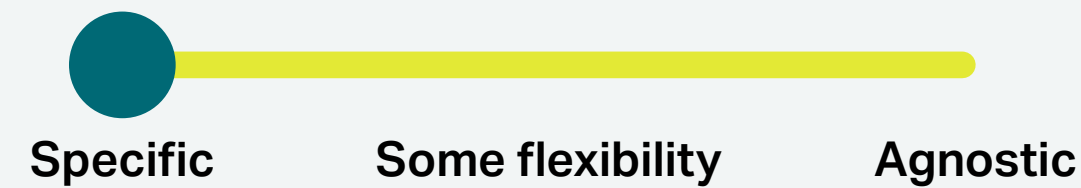
Each policy has a unique profile across six features

Carbon leakage risk



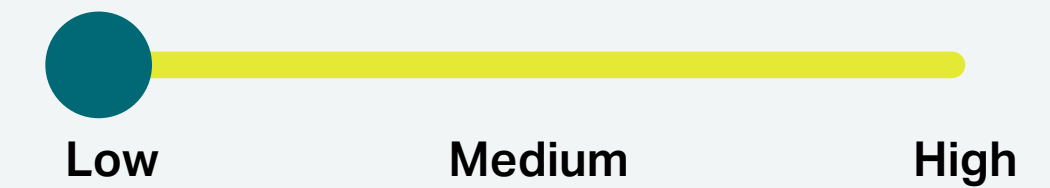
What is the risk a policy will drive emissions intensive production to other jurisdictions with less stringent environmental regulations – undermining the policy's effectiveness in reducing GHG emissions?

Technology agnostic



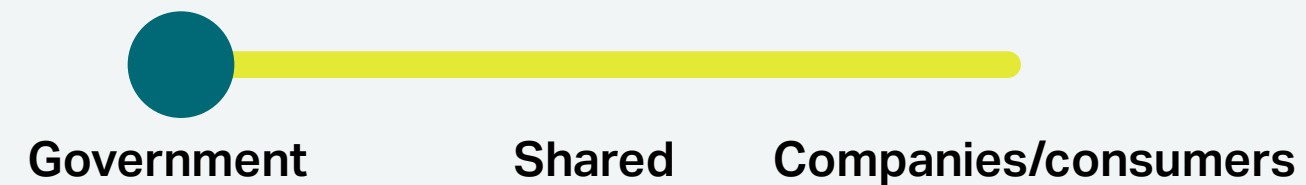
Does the policy stipulate the use of specific technological pathways, or does it offer flexibility, promoting a range of decarbonisation approaches?

Ability to ramp up over time



Can this policy and its impact be scaled over time to increase the impact on GHG emission reductions?

Burden of cost



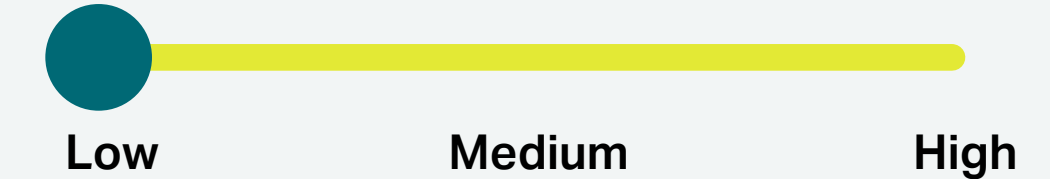
Does the policy create costs for government or companies/consumers?

Long-term stability



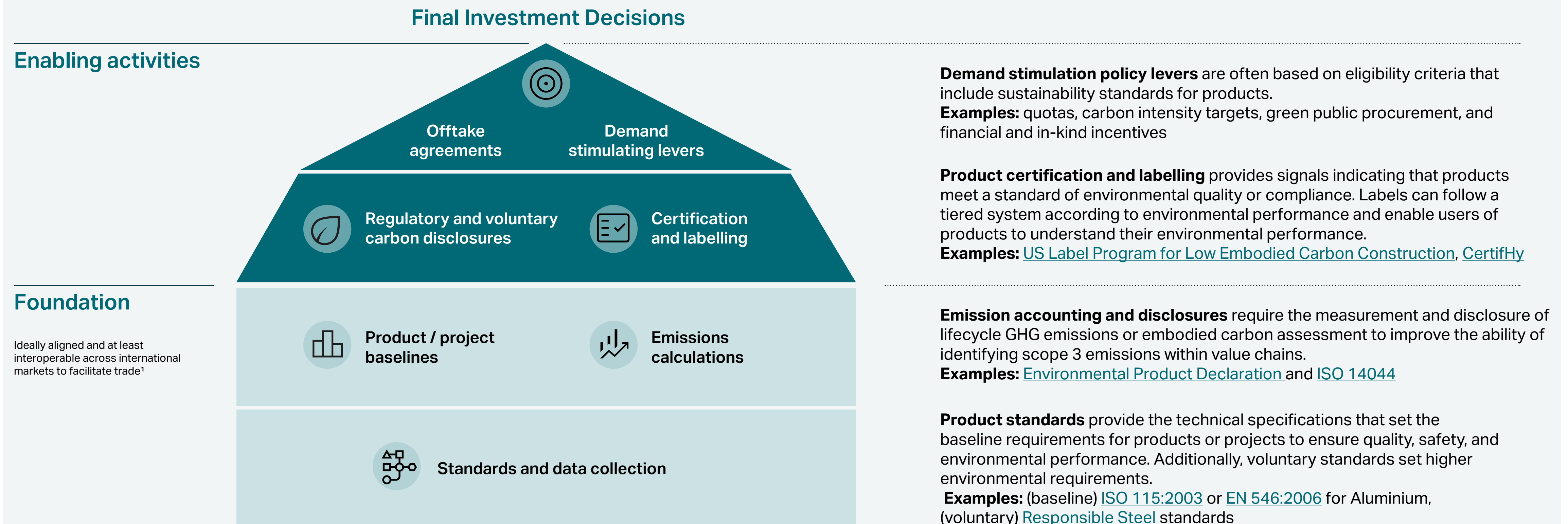
Can this policy be implemented over a long-term time horizon, or is it only possible to implement it over a short timescale? Consequently, what is the level of market certainty provided?

Complexity



What is the level of complexity associated with implementing the policy? For instance, does it require detailed technical standards for a wide range of products, or does it require a significant level of enabling policies / infrastructure?

The policies in this playbook must be underpinned by a foundation of robust standards consisting of accounting methodologies, definitions and certification



For more details on standards, see Mission Possible Partnership (MPP)'s [Standards Map](#)
Figure adapted from CEM Industrial Deep Decarbonisation Initiative

1: IRENA (2024): [Global trade in green hydrogen derivatives](#) gives examples of how certification schemes for products like green hydrogen and its derivatives can be made interoperable.

Sources: Agora Industry (2024): [Creating markets for climate-friendly basic materials. Potentials and policy options](#), MPP (2022): [Low Carbon Concrete and Construction: A Review of Green Public Procurement Programmes](#)

This playbook focuses on nine types of policy that can create green demand

Category	Government policy	Features						Key function
		Risk of carbon leakage	Burden of cost	Technology agnostic versus specific	Long-term stability	Ability to ramp up over time	Complexity	
Mandatory mechanism	Mandatory Quotas	High	Companies/ consumers	Specific	20 – 30 years	High	High	Creates a differentiated low and/or near-zero carbon market
	Transportation Fuel Standard Programs	Low	Companies/ consumers	Agnostic	20 – 30 years	Medium	Medium	
	Embodied Carbon Limits for Basic Materials	High (can be low depending on design)	Companies/ consumers	Some flexibility	20 – 30 years	High	Medium	
	Embodied Carbon Limits on End Products	Low-medium	Companies/ consumers	Agnostic	20 – 30 years	High	High	
Government procurement mechanism	Green Public Procurement	Low	Government	Some flexibility	20 – 30 years	High	Medium	
	State Backed Intermediaries	Low	Government	Specific	5 – 15 yrs	Medium	Medium	
Market based mechanism	Carbon Pricing	High	Companies/ consumers	Agnostic	20 – 30 years	High	High	Increases fossil costs
	Demand-Side Subsidies & Tax Credits	Low	Government	Some flexibility	5 – 15 yrs	Low - Medium	Low - Medium	Makes using low and near-zero products and fuels cheaper, more convenient, and/or less risky
Non-financial incentives	In-Kind Incentives	Low	Government	Some flexibility	5 – 15 yrs	Medium	Medium	

Through this work, we have identified policies with the greatest potential in scaling the adoption of low and near-zero-carbon commodities

	 Hydrogen derivatives and long-distance transportation fuels (aviation, maritime)	 Materials (aluminium, cement and steel)
Priority	Gradually ramp up use of clean hydrogen and its derivatives (as chemical and fertiliser feedstocks and/or fuel), and sustainable bio-based fuels over time - as increased volumes drive cost reduction.	Establish and scale lead markets for low and near-zero carbon commodities that can effectively support early clean industrial projects .
Key measures	• Global fuel standards and carbon pricing, implemented through the International Maritime Organisation (IMO) or International Civil Aviation Organisation (ICAO). • Domestic fuel standards and carbon pricing where these do not exist on a global level. • Mandatory quotas that become stricter over time for the use of clean hydrogen, ammonia, methanol, and SAF.	• Carbon pricing reaching a level that makes low and near-zero carbon materials competitive with grey alternatives. • Mandatory targets in public procurement, especially for cement, concrete and steel. • Embodied carbon emission standards and/or mandatory quotas for specific products (automotive, white goods) and buildings, with a progressive increase of the mandated shares to create lead markets.
	• Financial support mechanisms, e.g. subsidies and tax credits to support downstream sectors where small cost increases could have a social impact like agriculture. • Policies that facilitate transactions and help bridge the price gap for the next wave of projects, e.g. contracts for difference or market intermediaries like H2Global.	

The most impactful policies will vary by sector - mandates are particularly useful tools, alongside carbon pricing for materials

Demand creation potential of policies by sector

Government policies	Transport		Heavy Industry				Examples/case studies
	Aviation fuel	Maritime fuel	Chemicals ¹	Steel	Aluminium	Cement	
Mandatory Quotas for Use of Decarbonised Materials/Fuels	●	●	●	●	●	●	REFUELEU , RED III
Transportation Fuel Standard Programmes	●	●	●	●	●	●	California LCFS
Embodied Carbon Limits for Basic Materials	●	●	●	●	●	●	No examples identified
Embodied Carbon Limits on End Products	●	●	●	●	●	●	RE2020
Green Public Procurement	●	●	●	●	●	●	Canadian policy on green public procurement
State-Backed Intermediaries ²	●	●	●	●	●	●	H2Global
Carbon Pricing	●	●	●	●	●	●	EU ETS + CBAM
Demand-Side Subsidies & Tax Credits	●	●	●	●	●	●	CCFDs , National Green H2 Mission
In-Kind Incentives	●	●	●	●	●	●	Priority Green , Seattle

Relevant for domestic shipping/aviation. At the international level, shipping and aviation will be/are subject to multilateral measures (e.g. those under consideration at IMO for maritime and CORSIA³ for SAF). Other measures would need to be carefully coordinated with these multilateral systems.

Demand creation potential of sub-national/national/ regional measure

● High ● Medium ● Low ● Not applicable ● Subject to multilateral measure (not a focus of this work)

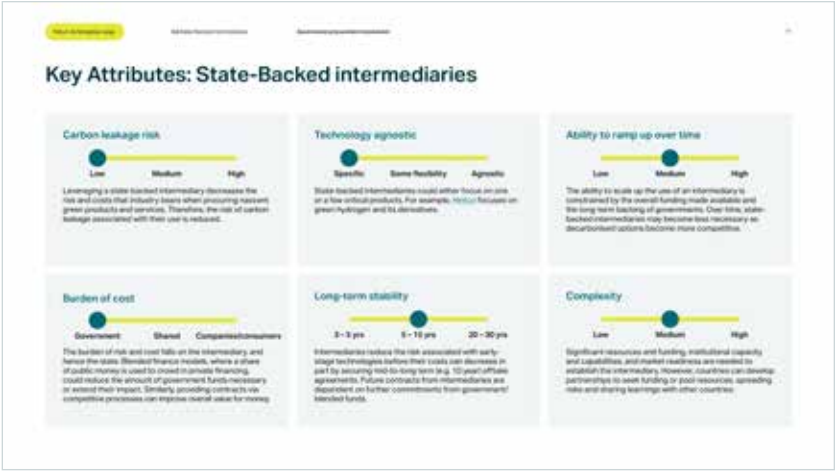
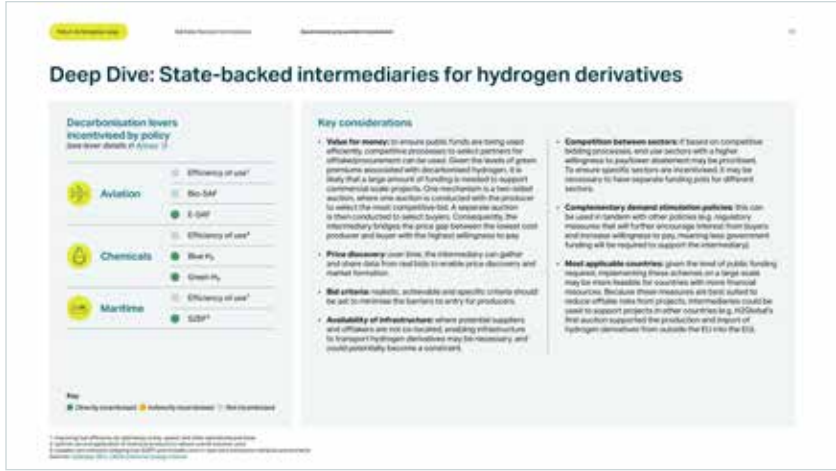
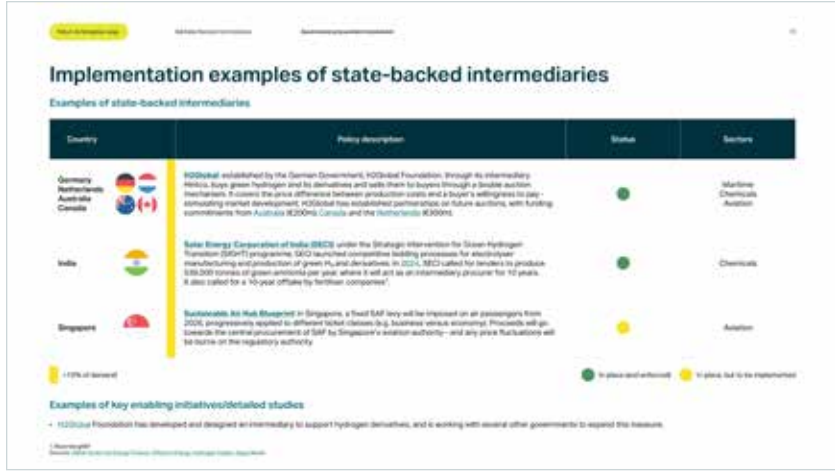
■ Government procurement mechanism ■ Mandatory mechanism ■ Market-based mechanism ■ Non-financial incentives

1: focusing on ammonia (including for fertilisers) and methanol
2: alternatively, these could also be based on a blended finance model with a mix of public and private funds
3: [Carbon Offsetting and Reduction Scheme for International Aviation \(CORSIA\)](#)

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Using this playbook

The following chapters in this playbook describe each policy in detail. Each chapter contains a consistent sequence of content:

1  Overview: descriptions of each lever, with an indicative assessment of applicability for given sectors	2  Key attributes: of policy lever (e.g. carbon leakage risk, long-term stability), assessed on a scale	3  Deep dives: on applying the lever in specific sectors	4  Identified examples: of uptake from across the world	5  Case studies: of implementation
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3.1

Mandatory Quotas

Overview: Mandatory quotas

These are binding targets set on an industry requiring a specified level of uptake of low or near-zero carbon commodities, thereby increasing demand. They can start relatively low and ramp up over time as supply scales up and becomes cheaper, giving the industry time to adapt to the new requirements. Quotas can be set as a percentage of total consumption of the commodity (%), or by volume (e.g. MT). These measures have been applied to support the introduction of [biofuels](#) and [electric vehicles](#) in various jurisdictions. In the long term, these can be increased to effectively ban a commodity. For example, [Denmark aims to eliminate all fossil-fuelled domestic flights by 2030](#). Bans could also be implemented at the point of supply, e.g. other [studies](#) explore the impact of phasing out unmitigated coal-based blast furnaces.

At least initially, it can be challenging for all impacted stakeholders to meet such quotas, as the supply of many of the commodities in question is likely to be constrained to a limited number of facilities. Therefore, it is usually crucial that quotas are implemented in conjunction with a **flexibility mechanism** (e.g. a [book and claim](#) mechanism). For example, for every unit of a low carbon commodity used, **tradable certificates would be issued**. The regulatory authority would define a compliance window, at the end of which companies would need to surrender enough certificates to correspond to their overall consumption, or pay a fine for non-compliance and/or a buyout. Companies using a surplus of low or near-zero carbon commodities could monetise this by trading certificates with companies that fall short.

Green demand creation potential by sector

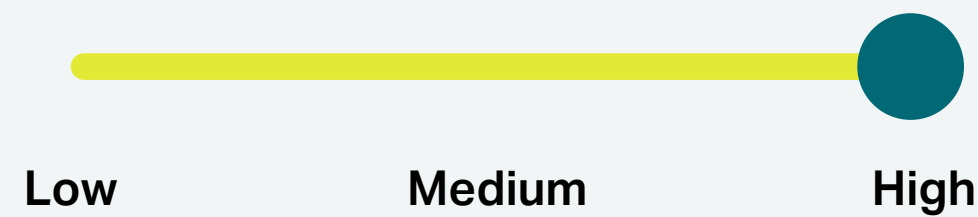
We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand it can apply to, and its potential impact on an indicative business case. Depending on local/national context, this may be more or less impactful in different sectors. A full methodology can be found in [Annex 2](#) for each sector. Based on these criteria, mandatory quotas are deemed as high priority across all sectors, given they can cover a large percentage of the market, send clear demand signals to suppliers, and can effectively help create a differentiated market for green products.

Demand creation potential rating by sector

Sector	Aviation	Maritime ¹	Chemicals	Aluminium	Cement	Steel
Demand creation potential	High	High	High	High	High	High
Included for deep dive in this report		Included for deep dive in this report				

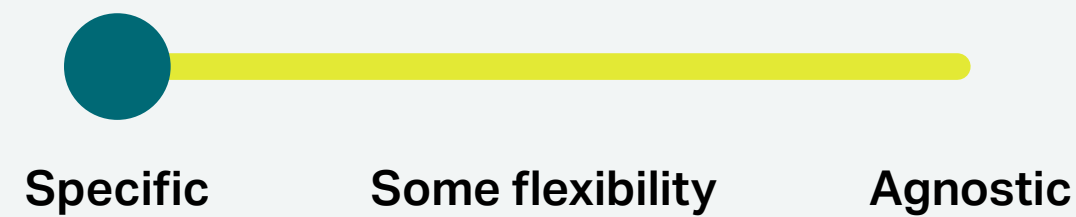
Key Attributes: Mandatory quotas

Carbon leakage risk



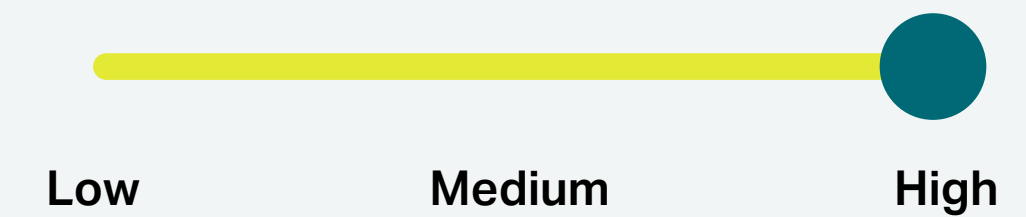
International transport and heavy industry are subject to global competition. In transport, risks include tankering¹ for aviation and relocation of trips or stopovers to ports/airports outside of the mandate's reach. For materials, value chains could shift to regions with less stringent regulations. Complementary policies (e.g. subsidies or border controls) may be needed to mitigate these risks.

Technology agnostic



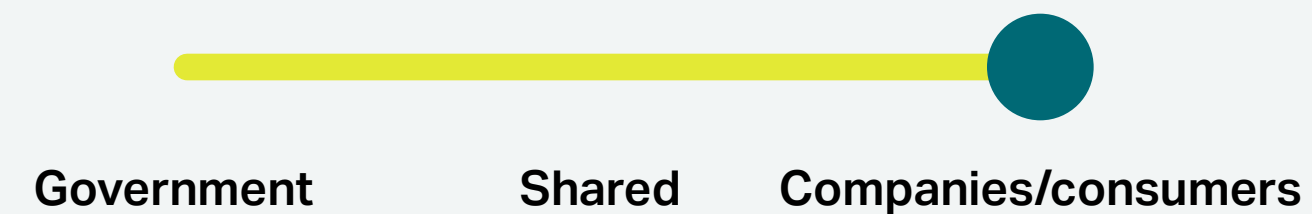
Mandatory quotas typically apply to specific products and fuels that conform to a pre-determined standard - to ensure uptake and intended climate impact is achieved.

Ability to ramp up over time



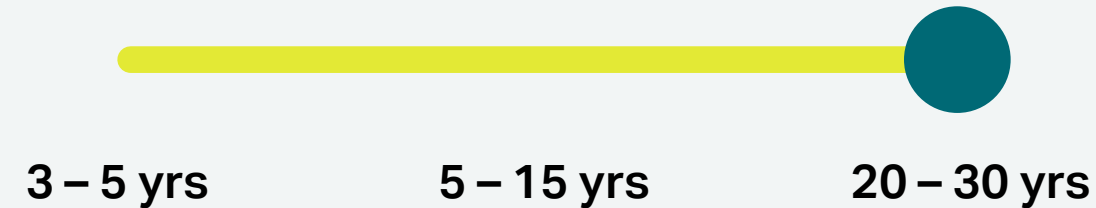
The mandated percentage or volume of decarbonised commodities can start at a manageable level (while costs are high and supply is limited). They can be gradually increased over time as low and near-zero carbon options scale and production costs are reduced.

Burden of cost



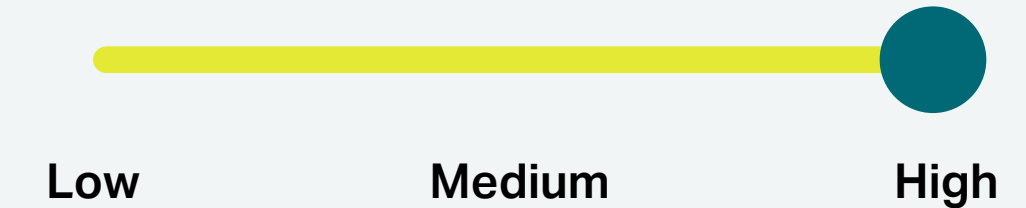
Industry bears the burden of meeting the mandates or paying buyouts/penalties. Proceeds could be re-invested in clean technologies. Industries facing international competition may become less competitive and will need to adapt or receive government support.

Long-term stability



Quotas can be set with a long-term time horizon, increasing the certainty for producers of low and near-zero carbon commodities.

Complexity



Complexities include the need to ensure that quotas are set at a manageable level for industry, while also driving additional demand, as well as implementing suitable enforcement mechanisms and determining complementary policies to support scale up.

1: tankering is the practice of carrying extra fuel on airplanes to avoid paying higher prices on arrival

Deep Dive: Sustainable Aviation Fuel (SAF) Blending Mandates

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))



Aviation

● Efficiency of use¹

● Bio-SAF

● E-SAF

Key

● Directly incentivised ● Indirectly incentivised ● Not incentivised

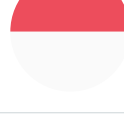
Key considerations

- **Blending levels:** several countries have imposed binding quotas on the aviation sector to consume a share of SAF that increases over time. Given SAF is currently two to five times more expensive than conventional jet fuel, blending levels have typically been set to start at or below 10% and to ramp up over time. Quotas for SAF should ensure that sufficient lead times are given to allow scale up of SAF pipelines. It may take four to seven years, or more, for SAF plants to reach operations following final investment decisions. They should also be matched against a technically feasible ramp up of supply to ensure achievability, taking into consideration feedstock availability (by different SAF types), maturity of the value chain, and supporting infrastructure.
- **Support for nascent technologies:** due to limits in the overall supply of sustainable biogenic feedstocks, more nascent SAF production (e.g. e-SAF) pathways are expected to be necessary in the long term. To ensure these options are also supported, policies may include sub quotas to enable nascent technologies to scale up.
- An **enforcement body** will be needed to ensure compliance, with penalties/buyouts set at a high enough level to make SAF adoption the more attractive option. Setting these at appropriate levels may be difficult due to a lack of market data (e.g. for emerging technologies such as e-SAF). Revenues from financial enforcement can be used to support scaling low-carbon solutions.
- **Risk of carbon leakage:** SAF mandates will increase the cost of aviation. Because aviation is exposed to international competition, this may result in market distortions that could result in carbon leakage (e.g. tankering practices). Measures can be put in place to mitigate such risks (e.g. financial support for users of SAF).
- **Complementary policies:** carbon taxes and reduced subsidies for fossil-derived fuels can complement quotas for SAF. Measures focussed on increasing the supply of SAF (for example, prioritising production of SAF over renewable diesel, offering low-cost loans and supply-side subsidies) and demand side subsidies can all support the effective delivery of mandates.
- SAF mandates may be particularly well suited to countries that have access to significant potential supplies of sustainable biogenic feedstocks (and/or clean hydrogen), and countries with a significant demand for aviation fuel - where increasing the use of SAF can contribute to energy security goals.

1: efficiency is indirectly incentivised due to SAF blending increasing the overall cost of fuel
Sources: S&P Global, [WEF Clean Skies for Tomorrow](#), [MPP Making Net Zero Aviation Possible](#).

Implementation examples of SAF Blending Mandates

Examples of Adoption of SAF mandates

Jurisdiction		Policy description	Status	Sectors
UK		SAF Mandate : requires 2% of all jet fuel in flights departing the UK by 2025 to be SAF, increasing to 10% in 2030 and 22% in 2040		Aviation
Japan		Basic Guidelines for Promoting Decarbonisation of Aviation : requires 10% of Japan’s jet fuel demand to be met by SAF by 2030		
EU		Fit for 55 and Refuel EU : requires a 2% share of SAF in jet fuel in flights departing the EU by 2025 and 6% by 2030 and 70% by 2050 (including a 1.2% e-SAF sub quota by 2030, and 35% by 2050)		
Malaysia		National Energy Transition Roadmap : requires a 1% share of SAF in 2026, rising to 47% in 2050		
Singapore		Sustainable Air Hub Blueprint : 1% SAF mandate in 2026, rising to 3-5% by 2030		
Indonesia		National Roadmap : 5% SAF mandate by 2025		
South Korea		SAF Expansion Strategy : considering a 1% SAF mandate from 2027 for all international departing		
Turkey		Considering a 5% SAF mandate for 2030		
Covers ≥10% demand (by 2030) <10% of demand		In place (and enforced) In place, but to be implemented Under consideration		

Examples of key enabling initiatives/detailed studies

- ICCT: [Scenarios of UK SAF mandate](#), [Potential tankering under an EU SAF mandate](#)

Case Study: ReFuel EU Aviation (1/2)

Jurisdiction: European Union 

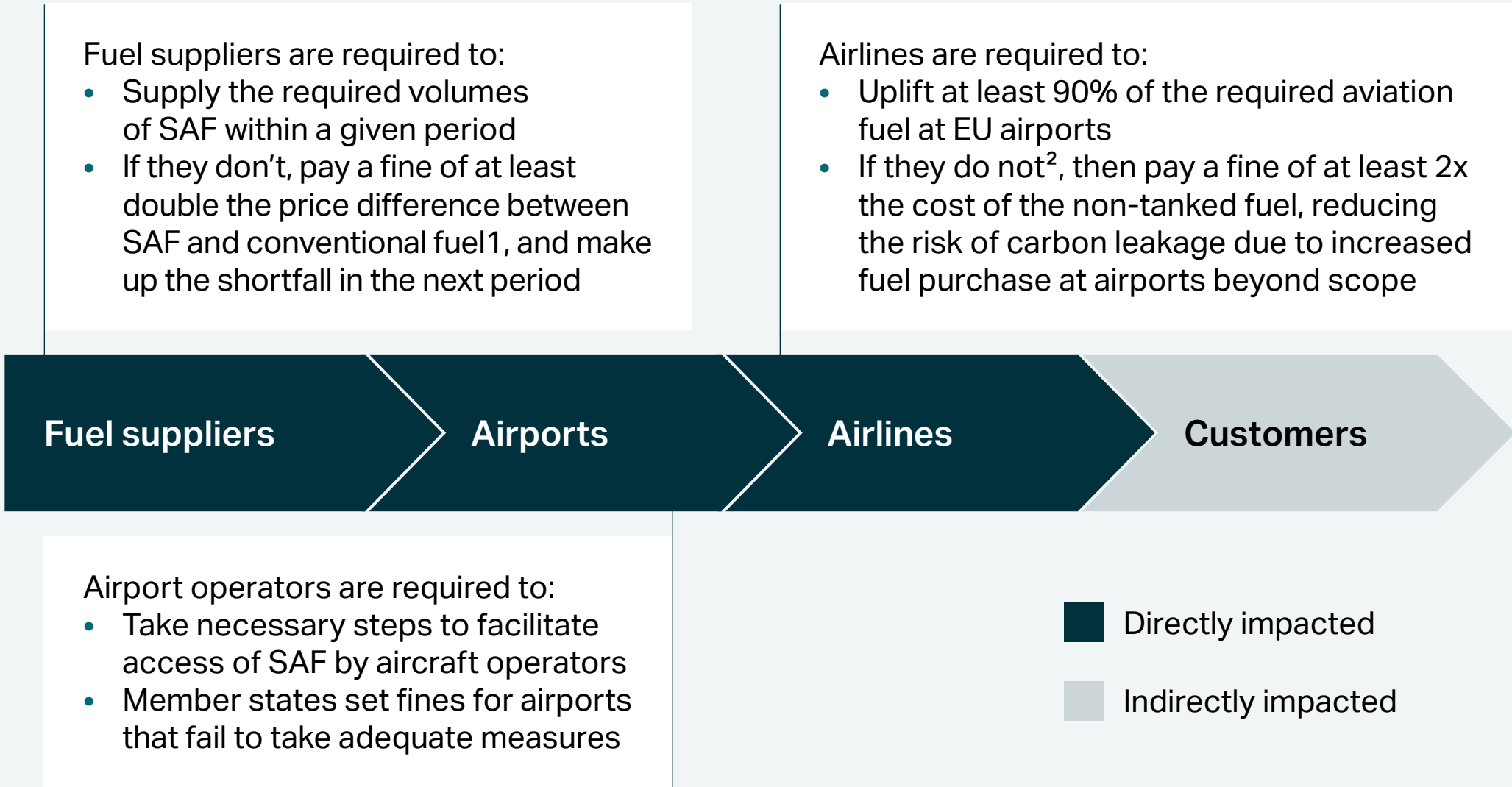
Adopted: 2023

Applies to: Flights departing EU airports

ReFuel EU is the European Union’s SAF blending mandate. It sets blending quotas for SAF, where fuel suppliers must incorporate 2% of SAF by volume into jet fuel supplies by 2025, rising to 70% by 2050. From 2030, 1.2% of fuels must be synthetic fuels. This increases to 35% in 2050.

Aviation value chain

Stakeholders impacted



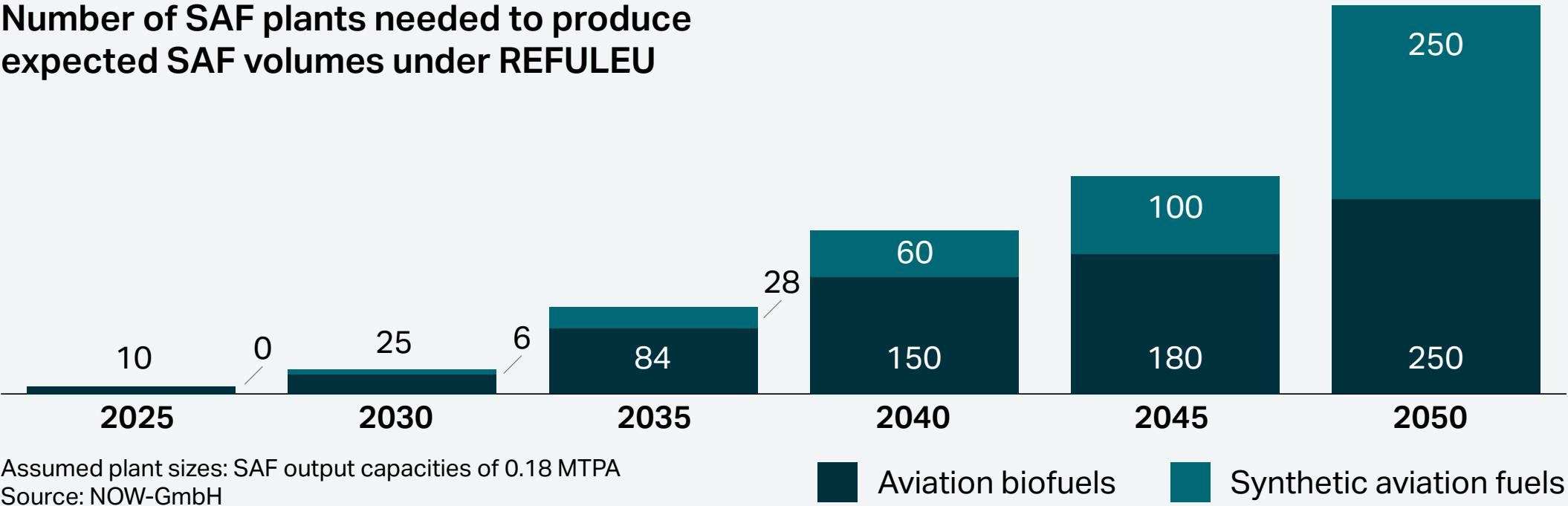
Impact

- The EU currently has the largest pipeline of both announced (pre-FID) and past-FID SAF projects of any jurisdiction.
- Since ReFuelEU was announced, 12 offtake agreements have been signed globally. Two out of the top five largest disclosed agreements involve European airlines:

Date	Offtaker	Contract Length	Supplier	Volume (Million litres)
Feb 2024	International Airlines Group	14-year	Twelve	981.3
Jan 2024	Ryanair	6-year	Enlive	125

- If fully realised, the mandate would create demand equivalent to approximately 31 SAF plants by 2030.

Number of SAF plants needed to produce expected SAF volumes under REFULEU



1: for the Power-to-Liquids sub-quota, the fine is at least twice the price difference between fuel derived via e-SAF and conventional jet fuel
2: barring exceptional circumstances
Sources: ICAO, [NOW-GmbH](#), [European Commission](#), [Ishka Sustainable Aviation Intelligence](#)

Case Study: ReFuel EU Aviation (2/2)

Key challenges/risks



1 Variations in ability to meet targets across the EU

- ReFuel EU includes a flexibility mechanism that allows the blending of SAF to be averaged across EU airports before 2035, with further flexibility granted to peripheral airports.
- As the early market for SAF will be fragmented, it is key that quotas for the use of sustainable fuels are underpinned by flexibility systems to ensure these function efficiently.

2 Regulatory uncertainty

- The legislation includes a revision clause stating it will be reviewed in 2027. This may lead to adjustments to the definition of SAF, fuels permitted, fine levels and mandated blending percentages.
- The review clause reduces the strength of the demand signal sent by the legislation. It may undermine its efficacy, particularly if SAF production does not increase as anticipated. This in turn creates uncertainty among investors and weakens the policy's effectiveness as a market signal.

3 Carbon leakage

- One of the key carbon leakage risks associated with the policy are tankering practices. This involves airlines uplifting additional fuel in jurisdictions outside of the mandate's scope, to mitigate increased fuel costs associated with the mandates. This would increase emissions.
- The policy requirements for uplifting 90% of necessary fuel at EU airports are a key measure to mitigate such a risk.

4 Establishing fines

- The fines set under ReFuel EU need to be sufficiently high to ensure that compliance is the cheapest option. As such, they are specified as twice the cost difference between SAF and e-SAF and conventional jet fuel.
- However, it may be challenging to establish accurate fines given the current lack of transparent pricing data for SAF routes (especially e-SAF, because there are not yet any commercial scale operational or past-FID in Europe). This will likely improve over time as SAF scales in the market.

5 Ensuring compliance across EU member states

- Member states must designate a regulatory authority to enforce fines and ensure that reporting standards are in line with the regulation. Member states are encouraged to use any fines collected to support SAF uptake.

Deep Dive: Mandatory quotas for clean hydrogen and hydrogen derivatives

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

	Chemicals	 Efficiency of use ¹
		 Blue H ₂
		 Green H ₂
	Maritime	 Efficiency of use ²
		 SZE ³
	Aviation	 Efficiency of use ²
		 Bio-SAF
		 E-SAF

Key

 Directly incentivised  Indirectly incentivised  Not incentivised

Key considerations

- Ramp up over time:** clean hydrogen quotas should increase in over time, depending on a country’s climate goals and considering the availability of supply. They could include sub-mandates by sector. The cost of hydrogen is expected to decrease over time as production scales, so a gradual ramp up can balance the impact of costs further down the value chain. The exact levels should be signposted well in advance to ensure sufficient lead times are given to allow scale up of low carbon hydrogen supply. For example, it may take four to seven years or longer for decarbonised hydrogen plants to reach operations following FID.
- Sectoral coverage:** there are important sectoral differences in the changes needed to adopt green products (e.g. sectors that use grey hydrogen today such as refining and fertilisers, versus sectors that will transition to using clean hydrogen, such as steel and shipping), as well as the impact on consumers. For example, farmers often have tight margins and fertilisers can make up a large share of their operating cost. As such, it may be difficult for them to manage the premium associated with green fertilisers, made from green ammonia. Furthermore, the knock-on costs of using green fertilisers could impact downstream sectors, e.g. competitiveness in the food industry. Additional support mechanisms to support end users may therefore be needed in parallel.
- Enforcement:** an enforcement body may be needed to ensure compliance, with penalties/buyouts set at a high enough level to make clean hydrogen adoption the most attractive option. Given the nascency of the hydrogen market, with relatively little real-world pricing data, it may be difficult to set these accurately. Revenues from financial enforcement can be used to support scaling low carbon solutions.
- Imports:** hydrogen derivatives such as ammonia are traded internationally today. Therefore, imports should be covered under quotas to create a level playing field and avoid carbon leakage. At present there are a limited [number of ammonia terminals worldwide](#) so monitoring imports at some stages of the value chain effectively may be feasible (this would however be much more challenging for end products like food).
- Complementary policies:** these may be needed to support underpinning hydrogen/derivative transportation infrastructure, support downstream users and reduce carbon leakage risks.
- National context:** such mandates may be particularly well suited to countries that have access to significant existing demand for grey hydrogen - that can be required to switch over to decarbonised hydrogen. Otherwise, policies could focus on applying mandates for imported downstream products. For countries with strong hydrogen production potential, but low existing demand, measures to build domestic hydrogen demand could be adopted in parallel with the added benefit of improving energy security or a dependence on imports (e.g. India is seeking to displace all [ammonia-based fertiliser imports by 2034-5](#)).

1: optimal application of chemical products to reduce overall associated emissions
2: improving fuel efficiency by optimising routes, speed and other operational practices
3: SZE³ means ‘scalable zero emission shipping fuel’ and includes zero/near-zero emissions methanol and ammonia
Sources: India National Green Hydrogen Mission, European Union [Renewable Energy Directive](#)

Implementation of mandatory quotas for low carbon hydrogen

Examples of mandatory quotas by jurisdiction

Jurisdiction	Policy description	Status	Sectors
European Union 	Renewable Energy Directive (RED): the EU requires member states to ensure 42% of hydrogen in industrial use is green by 2030. This increases to 60% by 2035. Member states are currently determining how to meet this, e.g. they can set mandatory quotas of their own to achieve this, or use other measures (e.g. increased subsidies or alternative demand side measures). ReFuelEU Aviation also sets quotas for the use of synthetic aviation fuel, which is kerosene made with renewable or low carbon hydrogen.		Chemicals Aviation
	 Covers ≥10% demand	 In place, but to be implemented	

Examples of key enabling initiatives/detailed studies

- [Hydrogen for Net Zero \(2021\), Hydrogen Council & McKinsey](#)

Case Study: Renewable Energy Directive (RED) III (1/3)

Jurisdiction: European Union 

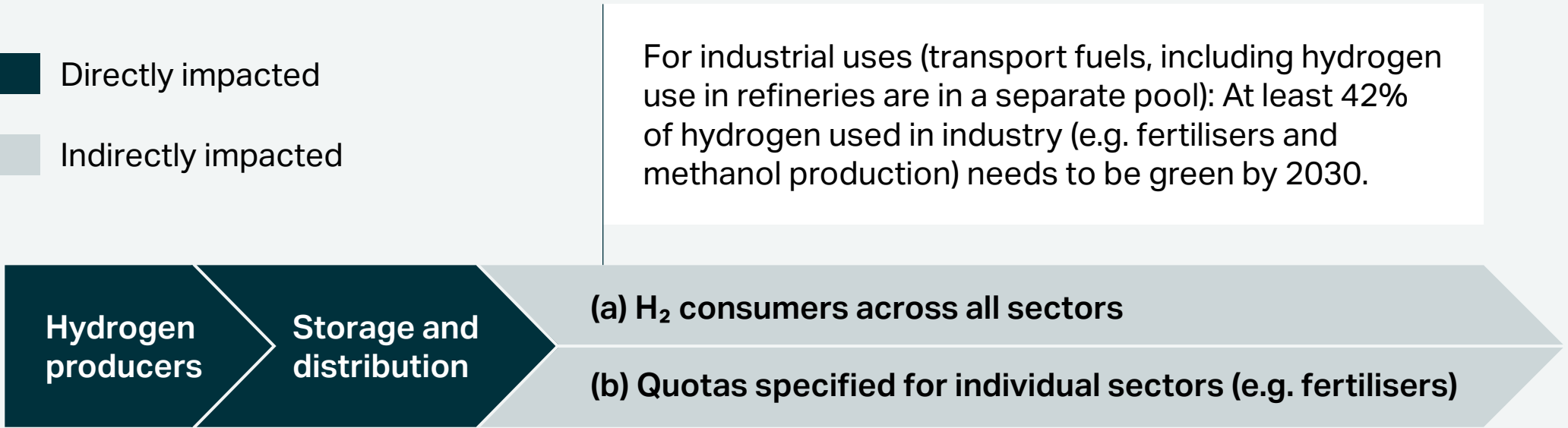
Adopted: 2023

Applies to: Industrial hydrogen users

RED requires member states to ensure that at least 42% of hydrogen used in the industry by 2030 is green - rising to 60% in 2035. Depending on the wider context (e.g. progress on economy-wide decarbonisation, consumption of other non-fossil hydrogen, and plans to abate existing production emissions via carbon capture and storage) these targets could be reduced. By 2025, member states are required to transpose these targets into national law and choose a range of implementation options including a) passing the quota onto industry b) setting mandates on specific sectors or c) introducing subsidies and demand-side measures to spur uptake. Thus far eight of 27 EU member States have done so. Here we consider options 'a' and 'b' in detail.

Industrial hydrogen value chain

Stakeholders impacted by option (a) and (b)

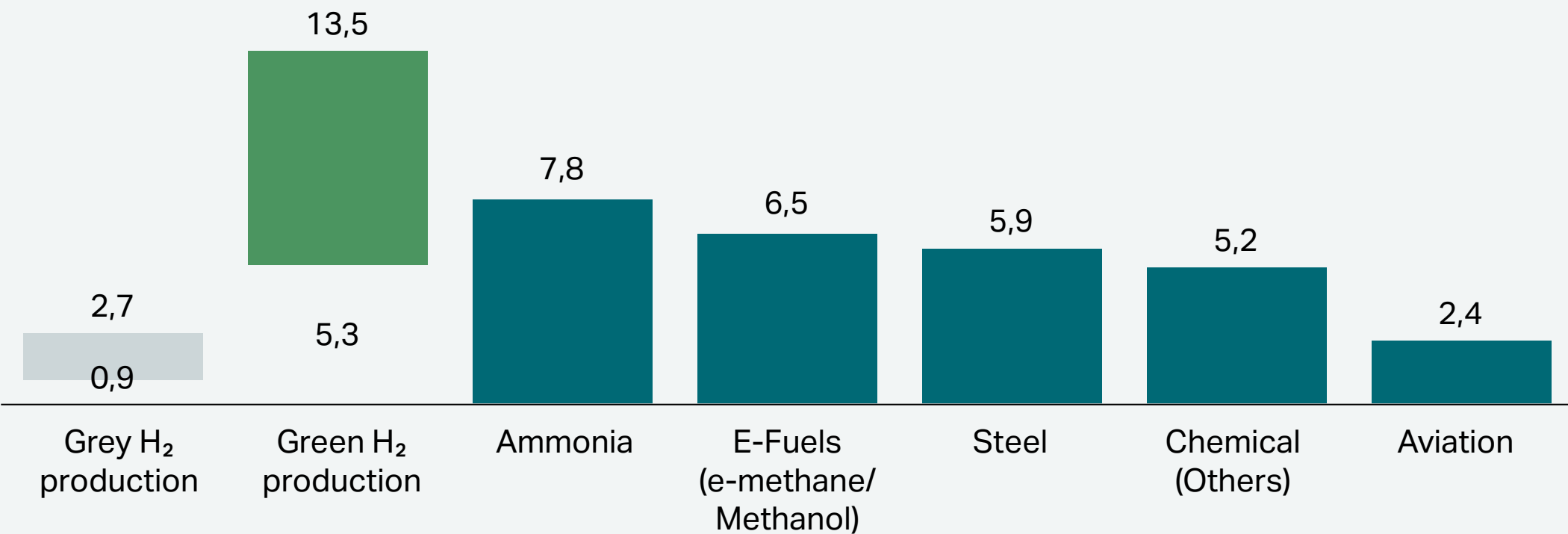


Note: many industrial players produce their own hydrogen on site, so these stakeholders may not be distinct

Details on next slide →

- Demand creation:** if achieved, the RED targets could drive consumption of green hydrogen to 1.6 – 4 million metric tonnes (MMT) by 2030, and 2.3 – 7.5MMT by 2035. Estimates vary depending on forecasted total hydrogen demand¹.
- Impact on willingness to pay:** although states have yet to implement the RED targets, there are already indications that RED and other measures have increased European willingness to pay for green hydrogen. The European Hydrogen Bank (EHB), an auction-based subsidy mechanism run by the European Commission, published average hydrogen production costs and average offtake prices by sector, identified through its pilot auction. Average offtake prices ranged from €5.7 – €8.3/kg H₂ (\$6.2 – \$9.0/kg H₂) depending on sector, which are significantly higher than grey H₂ levelised costs.

Grey and green hydrogen production costs (€/kg H₂) vs average offtake bid prices by sector (EHB) (non-exhaustive)



1: [BNEF](#), European Hydrogen Observatory
Sources: TUV Sud, [European Commission](#), European Environment Agency, [Hydrogen Europe Position Paper](#), Bloomberg NEF, [S&P Global Commodity Insights](#), [NOW gmbh](#), [H2Global Pilot Auction Results – Bid insights](#) – Bid insights;

Case Study: Renewable Energy Directive (RED) III (2/3)

RED places a requirement on EU member states to meet the 2030 and 2035 targets, but does not prescribe the national and sub-national regulatory incentives that should be used to meet these. Member states have the flexibility to adapt their policies to ensure a level playing field for hydrogen consumers. The mandatory quotas send a clear demand signal to hydrogen producers, encouraging an increase in investment and in the supply of green hydrogen. Below, we explore the advantages and disadvantages of two indicative options for passing on the mandate to industry.

	Option A: applying the mandate across ALL sectors	Option B: quotas specified for individual sectors
Description	Companies are responsible for achieving mandated targets, which are applied uniformly across all sectors. The mandate/quota can be applied one time or gradually increased over time.	Companies are responsible for achieving mandated targets. Different targets are applied depending on the sector.
Pros	- With the same standard/target being implemented across all sectors, it will be easier for the government to enforce such standards and ensure compliance. - It could be implemented with a book and claim mechanism, spreading the impact across a wider range of actors.	By tailoring the targets to specific sectors, the targets can be made more achievable within the given time frame, helping companies navigate specific sectoral challenges e.g. international competition and economic structures.
Cons	- This option does not consider the differences between sectors in investment cycles, exposure to international competition, level of risk of carbon leakage, etc. Thus, some sectors may struggle more to meet the targets than others. - Downstream companies may decide to procure from competitors outside the scope of the mandate if the uptake of green materials/ fuels implies rising cost.	- The regulation and level of stakeholder engagement increases in complexity as measures are tailored by sector, increasing the difficulty of monitoring and enforcement. - Member states with a larger industrial footprint have more flexibility on implementing the mandates, while those with a smaller footprint will impose more restrictions on a smaller group of stakeholders. This could increase the risks of market distortions within the EU.

Case Study: Renewable Energy Directive (RED) III (3/3)

Key challenges/risks

1 Carbon leakage

- Member states are encouraged to coordinate their policies in order to reduce intra-EU carbon leakage risks. The EU has also published [implementation guides](#), including the implementation of targets for [green hydrogen](#) for RED.
- The rules on how imported grey hydrogen derivatives (e.g. methanol, ammonia) are accounted for through the quota are currently not clear. To avoid carbon leakage and ensure a level playing field, it is key that the quota applies fairly to imports and domestic production.

2 Uncertainty over prices

- It is currently not yet clear how member states will transpose the RED targets into national laws. If they choose to implement this via national level binding quotas, these will need to be underpinned by sufficiently high penalties/buyouts for non-compliance. Setting these may be a challenge due to lack of market data.

3 Need for flexibility to cater to varying geographical/sectoral contexts

- In order to function effectively, it is key that any mandatory quota is underpinned by a book and claim system that can improve the overall efficiency of meeting the requirements. This is particularly important in the case of industrial use of green hydrogen/hydrogen derivatives, where distribution infrastructure is currently very nascent - and the use of such commodities is likely to be predominantly concentrated to a handful of large industrial facilities (e.g. chemical/DRI-steel plants and refineries).

4 Means to reduce targets could lower hydrogen uptake

- Targets can be reduced by 20% in 2030 and 2035 if certain conditions are met.¹ On a specific case-by-case basis, low carbon hydrogen (i.e. with at least a 70% reduction relative to fossil fuels) produced via means other than electrolysis, may be excluded from the quota. This could potentially reduce the overall impact on green hydrogen uptake.

5 Managing the green premium and increased risks

- The increased costs of green hydrogen for downstream industries needs to be managed alongside the mandate. Additional funding to support green hydrogen producers and offtakers could be used to manage this. This may be particularly key for industries where margins are especially tight (e.g. in the agricultural sector, additional support may be necessary to support farmers to manage increased fertiliser costs).

6 Ensuring sufficient supply

- To meet mandatory targets, it is important that the supply of green hydrogen is supported to ramp up. While increased certainty of demand will incentivise production, measures to support the production and distribution of green hydrogen, and its derivatives directly, can also be used. The EU Hydrogen Strategy also includes policies to increase investment in green hydrogen production.

1: For more information, see the European Commission's [Guidance on targets](#);

Source: TUV Sud, [European Commission](#), European Environment Agency, [Hydrogen Europe Position Paper](#), BloombergNEF, [S&P Global Commodity Insights](#), NOW gmbh, [H2Global Pilot Auction Results – Bid insights](#) – Bid insights;

Deep Dive: Quotas for low/zero emissions materials

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

 Steel	 Efficiency of use ¹
	 Recycling
	 CCUS/H ₂ DRI
 Cement	 Efficiency of use ¹
	 Low carbon production (e.g. via SCMs, CCUS)
 Aluminium	 Efficiency of use ¹
	 Recycling
	 Low/near-zero carbon primary production ²

Key

 Directly incentivised  Indirectly incentivised  Not incentivised

Key considerations

- Novel instrument:** though these have not yet been implemented in these sectors, quotas for the use of low/near-zero emission materials could work in a similar way to blending mandates set for biofuels and quotas for zero emission vehicles. This would involve requiring that a percentage of material (e.g. steel, cement or aluminium) used by companies within a jurisdiction, and/or a specific sector, conforms to a given low carbon or near-zero standard. Sub-mandates could be used to support specific technologies. Ideally, a book and claim system would support this, i.e. for every unit of compliant material used, tradable certificates would be issued. The overseeing regulator would define a compliance window, at the end of which companies would need to surrender a corresponding number of certificates to their overall material consumption, or pay a fine and/or buyout. This would allow companies that produce a surplus of low carbon or near-zero carbon materials to monetise this by trading certificates with companies that fall short, creating a valuable revenue stream for early plants.
- Ramp up over time:** quotas should increase over time, depending on the country’s climate goals. As supply scales up, the cost of low and near-zero solutions across these sectors is expected to reduce over time - and as this happens the shares mandated can be increased.
- Stage of the value chain:** whether quotas could be applied to end-use industries, suppliers or intermediate players, or a combination of these actors, would need to be considered. It may be easier to apply quotas to a market segment that is more concentrated, for ease of enforcement. Furthermore, quotas place a burden on industry players to absorb the green premium, so the feasibility should also be assessed based on the buyers’ ability to pay.
- Risk of carbon leakage:** to mitigate the risk of carbon leakage, importers of the relevant commodities into the jurisdiction would also need to ensure they are certified low/zero emissions. Where downstream products containing the commodities are imported, further measures covering embodied content may be necessary. For widely traded commodities/products, especially complex end products, this may be challenging to implement.
- Substitution:** such quotas would increase the overall costs of the relevant commodities. This may drive increased material substitution in end products. Depending on the materials substituted and specific end products, these could either drive lower or higher overall emissions.
- End-user markets:** quotas could be applied to specific end-user markets, tailored to lower risks of carbon leakage or inappropriate substitutions. For example, in the automotive sector, there would be very limited substitution options for metals (though a green steel quota could increase the share of aluminium used in a vehicle).
- Scale of jurisdiction:** the more facilities that are within scope of the regulation, the easier it would be to establish a functional market for trading certificates and hence to share the cost across multiple producers. Therefore, such a measure is particularly well suited to large jurisdictions.

1: refers to the optimal use of the material to reduce the overall embodied emissions of a product
2: adopting production technologies with a lower carbon footprint (e.g. using clean power for aluminium smelting, inert anodes and/or mechanical vapor recompression (MVR))
Sources: [Colombia Centre for Energy Policy](#), Centre for European Policy Studies (CEPS)

Implementation examples of quotas for low carbon and zero emission materials

Status of adoption of quotas for low carbon and zero emission materials

- At the time of writing, we have not identified examples of mandatory quotas being applied in the materials sectors¹. However, these have been applied across a range of other decarbonisation technologies, such as SAF, bio-fuels more generally and zero emission vehicles.
- Several publications explore the impact of such policies across different sectors:
 - Cement and concrete in California: [Columbia Centre on Global Energy Policy](#)
 - Green steel in the automotive sector: [Transport and Environment](#), [ICCT](#)



1: Some voluntary initiatives set targets for the procurement of near-zero materials. For example, under SteelZero and ConcreteZero, organisations commit to buy and use 50% lower emission steel and concrete by 2030, and 100% net zero by 2050 at the latest.

3.2

Transportation Fuel Standard Programmes

Overview: Transportation Fuel Standard Programmes

These are instruments that incentivise the adoption of decarbonised fuels by imposing a limit on the carbon intensity of fuels used in transportation. They are often applied to fuel suppliers and retailers and encompass a range of transport sectors (e.g. they can include road transport, aviation and maritime fuels in different ways). They work by establishing:

- A limit on the overall carbon intensity of transport fuels supplied within a given scope. The limit is then applied to suppliers
- A set of eligible fuels that when sold generate tradable credits to contribute to the overall carbon intensity limit
- A requirement that suppliers need sufficient credits to represent their overall fossil supply
- A revenue stream for the use of low carbon fuels, as suppliers with a deficit of credits can procure them from those with a surplus
- Demand indirectly by influencing the selection of fuels by consumers.

Green demand creation potential by sector

We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand it can apply to, and its potential impact on a business case. Depending on local or national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. Based on this analysis, domestic fuel standards programmes can be applied to support the aviation and maritime sectors, but may need to be paired with other measures. For example, in the international maritime sector, these would need to be carefully co-ordinated with the regulatory measures currently under consideration in the IMO.

Demand creation potential rating by sector

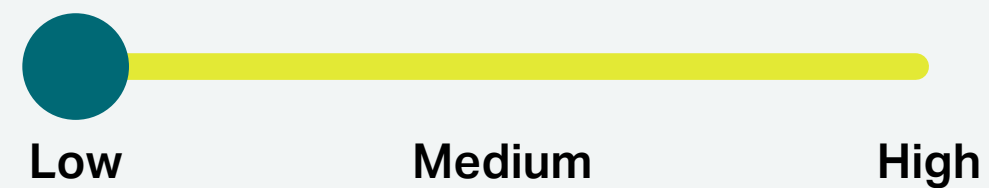
Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Demand creation potential	Medium	Medium	N/A	N/A	N/A	N/A

Included for deep dive in this report

Note - A multilateral measure establishing a Global Fuel Standard for the maritime sector is currently under development at IMO which national measures would need to be carefully coordinated with.

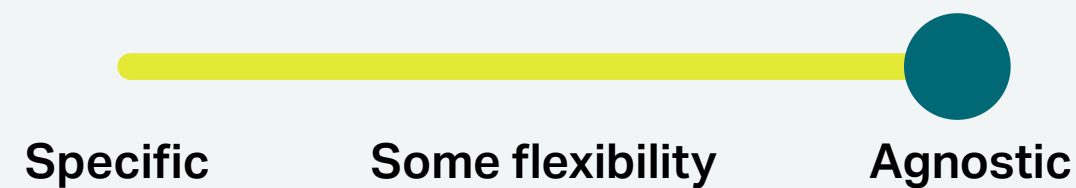
Key Attributes: Transportation Fuel Standard Programmes

Carbon leakage risk



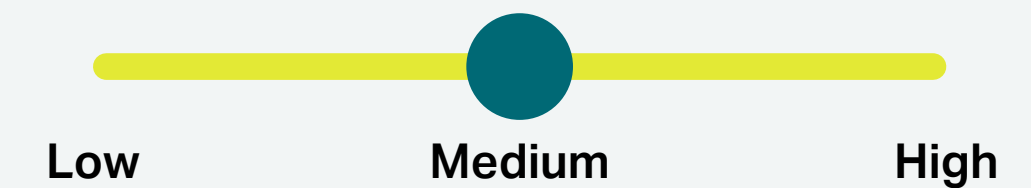
Depending on how a fuel standard incentivises transportation fuels, it could increase costs and increase carbon leakage risks in internationally exposed transportation sectors. However, since the cost is likely to be shared with more localised transport services (e.g. road transport) this is likely to be relatively low.

Technology agnostic



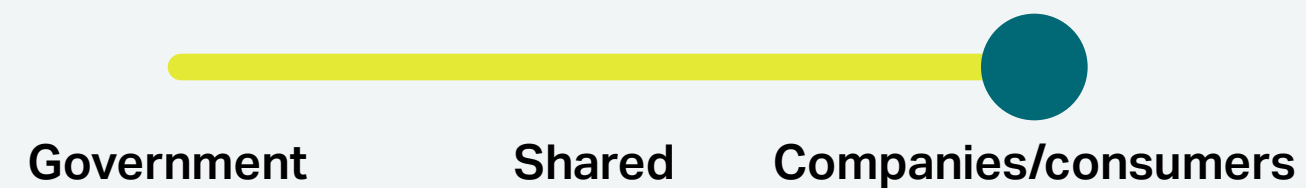
Fuel standard programmes typically include several sectors in their scope, and allow multiple decarbonisation levers to contribute to overall targets.

Ability to ramp up over time



Intensity limits can be increasingly tightened through the low carbon standard over the years. However, as low carbon solutions proliferate across sectors, the overall demand for credits may drop - reducing their value and the overall financial impact of the instrument.

Burden of cost



Buyers bear the burden of incurring additional costs that come with procuring lower carbon fuels. This could disproportionately impact smaller businesses and lower margin industries/ sub-sectors with less resources to absorb the cost.

Long-term stability



Fuel standard programmes can be put in place with a long-term horizon, but the overall value of the associated incentives may vary over time.

Complexity



To ensure the success of these policies, governments need robust systems in place to facilitate emissions reporting; measurement; monitoring; and enforcement. Trade-offs between different sub-sectors also need to be considered (if multiple sectors fall under the standard's scope).

Deep Dive: Fuel standards for heavy transport fuels

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

	Aviation	 Efficiency of use ¹
		 Bio-SAF
		 E-SAF
	Maritime	 Efficiency of use ¹
		 SZE ²

Key

 Directly incentivised  Indirectly incentivised  Not incentivised

Key considerations

- **Inclusion of more nascent fuels:** for less mature/more expensive fuels (e.g. hydrogen derivatives and advanced biofuels) governments can consider awarding additional credits (i.e. 'multipliers') to further incentivise such fuels. When determining the appropriate application of multipliers, trade-offs between the decarbonisation of different sub-sectors need to be carefully considered. Alternatively, limits for specific fuels in sub-sectors can be implemented (e.g. prioritise the use of sustainable biofuels in hard-to-abate sectors over road transport that can be more readily electrified).
- **Implementation over time:** fuel standards can be tightened over time as the availability of decarbonised fuels increases, production costs fall, and enabling infrastructure becomes more widespread. The supply and demand of credits will need to be taken into account, as rapid decarbonisation of specific sub-sectors (e.g. road transport) may make the price of credits too cheap to have an impact in more costly-to-abate, heavy transport sectors.
- **Method of inclusion:** standards can be applied differently for different fuels and sectors. For maritime and aviation fuels, there are three main ways:
 - 1 Not in scope of programmes: those that do not include maritime or aviation, but focus on other sectors (e.g. road transportation)
 - 2 'Opt in' programmes: in this case, the sale of sustainable maritime or aviation fuels generates credits. However, retailing of fossil aviation and maritime fuels does not generate a deficit
 - 3 Full inclusion: where retailers of fuels receive credits, but the sale of fossil aviation or maritime fuels generate credit deficits.
- **Accounting methodologies:** variations exist between GHG emission accounting methods used, e.g. tank-to-wake or well-to-wake in maritime. Certain fuels with low tank-to-wake emissions can have high emissions from its upstream production. Thus, using a well-to-wake method can give a more comprehensive life cycle assessment and should be adopted consistently across transport modes in scope of fuel standard programmes.
- **Risks of increasing demand for unsustainable, cheaper fuels:** without the right guardrails restricting or stopping the use of unsustainable fuels, standards could increase demand for fuels made from less sustainable feedstocks. This in turn could increase stresses on food security/ feedstock supply. Ideally, policies should prioritise the use of appropriate feedstocks, particularly in sectors with very limited decarbonisation options (like aviation).
- **Need for co-ordination with other instruments/regulations:** the international maritime sector is globally regulated by the IMO, and a mandatory Global Fuel Standard and GHG pricing mechanism is currently under consideration. The use of domestic fuel standards programmes would need to be carefully coordinated to support implementation of such instruments. One option may be to allow sellers of SZE² to opt in and receive credits, indirectly subsidising SZE².

1: improving fuel efficiency by optimising routes, speed, and other operational practices. This is incentivised given the higher cost of fuel

2: Scalable zero emission shipping fuel (SZE²), including zero/near-zero emissions methanol and ammonia

Sources: [RMI](#), [ICCT](#)

Implementation examples of fuel standards programmes incentivising heavy transport fuels

Examples of fuel standards programmes

Jurisdiction		Policy description	Status	Sectors
UK		Renewable Transport Fuel Obligation (RTFO): SZEFS for international shipping are allowed to opt in under the RTFO. Conventional fuel for international maritime is not included in the obligation. Inland maritime is fully included. SAF is currently fully included, but will be removed in 2025 when the UK SAF mandate comes into effect.		Maritime
US		SAF is permitted to opt in to state level Low Carbon Fuel Standards in California, Washington and Oregon in the US.		Aviation
Netherlands		Renewable Energy for Transport¹: Fuel distributors must reduce their GHG emissions from fuels by 6% compared to 2010 levels. Renewable Energy Units (HBEs) can be generated through GHG emissions or traded to meet obligations. International maritime and aviation fuel suppliers are allowed to opt in. Inland maritime is fully covered ² .		Maritime Aviation
European Union		FuelEU Maritime: set targets to reduce the GHG intensity of energy used in ships compared to 2020 baseline levels. Targets are tightened every five years. Green hydrogen derivatives are provided with a multiplier of two towards GHG intensity targets until 2033. There is a potential future mandatory quota requiring 2% from 2034 if the share of green hydrogen derivatives in the fuel pool is less than 1% by 2031.		Maritime
 Covers ≥10% demand			 In place (and enforced)	

Examples of key enabling initiatives/detailed studies

RMI: [How States Can Use Low Carbon Fuel Standards to Incentivise Clean Hydrogen-Derived Fuels; Refueling Aviation in the United States](#)

1: to apply to inland ships from 2025
2: [CEM Biofuture Platform – Policy Blueprint Country Profile Netherlands](#)
Sources: [Lloyd's Register](#)

Case Study: California Low Carbon Fuel Standard (1/2)

United States

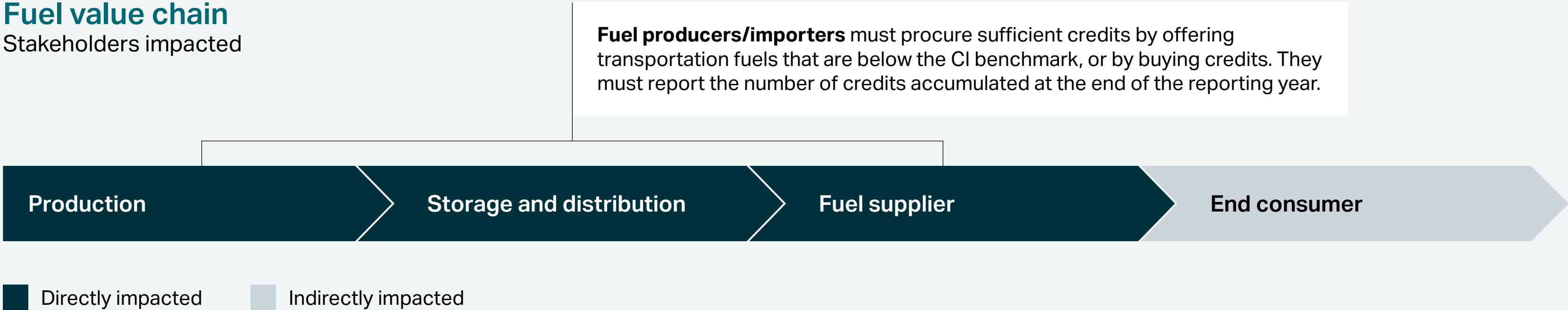
Adopted: 2011

Applies to: transport (including aviation on an opt-in basis)

- The California Low Carbon Fuel Standard aims to decrease the carbon intensity (CI) of transportation fuels, while offering consumers a range of low carbon and renewable fuel options, thereby reducing GHG emissions and improving the air quality in California.
 - The transportation fuels in scope primarily focus on road transport (with some exemptions) and include gasoline, diesel, compressed and liquefied natural gas (and their substitutes), biofuels, electricity and hydrogen. However, sustainable aviation fuels are currently able to opt in. This means SAF suppliers in California receive credits in return for selling SAF, but do not create deficits from selling fossil-based jet fuels.
- The carbon intensity standards account for emissions across production, distribution and fuel consumption. An overall limit on CI is set and gradually tightens over time, to 80% of a 2010 baseline by 2030 and staying constant thereafter.
 - The programme is implemented through a credit and deficit system. Fuels that are over the CI standard generate deficits, while those that are under the standard generate credits. One credit is equivalent to one MT CO₂ of avoided GHG emissions. At the end of the reporting year, if a fuel producer/importer has a deficit, they must purchase credits from those who have accumulated a surplus of credits. The programme therefore gives parties some flexibility in meeting the requirements.
- Credits can be generated in the following ways: firstly, fuel suppliers can certify and report the CI of their fuels; secondly, implementing CCS at a production facility along the fuel supply chain and/or using direct air capture; and by providing zero emission vehicle fuelling/charging infrastructure.
 - Similar policies have since been adopted by other states including Oregon, Washington and the Canadian British Colombia province.

Fuel value chain

Stakeholders impacted



Case Study: California Low Carbon Fuel Standard (2/3)

United States

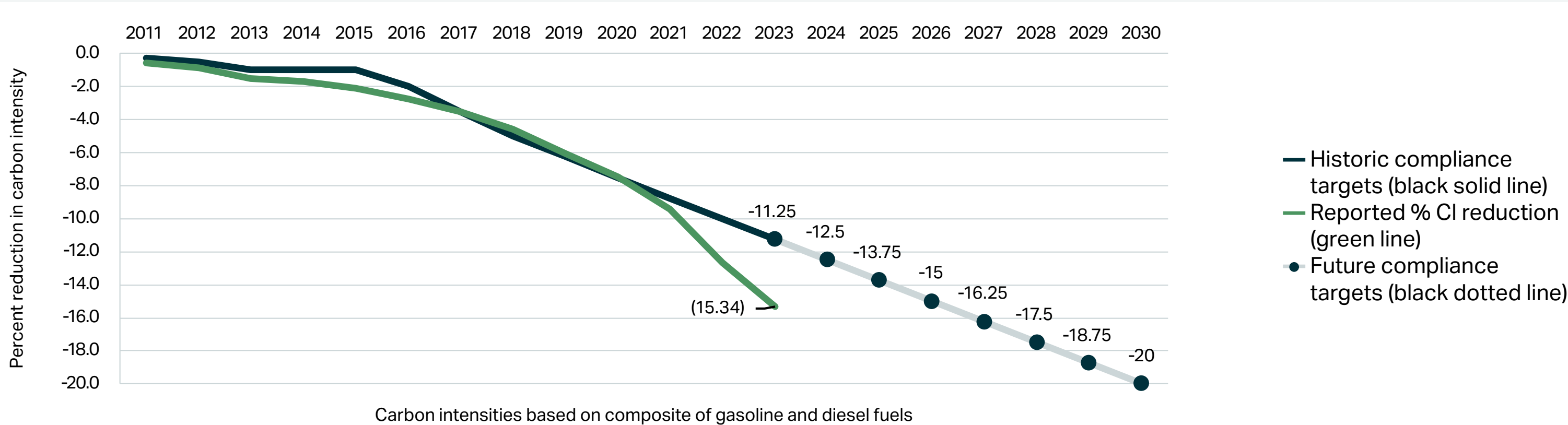
Adopted: 2011

Applies to: transport (including aviation on an opt-in basis)

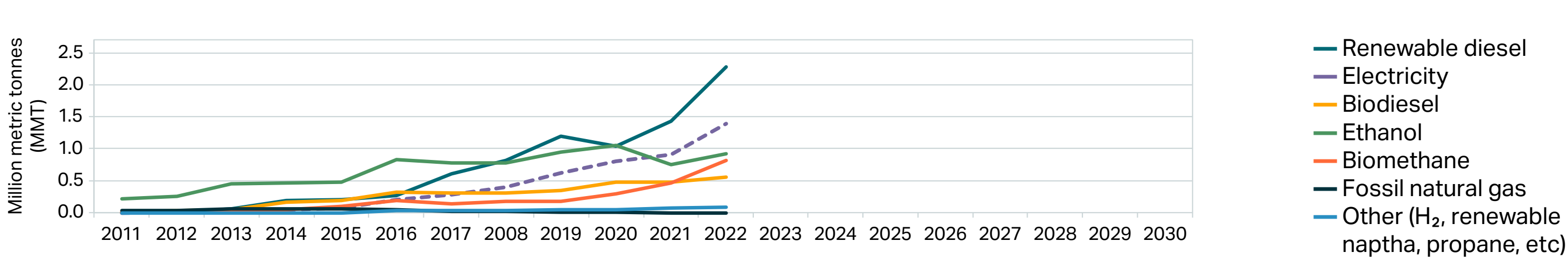
Impact

- The fuel standard has encouraged innovation in transportation fuels, resulting in a two-fold increase in the volume of low carbon fuels compared to a decade ago. Between 2011-2017, the share of alternative transportation fuels grew from [6.1% to 8.5%](#)
- The reported percentage CI reduction outperformed the compliance targets set in 2021-2022, signalling the increased adoption of low carbon fuels and increase in their economic viability.
- The credits market has seen continuous growth (see Graph B), with the market value exceeding [US\\$2bn](#) in 2018. Biomass-based fuels accounted for over 75% of the share.

Graph A: showing carbon intensity targets versus actual reported CI reduction (%)



Graph B: credits (MMT CO₂e avoided) dispersed by fuel type in 2011-2022



Case Study: California Low Carbon Fuel Standard (3/3)

Key challenges/risks

1 Preventing unintended environmental outcomes from alternative fuel consumption

- While some biomass-based fuels have a lower GHG emission footprint compared to fossil-based fuels, a surge in demand for specific fuel type could have unintended consequences, such as placing a strain on the feedstocks, or increasing competition for other products like vegetable oil, animal fats for foods, etc.
- This could potentially negatively impact food security in some areas if producing biomass-based fuels are more lucrative than producing products for cooking and food. To address this, policymakers could consider implementing caps on the level of specific feedstocks (e.g. lipid-based feedstocks) for fuel production, which would limit the negative impact on global food and animal feed markets and deforestation etc.

2 Limited impact on SAF uptake

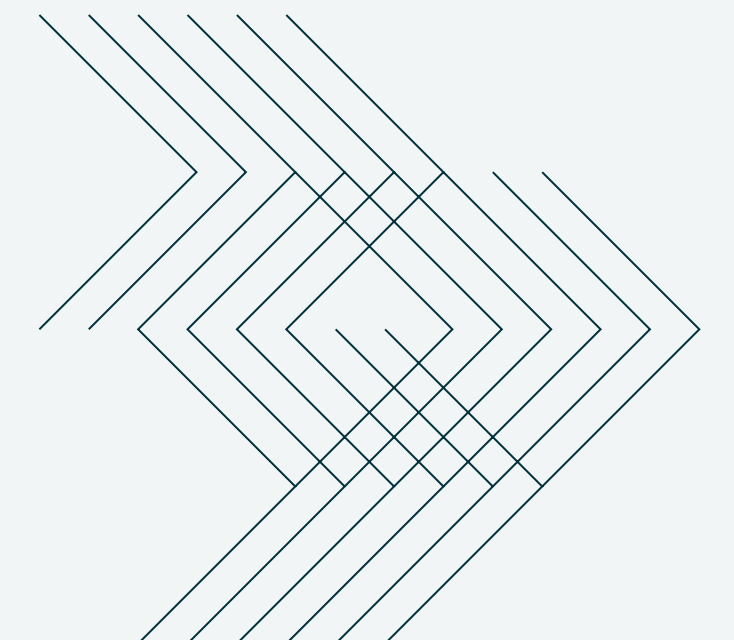
- SAF currently provides [less than 1%](#) of the credits generated in the market. This is likely due to two key factors:
 - 1 Aviation is only treated on an opt-in basis, limiting the overall incentive for the aviation sector to adopt SAF. Under proposed amendments, intrastate flights (accounting for approximately 10% of California's jet fuel demand) would be fully included in the programme
 - 2 Because SAF usage is incentivised less under the programme (though more costly to implement) relative to other pathways including using renewable diesel in road transport, this can lead fuel producers to prioritise the use of feedstocks for road transport fuels - despite road transport having a wider range of decarbonisation options.

3 Volatility on credit prices and lack of long-term certainty

- As the market for credits has grown, prices have also become volatile. Between 2019-2023, prices dropped from around \$185/tonne CO₂e to \$75/tonne CO₂e. This makes it difficult for project financing and securing the right offtake contracts/amount of capital, because the returns are uncertain. Furthermore, there are concerns over the lack of long-term certainty for the policy itself. Fuel producers/importers may thus be incentivised to act in a way that prioritises near term rather than longer-term outcomes. This could lead them to focus on more commercially-ready fuels rather than more nascent ones, thus stifling the means for fuels using more nascent production pathways to scale. Furthermore, as the credit market grows, credit prices have fallen, and this provides fuel producers with less incentive to focus on more nascent production pathways. The implementation of additional guardrails could be used to manage this market.

4 Level of ambition

- Although the LCFS is a leading example of a clean fuel standard in the US, a 20% reduction in emissions is not ambitious enough to advance significantly towards net zero. Stricter, long-term limits would create more certainty, particularly for more nascent solutions. An amendment has been proposed to require a 30% reduction by 2030, and a 90% reduction by 2045 - but has not yet been adopted.



3.3

Embodied Carbon Limits For Basic Materials

Overview: Embodied Carbon Limits for Basic Materials/Chemicals

These are restrictions set on the carbon intensity associated with the use of input materials (e.g. steel or concrete) or chemicals, calculated in terms of the carbon emissions per unit of output. These policies could either:

- Set a limit on the carbon intensity that applies to all basic materials sold, thereby indirectly influencing demand to shift towards lower-carbon materials. Such a policy could be used to gradually limit market access for the most polluting products, rather than directly creating an early market for deep decarbonisation technologies
- Or set a limit to reduce emissions intensity at a sectoral level, which would allow a range of incremental and deep decarbonisation options to come into play.

In either case, due to the limited availability of low or near-zero solutions, it is likely such limits would need to be set close to current emissions levels, and gradually reduced.

Green demand creation potential by sector

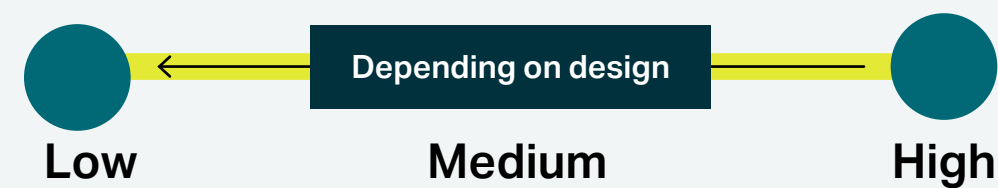
We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand it can apply to, and its potential impact on a business case. Depending on local/national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. This policy could be applied in the chemicals, aluminium, and cement and steel sectors.

Demand creation potential rating by sector

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Demand creation potential	N/A	N/A	Medium	Medium	Medium	Medium
Included for deep dive in this report						

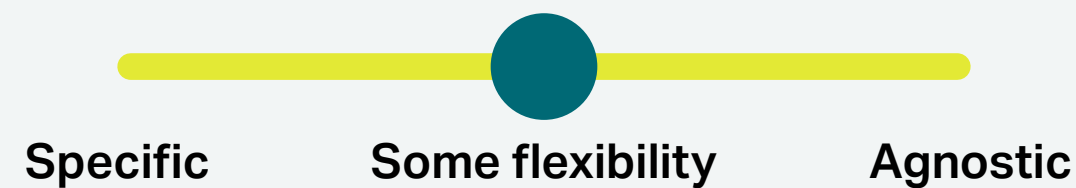
Key Attributes: Embodied Carbon Limits for Basic Materials/Chemicals

Carbon leakage risk



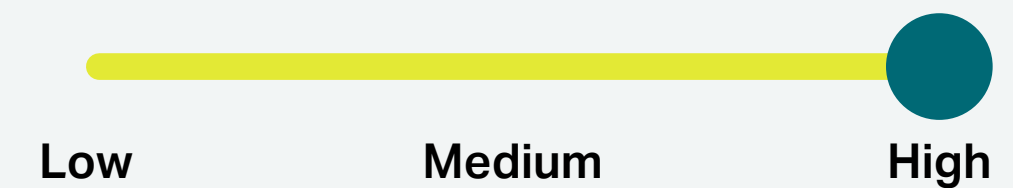
This could be high if limits are applied at the point of production, as buyers may decide to source cheaper basic materials from jurisdictions with less stringent environmental regulations. However, if applied at the point of sale, the limits could be applied to both domestic and imported goods, thereby lowering the risks of carbon leakage.

Technology agnostic



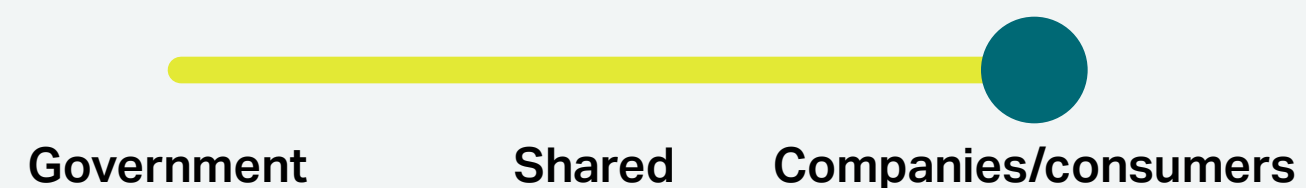
Embodied carbon limits would apply to specific categories of intermediary products, but would not specify the technology or production pathway through which this is achieved - so can provide some flexibility. In practice, if very low limits are set, it will likely limit options.

Ability to ramp up over time



Limits could be gradually tightened over time, progressively ensuring deeper decarbonisation of basic materials.

Burden of cost



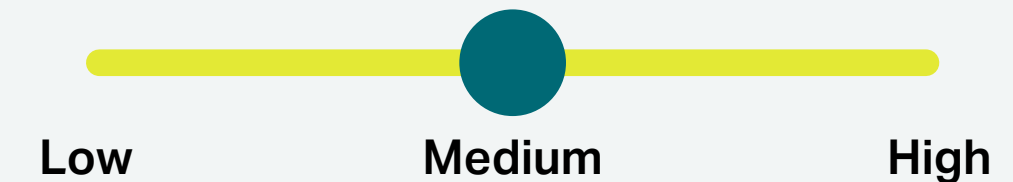
Buyers bear the burden of incurring additional costs that come with procuring lower carbon products. This could disproportionately impact smaller/intermediary businesses and lower margin industries with lower ability to absorb the cost, hold inventory, or secure guaranteed offtake.

Long-term stability



Embodied carbon limits for basic materials can be put in place with a long-term horizon, creating a stable trajectory to increasingly support industrial decarbonisation.

Complexity



To ensure the success of these policies, governments need robust systems in place to facilitate emissions reporting; measurement; monitoring; and enforcement. Additionally, they would need to evaluate the impact on industrial competitiveness and on downstream sectors, and potentially implement supporting measures to complement the limits.

Deep Dive: Embodied Carbon Limits for Basic Materials

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

 Steel	 Efficiency of use ¹
	 Recycling
	 CCUS/H ₂ DRI
 Cement	 Efficiency of use ¹
	 Low carbon production (e.g. via SCMs, CCUS)
 Aluminium	 Efficiency of use ¹
	 Recycling
	 Low/near-zero carbon primary production ²

Key

 Directly incentivised  Indirectly incentivised  Not incentivised

Key considerations

- **Material substitution:** unless complemented by other policies, or measures across multiple sectors, setting embodied carbon limits on basic materials that increase overall costs may pose the risk of material substitution. This could result in emission reductions or increases over the life cycles of downstream products (e.g. they may be less recyclable/durable and result in higher whole life emissions for end products). For instance, switching to timber-based materials could lead to increased emissions associated with land use change. Therefore, it is important that such policies are complemented by measures to ensure the overall life cycle carbon emissions of downstream products is also reduced.
- **Enforcement:** a regulatory body is needed to oversee the standards and compliance of carbon limits for material manufacturers and/or project developers.
- **Implementation over time:** carbon limits can take a few years to become fully effective, as both public and private stakeholders involved will need to mainstream and implement reporting practices and ensure data on products is readily available. Policymakers can first focus on mandatory disclosure of product data, before enforcing limits, and then progressively tightening the limits over time, and increasing the scope (e.g. scope of materials).
- **Impact on competitiveness:** unless the limits are applied to imported products, domestically produced products, and materials in products down the value chain, the competitiveness of domestic industries could be impacted. Furthermore, the impact may be different across the supply chain. Such limits could adversely impact intermediary businesses in the supply chain that may not have guaranteed offtake or have a lower ability to hold inventory.

1: refers to the optimal use of the material to reduce the overall embodied emissions of a building/product
2: adopting production technologies with a lower carbon footprint (e.g. using clean power for aluminium smelting, inert anodes and/or mechanical vapor recompression (MVR))
Sources: [Agora Industry \(2024\): creating markets for climate-friendly basic materials. Potentials and policy options](#)

Implementation examples of embodied carbon limits on basic materials

Examples of embodied carbon limits on basic materials

At the time of writing, we have not identified examples of mandatory carbon limits being applied on materials. However, embodied carbon limits on basic materials have been considered in the past, or applied to include on a non-mandatory basis into standards, labels and frameworks.

Jurisdiction	Policy description	Status	Sectors
European Union 	Ecodesign for Sustainable Products Regulation (ESPR): sets out a framework for ecodesign requirements for a list of products that is currently in the process of being published - with steel and aluminium a priority		Steel Aluminium
UK 	Mandatory Product Standards (MPS): this policy was under consideration by the UK Government in 2023. If implemented, it would set mandatory standards for embodied emissions for products - potentially including imports. Prioritised sectors would include steel, cement, concrete and chemicals.		Steel Concrete Chemicals
 Covers ≥10% demand		 Under consideration	

3.4

Embodied Carbon Limits On End Products

Overview: Embodied Carbon Limits on End Products

These are thresholds on embodied carbon applied to consumer products (e.g. a car or a building) taking into account embodied carbon (or as part of a wider metric together with operational carbon) in the whole product. This policy is technologically neutral, allowing the use of a range of multiple decarbonisation levers to meet the thresholds. Key design choices include:

- Identifying suitable lead markets for green products. These should represent a significant share of demand with end users that can feasibly absorb the green premium - and ideally have customers with a sufficient willingness to pay for a green product¹.
- Defining intensity limits. These could either be set against baselines of existing end products (e.g. a percentage reduction versus a baseline at a given date) or be based on a threshold (e.g. limiting the kg CO₂e/m² emissions embodied in a new building).

Green demand creation potential by sector

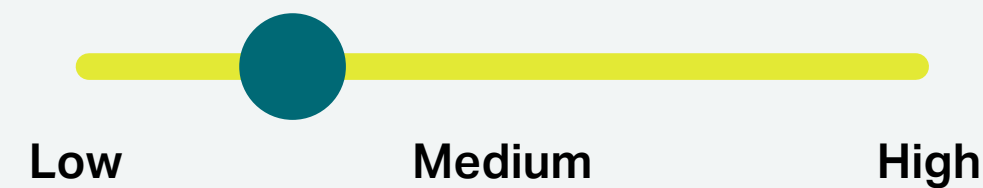
We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand it can apply to, and its potential impact on a business case. Depending on local/ national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. We assess embodied carbon limits in end products as the highest priority in the aluminium, cement and steel sectors.

Demand creation potential rating by sector

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Demand creation potential	N/A	N/A	Medium	High	High	High
Included for deep dive in this report						

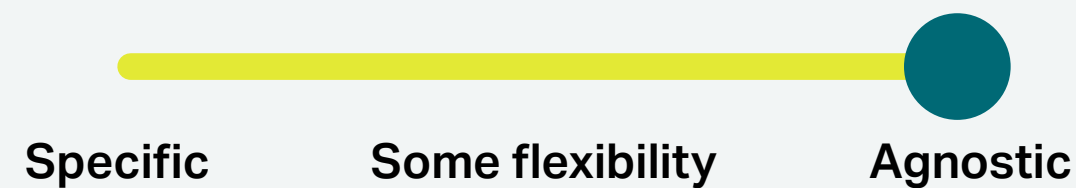
Key Attributes: Embodied Carbon Limits on End Products

Carbon leakage risk



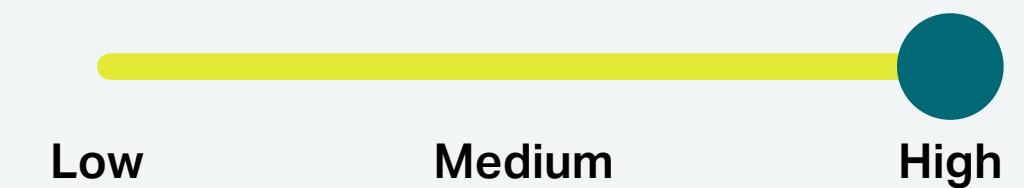
Carbon leakage risks can be mitigated by accounting for emissions embodied in imported materials, but may impact the competitiveness of exports of select products. For sectors where end products are internationally traded (e.g. the automotive sector), businesses could shift production or procurement of products to other jurisdictions with less stringent environmental regulations.

Technology agnostic



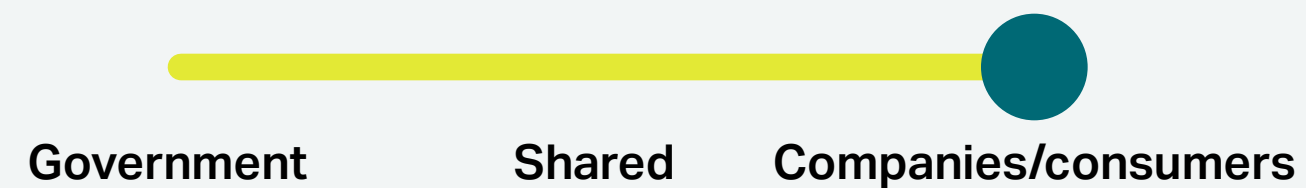
Because carbon intensity limits are set on end products in this case, there are various means in which the limits could be achieved, e.g. by substituting intermediate products, using green input materials or using inputs more efficiently.

Ability to ramp up over time



Limits on embodied carbon can be phased in and tightened over time as solutions for deep decarbonisation become more affordable and available.

Burden of cost



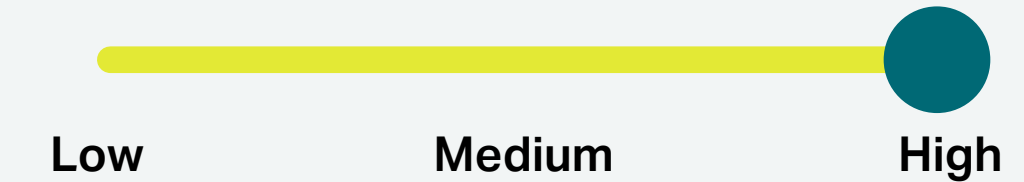
Companies and consumers bear the burden of incurring additional costs that come with procuring lower-carbon end products. This could disproportionately impact smaller businesses, or industries with lower margins, or consumers that are less able to absorb these costs.

Long-term stability



Embodied carbon limits can be set with a long-term horizon, thus incentivising long lasting changes in the industry as it switches to greener methods of production.

Complexity



The major complexity lies around the volume of individual end products that the policy would need to set requirements for. Furthermore, governments need robust systems in place to support: emissions reporting; measurement; monitoring; enforcement; and to analyse and mitigate the impact on industrial competitiveness and social objectives (e.g. housing costs).

Deep Dive: Embodied carbon limits in the construction sector

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

- In addition to the following decarbonisation levers, construction industry companies can consider other levers such as design optimisation, material substitution, digitisation and opting for energy efficiency equipment.

	Steel	● Efficiency of use ¹
		● Recycling
		● CCUS/H ₂ DRI
	Cement	● Efficiency of use ¹
		● Low carbon production (e.g. via SCMs, CCUS)
	Aluminium ²	● Efficiency of use ¹
		● Recycling
		● Low/near-zero carbon primary production ³

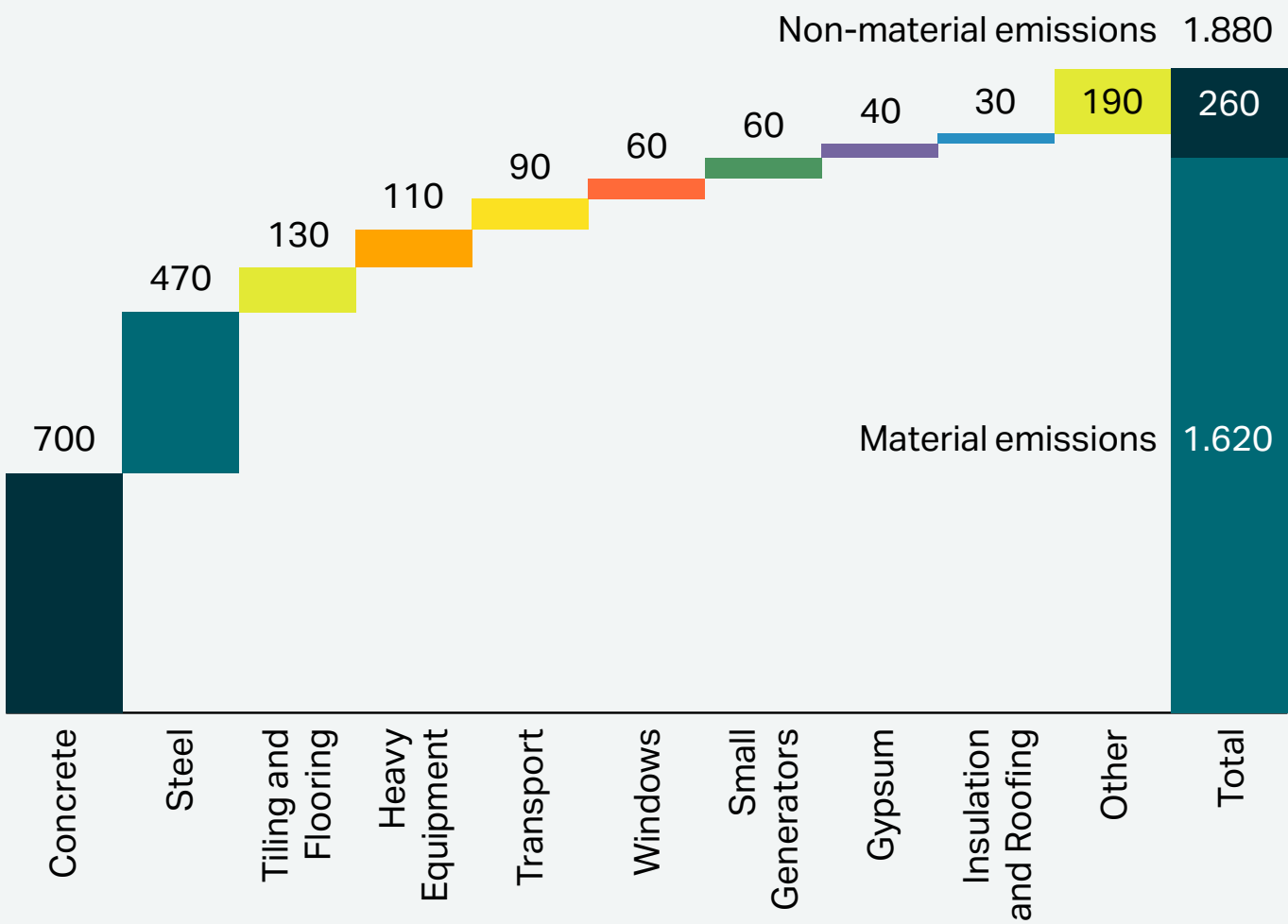
Key
● Directly incentivised ● Indirectly incentivised ● Not incentivised

Key considerations

- Whole lifecycle of projects:** ideally carbon intensity limits should consider the whole lifecycle of construction projects, including the production and sourcing of materials, the construction phase, use and maintenance, through to end of life, as well as a project’s overall resiliency and durability. This can avoid unintended negative consequences, such as increased long-term emissions as a result of material substitution or reductions in overall lifespan of buildings.
- Physical scope:** when introducing limits on the carbon involved in construction, it is key to define the physical scope involved consistently, so that like-for-like comparisons can be made between construction projects.
- Financial cost to end users:** low and near-zero carbon materials command a premium, resulting in a modest increase in consumer prices (e.g. we estimate using 10% green materials could increase a typical house cost by approximately 1% in 2030). This could be in tension with social and housing objectives, particularly in markets where house prices are already high, or for social housing. Regulations could be paired with financial support to reduce these risks.
- Enforcement:** a regulatory body is needed to oversee compliance by building developers. It may be costly and time consuming for some organisations (e.g. SMEs) in the construction value chain to demonstrate the environmental performance of their products. Tools to streamline these processes, and/or financial support may be necessary to support the creation of EPDs or other means of verification.

- Risk aversion:** it may take time to develop new regulations as important traditional criteria (e.g. strength, durability and safety) need to be maintained.
- Standardised reporting and certification:** these are essential to support the procurement of lower carbon materials and understanding their environmental impact, particularly compared to their substitutes (e.g. steel versus timber).

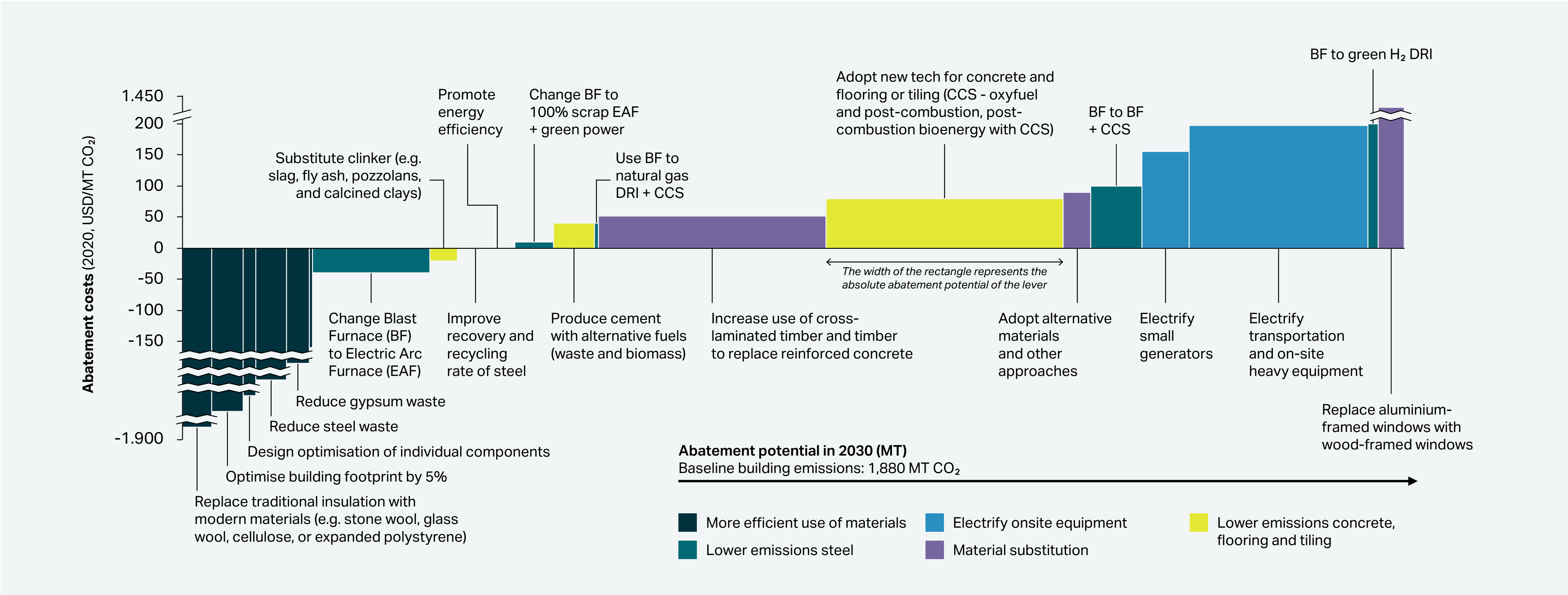
Construction related GHG emissions of an indicative, eight storey office building
MTCO₂e



1: optimising the use of material and reducing waste to reduce embodied carbon of a building
2: because aluminium only accounts for a small share of construction emissions, the impact on the aluminium sector is likely to be less pronounced
3: adopting production technologies with a lower carbon footprint (e.g. using clean power for aluminium smelting, inert anodes and/or mechanical vapor recompression (MVR))
Sources: BloombergNEF, European Commission, Agora Industry (2024): [creating markets for climate-friendly basic materials. Potentials and policy options. McKinsey & Co](#)

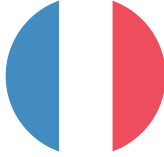
Reducing embodied carbon in construction incentivises multiple decarbonisation levers, not only material decarbonisation

Abatement costs to associated with embodied carbon of an indicative eight story office building
2020, USD/metric tonne (MT) of CO₂



Implementation examples of carbon intensity limits in construction

Examples of carbon intensity limits in construction

Jurisdiction		Policy description	Status	Sectors
France		RE2020 : sets limits on embodied carbon for various building types For instance, for single-family homes, the material production and construction-related emissions limit is 640kg CO ₂ /m ²) in 2022 and 415kg CO ₂ /m ² by 2031. For new apartment buildings it is 740kg CO ₂ /m ² in 2022, and 490kg CO ₂ /m ² by 2031.		Steel Aluminium Concrete
Denmark		National Strategy for Sustainable Construction : new buildings more than 1,000m ² are subject to a limit on combined operational and embodied emissions of 12kg CO ₂ e/m ² /y. The limit will tighten depending on progress made as a sector. By 2025, the limit is projected to average 7.1kg CO ₂ e/m ² per year, depending on building type.		
Netherlands		Millieu Prestatie Berekening : buildings must conduct a life cycle assessment and convert environmental impact metrics to a shadow price (e.g. €0.05/kg CO ₂ e), which allows for easy comparison across products. The cumulative price per floor area is limited to €1/m ² per year and will likely reduce to €0.5/m ² over time.		
USA		Regulations are currently set at state level, rather than at national level. For example, in CALGreen in California, new buildings over 100,000ft ² must conduct a 'cradle-to-grave' whole building lifecycle assessment. The building's global warming potential (GWP) must be at least 10% lower than a reference baseline building.		
European Union		Energy Performance of Buildings Directive : Requires EU member states to develop roadmaps for setting limit values on the lifecycle global warming potential (GWP) of new buildings from 2027 and set progressive targets from 2030.		

These are not the only examples of countries that have set such regulations. Further examples can be found [here](#) and include Finland, Norway and Sweden.

Covers ≥10% demand

 In place (and enforced)

 In place, but to be implemented

Examples of key enabling initiatives/detailed studies

- The **World Green Building Council** is a non-profit organisation with a global network of green building councils in more than 70 countries, aiming to catalyse the development of a sustainable built environment globally. Key initiatives include: [#BuildingLife](#), [Whole Life Carbon Policy Briefing](#), [Whole](#)
- [Life Carbon Roadmaps](#).
 - Many other examples of embodied carbon limits have been implemented at the sub-national level. For more details, see the [Carbon Leadership Forum's Policy Tracker](#).

Case study: RE2020 (Environmental Regulation 2020) (1/2)

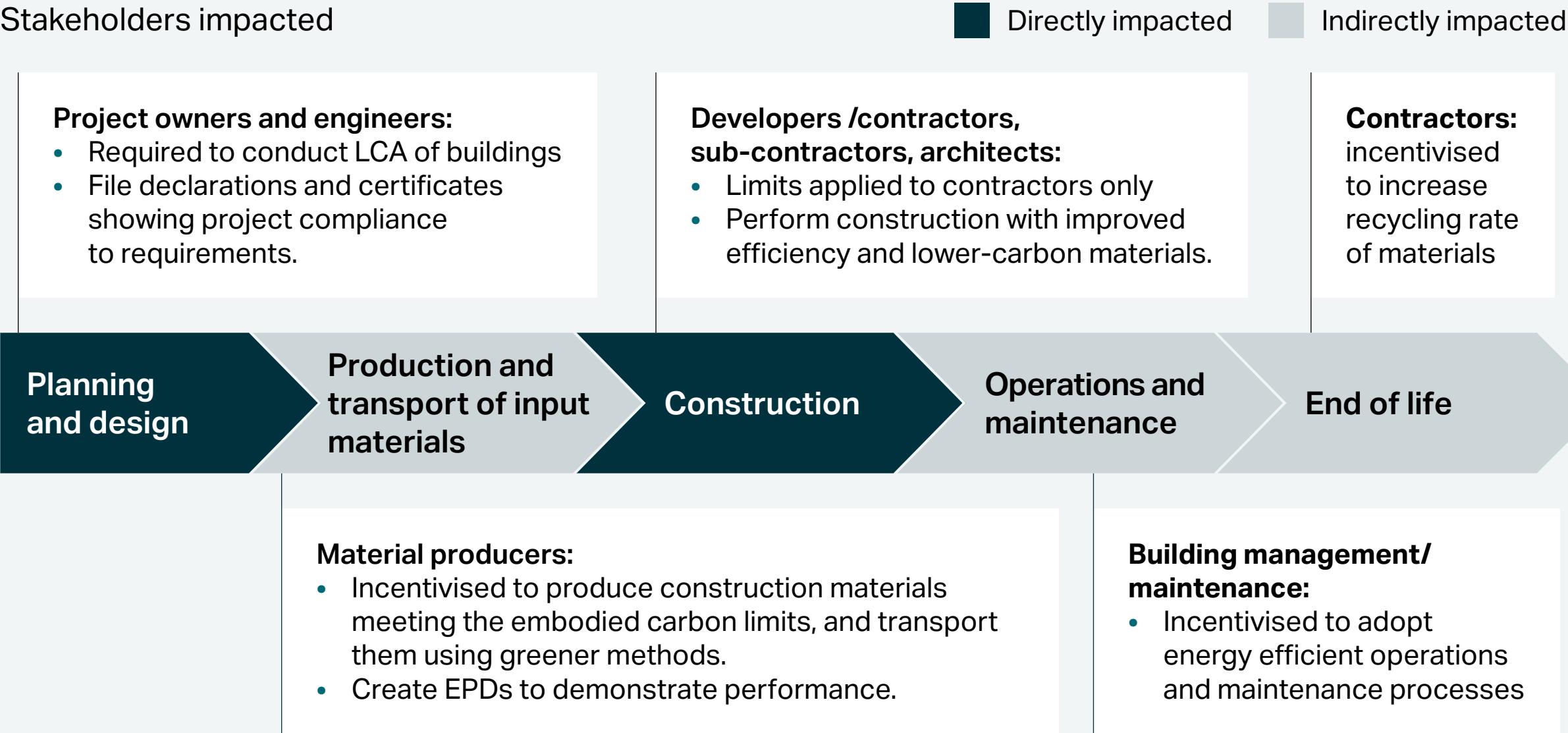
France

Adopted: 2022

Applies to: building materials

- **RE2020** aims to: firstly, improve energy performance and decarbonisation of operations-related energy consumption; secondly, reduce the lifecycle emissions of buildings; and finally, guarantee thermal comfort in case of heatwaves. It introduces environmental performance thresholds for new builds over their lifecycle (set at a reference building lifetime of 50 years).
- RE2020 uses a 'dynamic' LCA calculation method, where the carbon emitted today has more weight than those emitted later. For single-family homes, the material production and construction-related emissions limit is 640kg CO₂/m² in 2022 and 415kg CO₂/m² by 2031. For new apartment buildings, it is 740kg CO₂/m² in 2022, and 490kg CO₂/m² by 2031, applied at the building level.

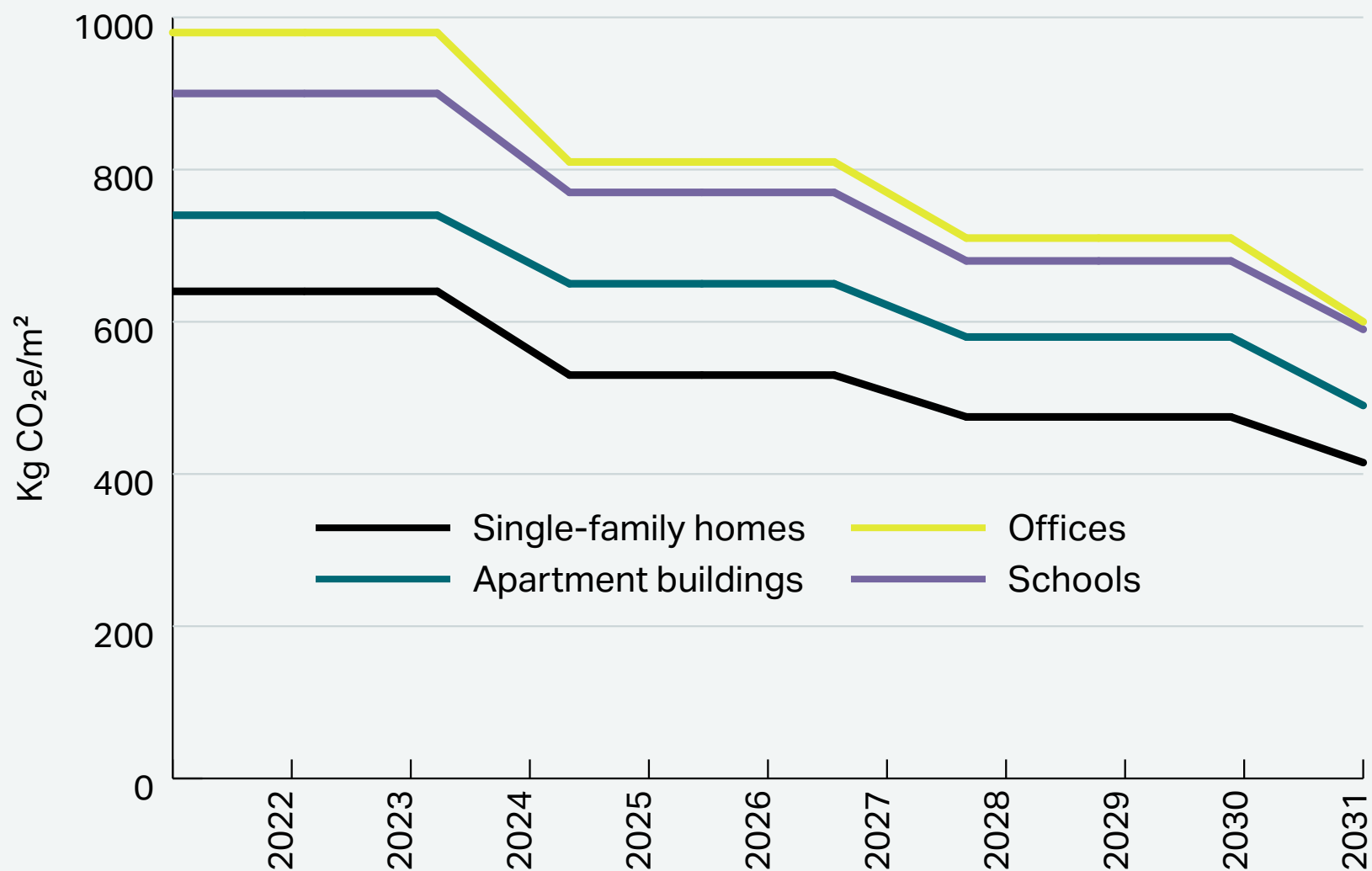
Construction value chain



Impact

- The limits are projected to tighten progressively, as shown in the following chart:

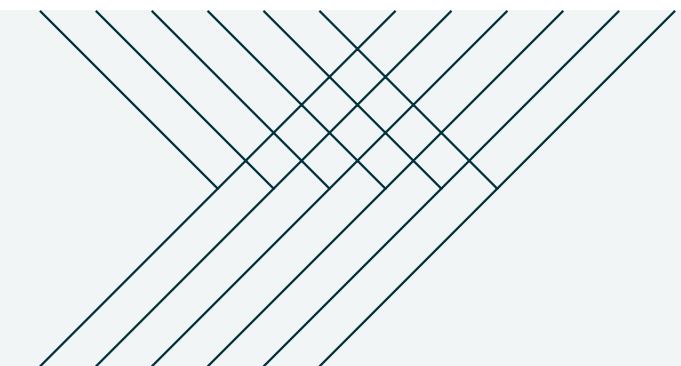
Maximum threshold for a building's CO₂ content in construction phase



- By 2031, France aims to reduce the overall emissions impact of new construction by more than 30% compared to the baseline reference level.

Case Study: RE2020 (Environmental Regulation 2020) (2/2)

Key challenges/risks



1 Ambition level of thresholds

- RE2020 is one of a few examples of national policies focusing on embodied carbon. It lends certainty to the demand for lower carbon construction materials and fosters market development for these greener products across a large jurisdiction.
- Currently, the average production and construction emissions of a residential building in France are estimated at 399kg CO₂/m². Critics have suggested the limit of 740kg CO₂/m² is too lenient. Because of such high limits, there is a risk that these will not on their own drive decarbonisation of input materials and other decarbonisation levers. Nevertheless, the limits are expected to tighten over time, increasing the impact.

2 The need for industry transformation

- Heavy industry needs to add new lower carbon solutions to their catalogue to make sure they will still be relevant in the construction market. Otherwise, there is a risk of material substitution using lower carbon materials such as timber.
- Construction companies will need to adapt the architecture of buildings to integrate new low carbon design and reduce the quantity of materials while preserving security.
- RE2020 hinges on Environmental Product Declarations (EPDs) registered in a publicly available database ('[base INIES](#)') managed since 2004 by stakeholders from the French construction sector. Companies and other stakeholders can submit an EPD that will be verified by an independent third party before official publication. With the introduction of the regulation, the number of EPDs registered has doubled since 2020, reaching more than 5,000 declarations.

3 Long lead time

- Establishing the limits has required considerable efforts to build an effective foundation. This has involved more than two years of public consultation, putting the new controls in place, and scaling up the creation of EPDs to underpin implementation.

4 Scope

- The regulation does not explicitly incentivise increased longevity of buildings, because the life cycle analysis is calculated on a fixed reference lifetime of 50 years. Nonetheless, the regulation does incentivise the reuse and recycling of materials. Designers are encouraged to use a more modular approach to facilitate the collection of materials during maintenance and demolition.

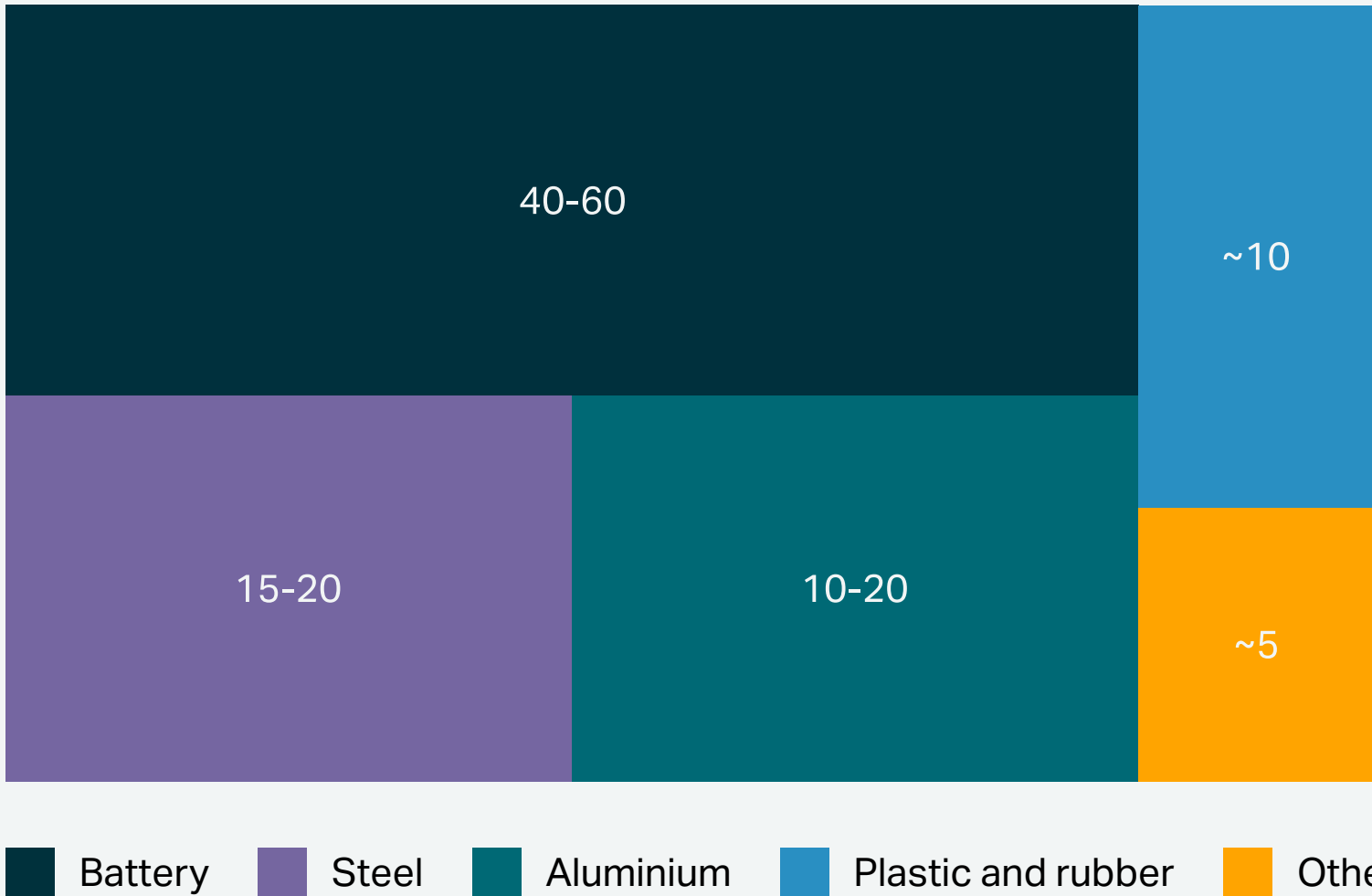
Deep Dive: Embodied Carbon Limits in the automotive sector (1/2)

Embodied carbon limits have also been proposed in the automotive sector, but not yet adopted. These would account for emissions associated with raw material extraction, manufacturing and end of life.

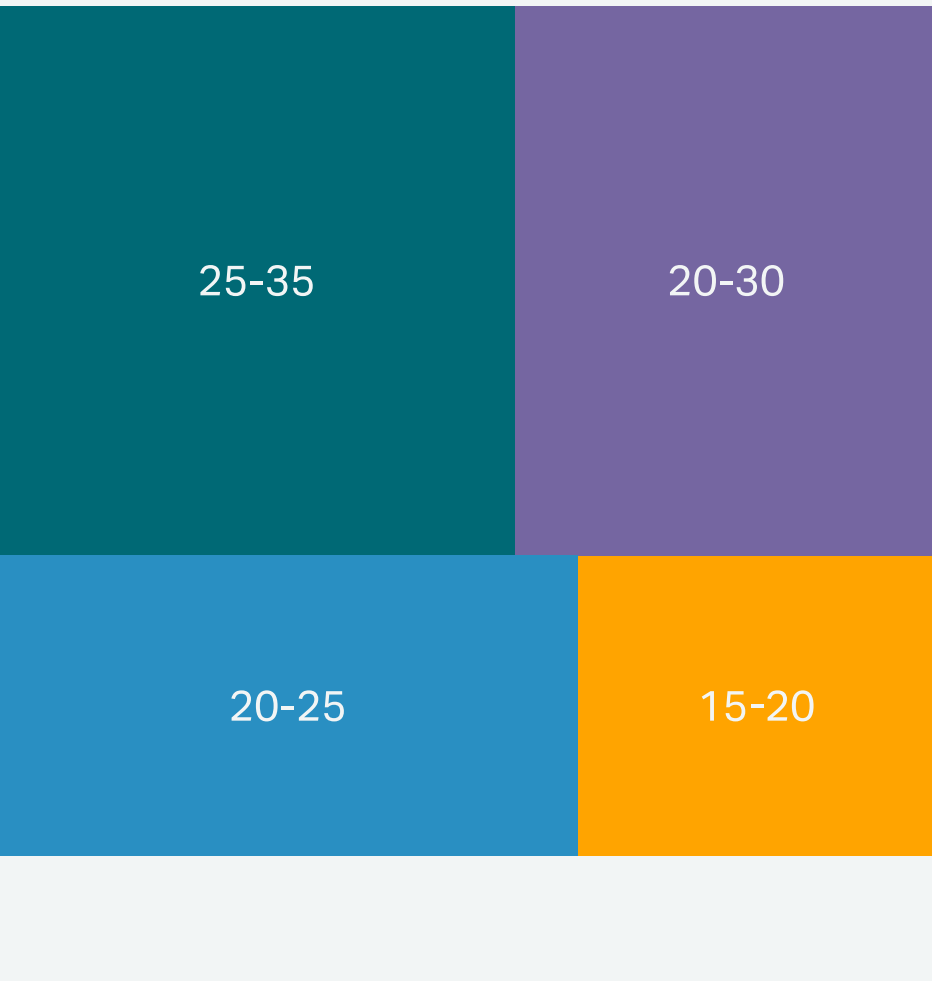
Typically, materials such as steel and aluminium comprise 35-40% of upstream emissions of EVs, and 45-65% for ICE vehicles. Therefore, setting embodied carbon limits on the materials used has significant potential to reduce GHG emissions for the sector, while stimulating demand in the materials sectors.

Indicative upstream emissions by vehicle type (%)³

Electric Vehicle (EV)



Internal Combustion Engine (ICE) vehicle



Decarbonisation levers incentivised by policy (see lever details in [Annex 1](#))

Because of the high grades of steel required for automotive manufacturing, limiting embodied carbon in the automotive sector is likely to drive demand for virgin steel. Additionally, car manufacturers can consider other decarbonisation levers such as: design optimisation; material substitution; process optimisation for production and logistics; and using energy efficient equipment.

	Steel	 Efficiency of use ¹
		 Recycling
		 CCUS/H ₂ DRI
	Aluminium	 Efficiency of use ¹
		 Recycling
		 Low/near-zero carbon primary production ²

Key
 Directly incentivised  Indirectly incentivised  Not incentivised

1: optimal use of the material in vehicles, reducing waste where possible, to reduce the overall embodied emissions
2: adopting production technologies with a lower carbon footprint (e.g. using clean power for aluminium smelting, inert anodes and/or mechanical vapor recompression (MVR))
3: Figure adapted from [McKinsey & Co, The race to decarbonize electric-vehicle batteries](#) indicative sizing based on EV embodied carbon being ~60% higher than an ICE vehicle. This does not account for recycling of materials
Sources: [Low Carbon Vehicle Partnership](#), ICCT, McKinsey & Co

Deep Dive: Embodied carbon limits in automotive sector (2/2)

Key considerations

- **Policy design:** embodied carbon limits could be incorporated into existing CO₂ emission performance standards for vehicles by type (e.g. light, medium and heavy-duty vehicles). In order to avoid carbon leakage risks, legislation would need to apply to both domestic and imported vehicles.
- **Scope:** although the automotive sector could be an ideal lead market for green metals, for non-electric vehicles, most of the life cycle emissions will be operational (i.e. from combustion of conventional road fuels). Therefore, if operational and embodied carbon are considered in one limit, material reduction levers will only be a small part of this. To effectively drive demand for greener materials, this could be based instead on embodied carbon, or % use of low carbon metals alone.
- **Implementation over time:** the limits can be gradually tightened to give manufacturers time to adapt and allow for the production/availability of inputs to scale as well.

- **Substitution:** due to increased costs of specific materials (e.g. steel) regulations may drive substitution with other materials (e.g. aluminium) that are also typically lower carbon. It could also result in increased lightweighting of vehicles, which would also result in decreased emissions.
- **Lead markets:** limits could be specifically set on premium submarkets (e.g. luxury cars) where there may be more ability/willingness to pay for lower carbon products.
- **Complementary policies:**
 - **Lower carbon material labels and standards:** Robust product standards and emissions accounting methodologies need to be in place to underpin embodied carbon limits. Clear labelling of products can also ease the process of procuring lower carbon materials for car manufacturers and help them navigate production pathways and associated emissions
 - **Financial support and carbon pricing:** while the cost impact to consumers may be relatively low (e.g. €57 or \$62 a vehicle), green steel may cost 20-50% more for car manufacturers. Subsidies and carbon pricing can also play a role in bridging the green premium between grey and green steel.

Adoption status of embodied carbon limits in the automotive sector

- Though embodied carbon limits have not yet been adopted that encompass all materials in a vehicle, the revised CO₂ regulations for cars in the EU proposes to allow Low Carbon Steel credits to contribute to electrification targets.

Examples of key enabling initiatives/detailed studies

- [International Council on Clean Transportation - Technologies to reduce GHG from automotive steel in the US and EU.](#)

3.5

Green Public Procurement (GPP)



Overview: Green Public Procurement (GPP)

These are policies to encourage public entities to procure goods, services and other works with a lower environmental footprint. This can be used to create demand for lower carbon products, helping to scale production of these goods. As of 2018, public procurement accounted for around 12% of global GDP and comprises a high share of the demand for construction materials - [40-60%](#) for concrete and [approximately 25%](#) for steel. This creates huge potential for GPP of green building materials. In the transport sector, many of the world’s major [ports](#) and many [airports](#)

are publicly owned, providing opportunities to support the development of enabling infrastructure via GPP, however government demand for aviation and shipping services themselves is a much lower share. Some countries have large [state-owned fertiliser companies](#) that could procure or produce green ammonia as a chemical feedstock.

Green demand creation potential by sector

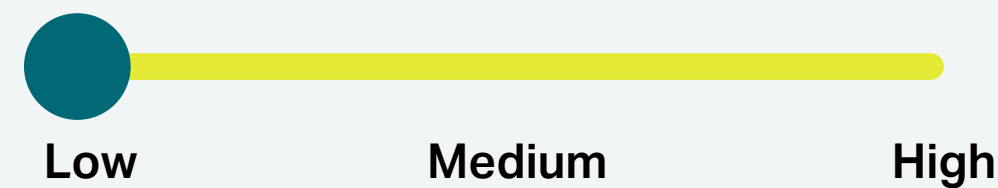
We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of a typical country’s demand it can apply to - and its potential impact on a business case. Depending on local or national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. Based on this analysis, GPP is assessed to be most critical for cement and steel given the high share of public sector procurement of these commodities.

Demand creation potential rating by sector

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Demand creation potential	Low	Low	Medium	Medium	High	High
						Included for deep dive in this report

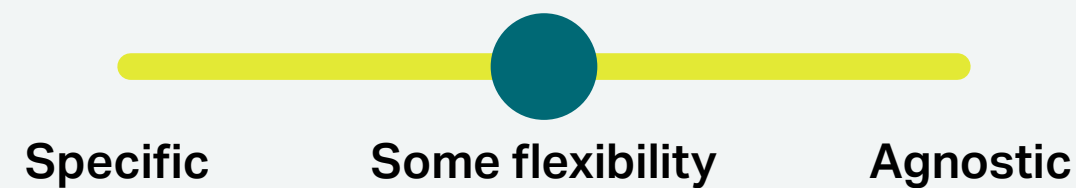
Key Attributes: Green Public Procurement

Carbon leakage risk



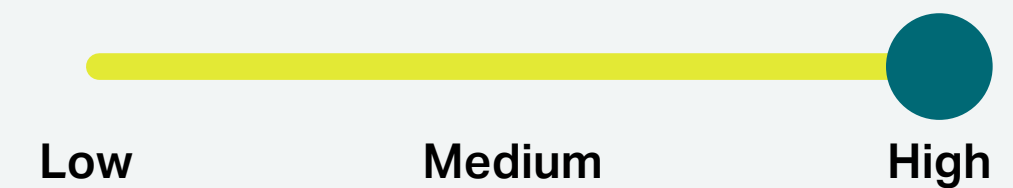
Public procurement policies are typically accompanied by a set of product or project requirements that determine eligibility. There is a low risk of public entities circumventing the policy by procuring materials that are excluded from the list. To avoid carbon leakage risks, importers of materials would need to demonstrate that they meet these requirements.

Technology agnostic



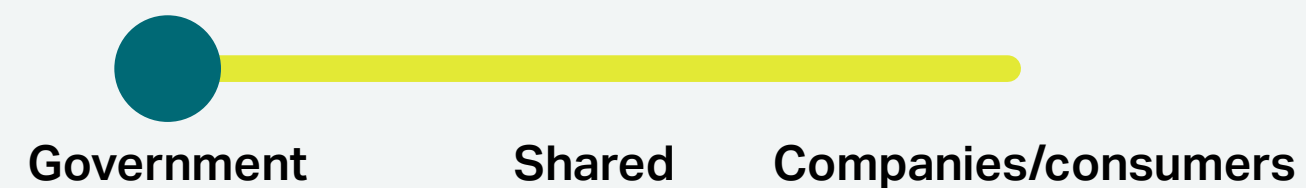
There is some flexibility in how GPP policies are set. For example, in the construction sector, this can be done at the product level (specific) or by setting emission limits at the project level (agnostic). A hybrid approach could be to set minimum standards at product level, with overall limits set at the project level.

Ability to ramp up over time



GPP policies can be reviewed over time and be made more stringent as low and near-zero products and services become cheaper and more widely available.

Burden of cost



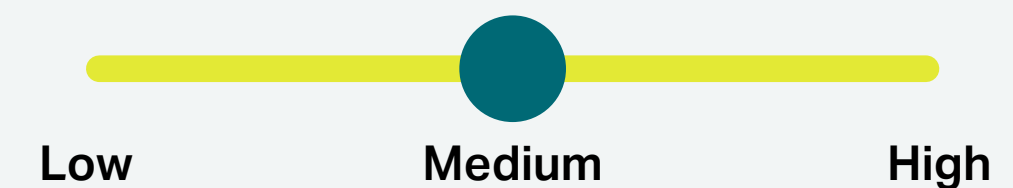
Because some low or near-zero carbon products and services are more costly than carbon intensive incumbents, the burden of cost falls on the government to increase spending to afford these products.

Long-term stability



GPP policies are dependent on public funding, but have shown longevity as instruments (e.g. more than 20 years). For example, [Japan's Act on Promoting Green Purchasing](#) was first established in 2001 and remains in force today.

Complexity



To ensure the success of these policies, adequate funding is needed to procure green materials. A strong foundation of standards, emission accounting methodologies and certification needs to be in place. Furthermore, responsibility for decarbonisation and procurement is often split across different departments and bodies requiring co-ordination.

Deep Dive: GPP of building materials (cement/steel)

Decarbonisation levers incentivised by policy

(see further details of sectoral decarbonisation levers in [Annex 1](#))

 Steel	 More efficient use of steel
	 Recycling
	 Virgin steel production
 Cement	 Efficiency of use ¹
	 Low carbon production (e.g. via SCMs, CCUS)

Key

 Directly incentivised  Indirectly incentivised  Not incentivised

Key considerations

- Underpinning foundations:** GPP programmes need to be underpinned by robust evidence, including a foundation of life cycle assessment standards and calculation tools. Environmental Product Declarations (EPDs) are becoming an increasingly mainstream tool to demonstrate and verify the environmental impact of products and underpin GPP programmes such as US Buy Clean. One barrier to accessing, particularly to small and medium enterprises, is the cost and time associated with creating EPDs. Governments can consider measures to make it easier to produce EPDs (e.g. [subsidising their production](#)). Similarly, non-state actors are producing tools to simplify their creation (e.g. [Global Cement and Concrete Association’s EPD tool](#)). EPDs are not the only system, and in some cases additional information may also be needed.
- Eligibility criteria:** emission limits could be set on the key materials used (e.g. near-zero or low emission cement and steel). Limits on emission intensity could alternatively be set at the project level, with overall emission limits for projects as a whole. Ideally, GPP programmes should consider emissions over the whole life cycle of construction projects², including: the production and sourcing of materials; construction; use and maintenance through to end of life; as well as the overall resilience of the project when evaluating a its carbon footprint. This avoids the risk of increasing emissions inadvertently (e.g. when substituting materials).
- Financial cost to the government:** low and near-zero carbon materials are expected to command a premium. Hence, the government must allocate extra budget to finance GPP programmes, and in return benefit from incentivising future job growth and the creation of new industries. However, these could present constraints for certain governments (e.g. in developing economies and trade-offs with other priorities).
- Implementation over time:** GPP programmes can be gradually phased in. Initially, policymakers can focus on information gathering, mainstreaming the use of EPDs by suppliers, and commencing pilots at relatively small scale. Mandatory requirements can then be introduced and strengthened by progressively increasing the share of low and near-zero carbon products targeted, or increasing the scope of materials, projects and the number of public entities covered.
- Virgin steel production:** for most applications involving steel use in the public sector, recycled steel is likely to be appropriate, where this is widely available it is likely to outcompete virgin steel production. Therefore, sub-quotas for virgin green steel, or complementary policies in other lead markets, may be necessary to drive this demand.
- Most applicable countries:** although public procurement of construction materials is high in many countries, GPP programmes will have higher green demand creation potential in countries where public procurement accounts for a larger share of demand. This is often the case in developing and emerging economies.

1: refers to the optimal use of the material in construction projects to reduce the overall embodied emissions of a building
2: in line with [IDD’s GPP pledge](#)
Sources: BloombergNEF, [Stockholm Environment Institute](#), European Commission, Breakthrough Energy, Rocky Mountain Institute, WEF, Sustainability by Numbers, GCCA [EPD tool](#)

Implementation examples of GPP programmes

Key examples of policies adopted by countries

Jurisdiction		Policy description	Status	Sectors
Sweden		Trafikverket Climate Requirements: Sets progressively tightening GHG reduction requirements (versus a 2015 baseline) on reinforcement steel, concrete, cement and structural steel in public infrastructure procurement.		Steel Cement
Netherlands		The Dutch Sustainable Public Procurement policy: includes a criteria database to measure the environmental impact of public projects, one of which is low CO ₂ impact materials for construction. However, more detailed underpinning standards have yet to be published.		Steel Cement
Canada		Canada's Policy on Green Procurement : requires a disclosure and reduction of the carbon footprint of materials in major construction projects. This sets limits (e.g. GHG emissions from ready mix concrete must be at least 10% below industry average). Standards for other materials are expected to be published in future.		Cement
EU		Proposed industrial accelerator act sets targets to procure at least 25% low carbon steel and aluminium (in infrastructure, buildings and automotive secotr) and 5% low carbon cement (in construction projects)		Steel Cement Aluminium

Covers ≥10% demand

 In place (and enforced)

 In place, but to be implemented

 Proposed

Examples of key enabling initiatives/detailed studies

- [The Industrial Deep Decarbonisation Initiative \(IDDI\)](#): this is a major collaborative effort bringing together governments and private entities to establish a fair and transparent global market for low carbon industrial products - with an initial focus on steel and cement. IDDI is promoting GPP by encouraging [pledges](#) and has developed a [GPP guide](#) that can assist governments in setting bold objectives for purchasing low carbon materials for construction projects.

Case Study: Canadian Policy on green procurement (1/2)

Canada



Adopted: 2022

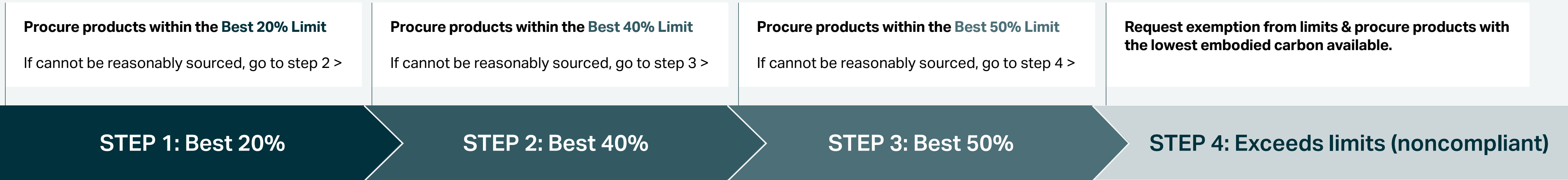
Applies to: steel and cement

Summary

In order to support overall Government emissions reductions targets sets requirements to use low carbon concrete, structural and reinforcement steel, and to develop whole-building level life-cycle assessments (to optimise design and material use). This includes a standard to reduce emissions from

ready-mix concrete used in major government projects, and to reduce the embodied carbon of major construction projects by 30%.

Steps to applying steel limits in procurement

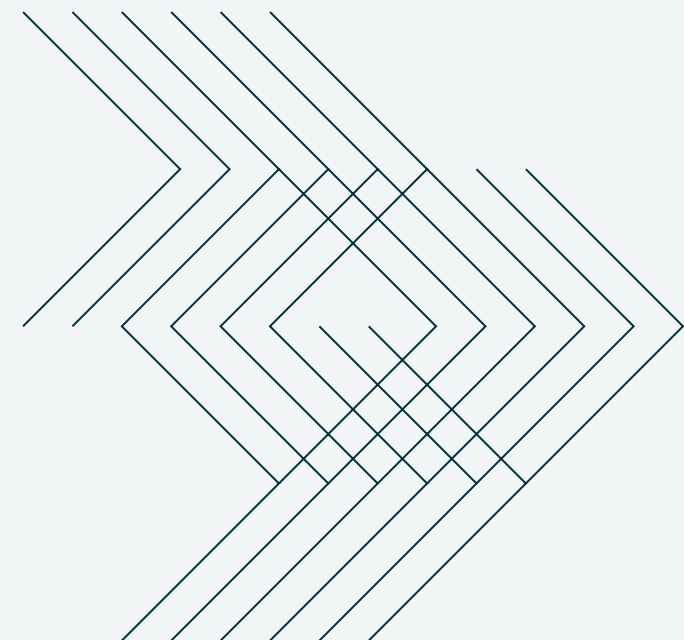


Impact

- The policy sets three threshold tiers, defined as the cleanest 20%, 40% and 50% of the market. Purchasers must buy products that are within the cleanest 20% of products available on the market if they can be "reasonably sourced". If they cannot, then they can move on to the next threshold.
- In 2024-25 result: one qualifying major project cut ready-mix concrete embodied carbon by 21% vs. its baseline – 31 tCO₂e below the regional average.
- Supplier disclosure: 34 of 36 qualifying contracts over \$25m (94%) applied the GHG-disclosure and target-setting standard in 2024-25 and 1,244 green Standing Offers/Supply Arrangements were in place as of March 2025.

Case Study: Canadian Policy on green procurement (2/2)

Key challenges/risks



1 Focuses on products only on the market

By focusing on products that are only on the market currently, there is a risk that policies based on banded systems do not incentivize the best performing products that may become available in future (e.g. 2030 or 2035). Setting a fixed bar based on expected best performers in 2030-35 would be more likely to unlock new clean supply. Where this is set (e.g. a flat 10% reduction in emissions across concrete products), this doesn't provide a distinct demand signal for deeper decarbonisation solutions. Given some solutions (e.g. H2 DRI) aren't available in Canada today this limits the policy.

2 Does not target subsectors like primary steel

Thresholds to buy steel do not account for the % of scrap contained in the steel (along the lines of product standards like the IEA definitions for low carbon steel). This may mean that the policy has a limited impact on primary steel production, because most construction grade steel can be produced via recycling.

3 Does not include a pre-set ramp up

The procurement requirements set do not escalate the share of low carbon steel that should be procured in public procurement. Without a predictable ramp up, this could limit the future market certainty that low carbon projects depend on.

3.6

State-Backed Intermediaries



Overview: State-Backed Intermediaries

They catalyse demand by purchasing a higher cost commodity (e.g. green ammonia) from a private sector producer and subsequently selling it on to a private sector buyer. Contracts between the intermediary and suppliers can be long term, with shorter-term contracts between the intermediary and offtakers. In the process, the intermediary absorbs a portion of the green premium and offtake risks. This method is best suited for commodities with small to moderate green premiums (e.g. approximately 300% relative to a grey product), like [ammonia and methanol](#). However, it has proven more challenging when applied to earlier stage green commodities with a higher green premium (e.g. synthetic kerosene at roughly 700-800%).

There are several choices that need to be made when designing a state-backed intermediary: the commodities in scope and the stage of the value chain to focus on; where suppliers and offtakers of the relevant products may be based; the contract lengths for suppliers and offtakers; and how such an intermediary would be funded (e.g. by one or several governments, or through blended finance).

Green demand creation potential by sector

We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand this lever can apply to, and its potential impact on a business case. Depending on local or national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. Based on this analysis, state-backed intermediaries have been assessed as particularly impactful for heavy transportation fuels and chemical feedstocks - where the private sector comprises a larger share of procurement, and where intermediaries can support and reduce risk in the initial phase of market development.

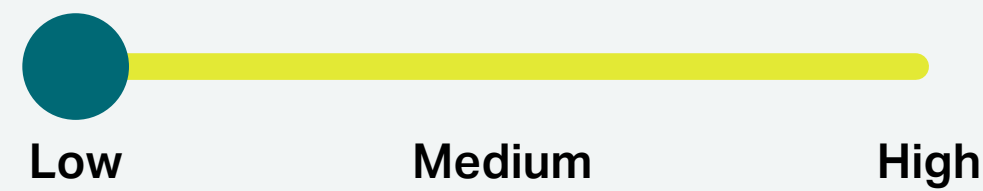
Demand creation potential rating by sector

Sector	Aviation Fuel	Maritime Fuel	Chemicals	Aluminium	Cement	Steel
Demand creation potential	High	High	High	Medium	Medium	Medium

Included for deep dive in this report

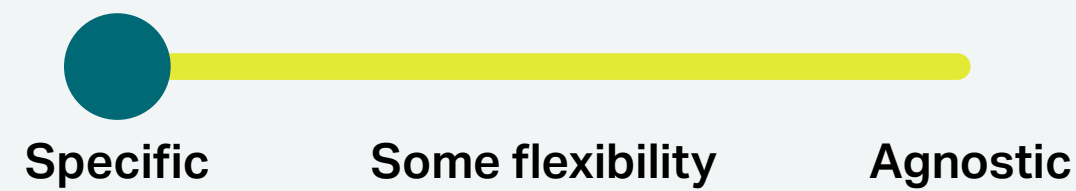
Key Attributes: State-Backed intermediaries

Carbon leakage risk



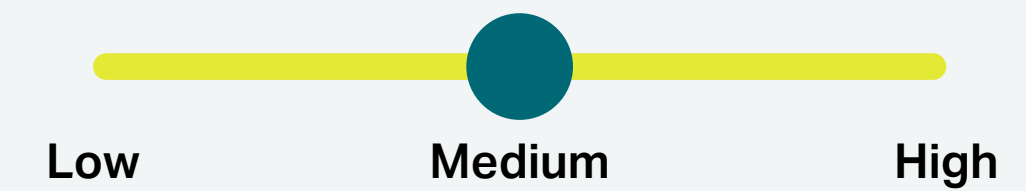
Leveraging a state-backed intermediary decreases the risk and costs that industry bears when procuring nascent green products and services. Therefore, the risk of carbon leakage associated with their use is reduced.

Technology agnostic



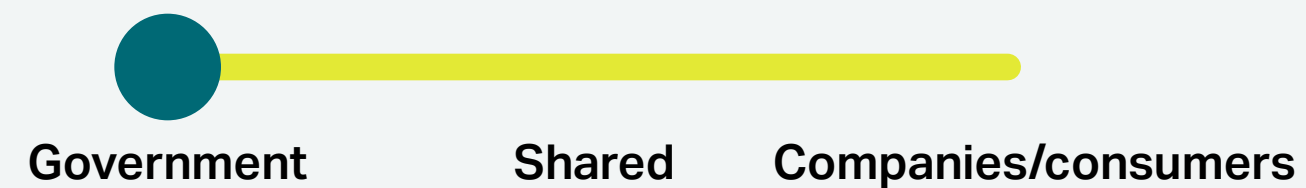
State-backed intermediaries could either focus on one or a few critical products. For example, [Hintco](#) focuses on green hydrogen and its derivatives.

Ability to ramp up over time



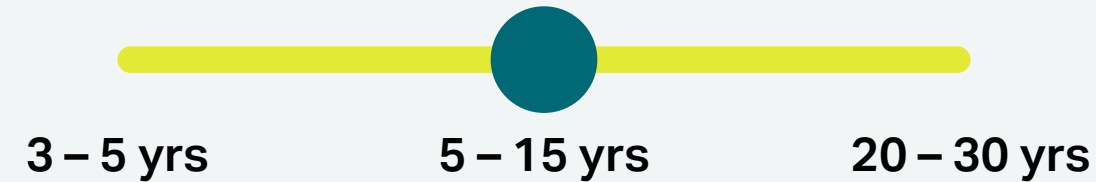
The ability to scale up the use of an intermediary is constrained by the overall funding made available and the long-term backing of governments. Over time, state-backed intermediaries may become less necessary as decarbonised options become more competitive.

Burden of cost



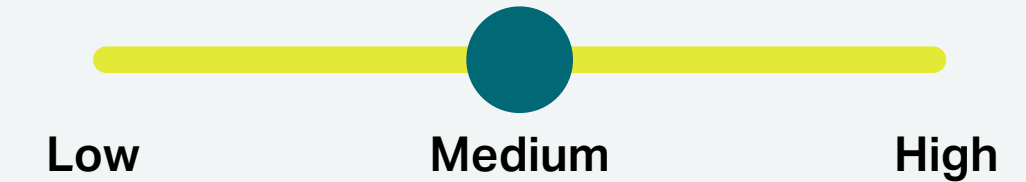
The burden of risk and cost falls on the intermediary, and hence the state. Blended finance models, where a share of public money is used to crowd in private financing, could reduce the amount of government funds necessary or extend their impact. Similarly, providing contracts via competitive processes can improve overall value for money.

Long-term stability



Intermediaries reduce the risk associated with early-stage technologies before their costs can decrease in part by securing mid-to-long term (e.g. 10 year) offtake agreements. Future contracts from intermediaries are dependent on further commitments from government/ blended funds.

Complexity



Significant resources and funding, institutional capacity and capabilities, and market readiness are needed to establish the intermediary. However, countries can develop partnerships to seek funding or pool resources, spreading risks and sharing learnings with other countries.

Deep Dive: State-backed intermediaries for hydrogen derivatives

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

	Aviation	 Efficiency of use ¹
		 Bio-SAF
		 E-SAF
	Chemicals	 Efficiency of use ²
		 Blue H ₂
		 Green H ₂
	Maritime	 Efficiency of use ¹
		 SZE ³

Key

 Directly incentivised  Indirectly incentivised  Not incentivised

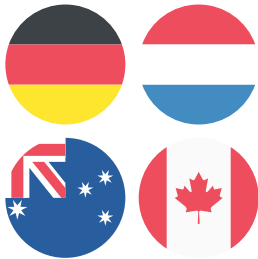
Key considerations

- Value for money:** to ensure public funds are being used efficiently, competitive processes to select partners for offtake/procurement can be used. Given the levels of green premiums associated with decarbonised hydrogen, it is likely that a large amount of funding is needed to support commercial scale projects. One mechanism is a two-sided auction, where one auction is conducted with the producer to select the most competitive bid. A separate auction is then conducted to select buyers. Consequently, the intermediary bridges the price gap between the lowest cost producer and buyer with the highest willingness to pay.
- Price discovery:** over time, the intermediary can gather and share data from real bids to enable price discovery and market formation.
- Bid criteria:** realistic, achievable and specific criteria should be set to minimise the barriers to entry for producers.
- Availability of infrastructure:** where potential suppliers and offtakers are not co-located, enabling infrastructure to transport hydrogen derivatives may be necessary, and could potentially become a constraint.
- Competition between sectors:** if based on competitive bidding processes, end use sectors with a higher willingness to pay/lower abatement may be prioritised. To ensure specific sectors are incentivised, it may be necessary to have separate funding pots for different sectors.
- Complementary demand stimulation policies:** this can be used in tandem with other policies (e.g. regulatory measures that will further encourage interest from buyers and increase willingness to pay, meaning less government funding will be required to support the intermediary).
- Most applicable countries:** given the level of public funding required, implementing these schemes on a large scale may be more feasible for countries with more financial resources. Because these measures are best suited to reduce offtake risks from projects, intermediaries could be used to support projects in other countries (e.g. H2Global's first auction supported the production and import of hydrogen derivatives from outside the EU into the EU).

1: improving fuel efficiency by optimising routes, speed, and other operational practices
2: optimal use and application of chemical products to reduce overall volumes used
3: scalable zero emission shipping fuel (SZE³) and includes zero or near-zero emissions methanol and ammonia
Sources: [H2Global](#), [SECI](#), [CEEW Centre for Energy Finance](#)

Implementation examples of state-backed intermediaries

Examples of state-backed intermediaries

Country	Policy description	Status	Sectors
Germany Netherlands Australia Canada 	H2Global: established by the German Government, H2Global Foundation, through its intermediary Hintco, buys green hydrogen and its derivatives and sells them to buyers through a double auction mechanism. It covers the price difference between production costs and a buyer’s willingness to pay - stimulating market development. H2Global has established partnerships on future auctions, with funding commitments from Australia (€200m), Canada and the Netherlands (€300m) and a large future window approved by the EU (up to €3bn).		Maritime Chemicals Aviation
India 	Solar Energy Corporation of India (SECI): under the Strategic Intervention for Green Hydrogen Transition (SIGHT) programme, SECI launched competitive bidding processes for electrolyser manufacturing and production of green H₂ and derivatives. In 2024, SECI called for tenders to produce 539,000 tonnes of green ammonia per year, where it will act as an intermediary procurer for 10 years. It also called for a 10-year offtake by fertiliser companies¹.		Chemicals
Singapore 	Sustainable Air Hub Blueprint: in Singapore, a fixed SAF levy will be imposed on air passengers from October 2026, progressively applied to different ticket classes (e.g. business versus economy). Proceeds will go towards the central procurement of SAF by Singapore’s aviation authority - and any price fluctuations will be borne on the regulatory authority.		Aviation

<10% of demand

In place (and enforced)

In place, but to be implemented

Examples of key enabling initiatives/detailed studies

- [H2Global](#) Foundation has developed and designed an intermediary to support hydrogen derivatives, and is working with several other governments to expand this measure.

Case Study: H2Global's first auction (1/2)

Germany 

First implemented: 2022

Applies to: e-methanol, e-ammonia and e-SAF

H2Global aims to stimulate the market for green hydrogen and its derivatives. Through its subsidiary, Hintco, H2Global has implemented a double-sided auction with hydrogen derivative producers and offtakers. This overcomes mismatches between production costs and willingness to pay, and expectations for contract durations. It also enables production projects to become bankable.

A first pilot auction has taken place, with results announced in 2024. This focused on procuring hydrogen derivatives from outside the EU for import into the EU. Future rounds are being developed with partner countries (such as Canada and Australia) and state aid has been approved by the European Commission for a future round worth up to € 3bn.

Hydrogen value chain

Stakeholders impacted

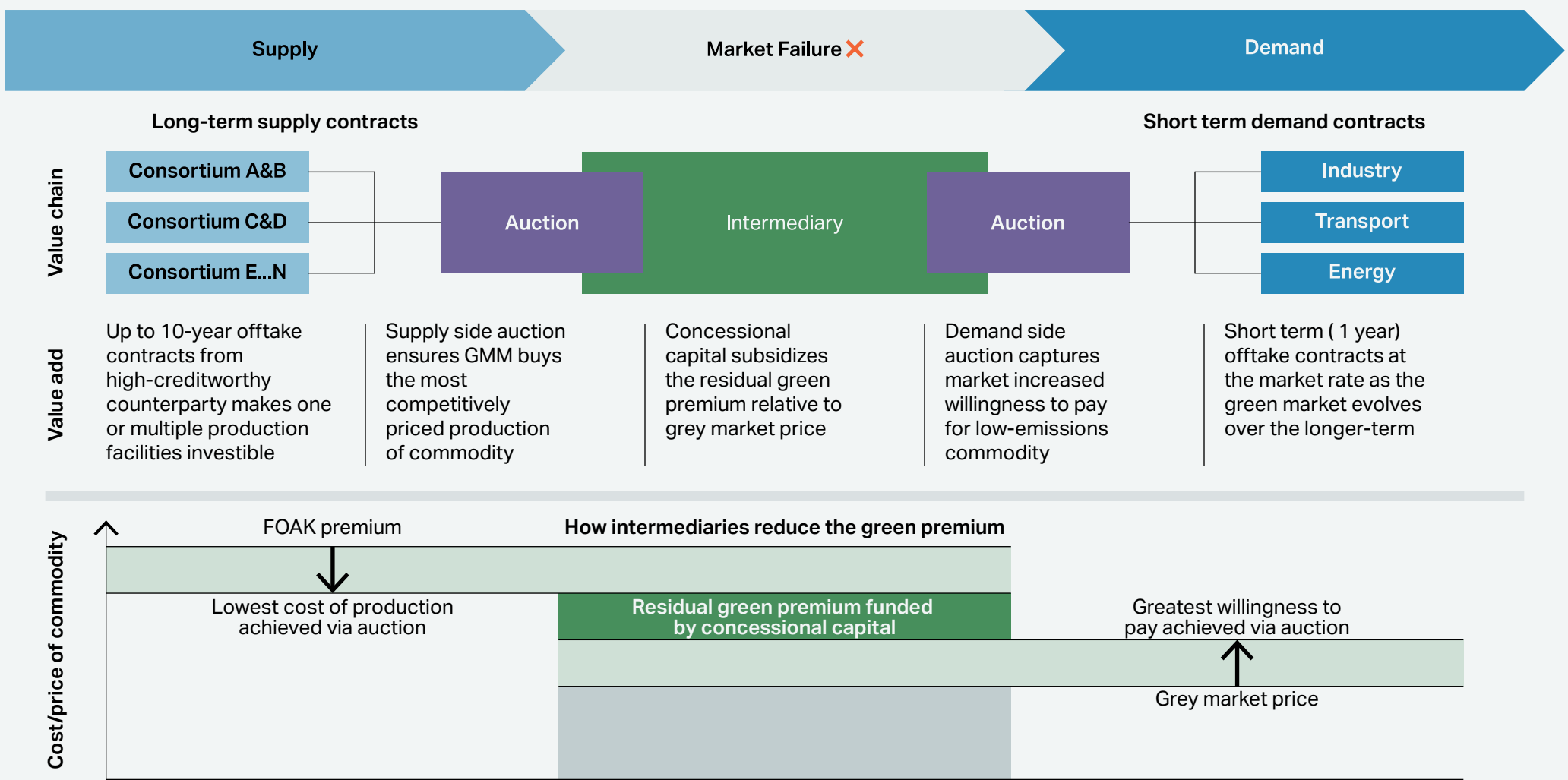
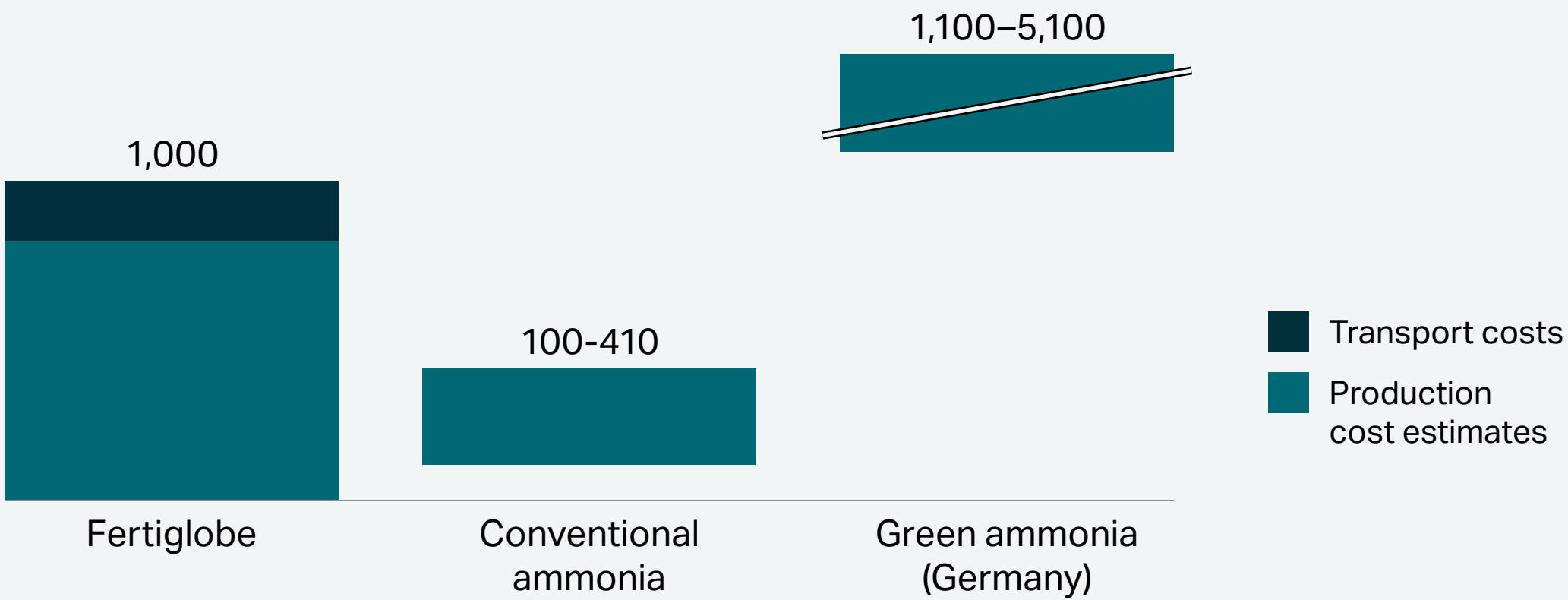


Figure adapted from MPP: [Unleashing Market Forces to Scale Green Industry \(2024\)](#)

Impact

- Fertiglobe won the pilot auction for renewable ammonia. It will deliver approximately 400,000 tonnes of ammonia to Europe via the Port of Rotterdam between 2027-2033. The renewable hydrogen will be produced by Egypt Green Hydrogen. Hintco secured the contract at €1000/tonne of ammonia with a net production price (excluding transport and import costs) of €810/tonne. This corresponds to a green hydrogen input cost of less than €4.5/kg.
- When compared with hydrogen production costs based on bid data disclosed via funding programmes (e.g. the [European Hydrogen Bank's first auction](#)) this is significantly cheaper. The estimated levelised cost of green ammonia in Germany ranges from €1100/tonne to €5100/tonne with an average price of €2300/tonne. This is much more expensive than conventional, grey ammonia, which ranges from €110/tonne to €410/tonne depending on geography.

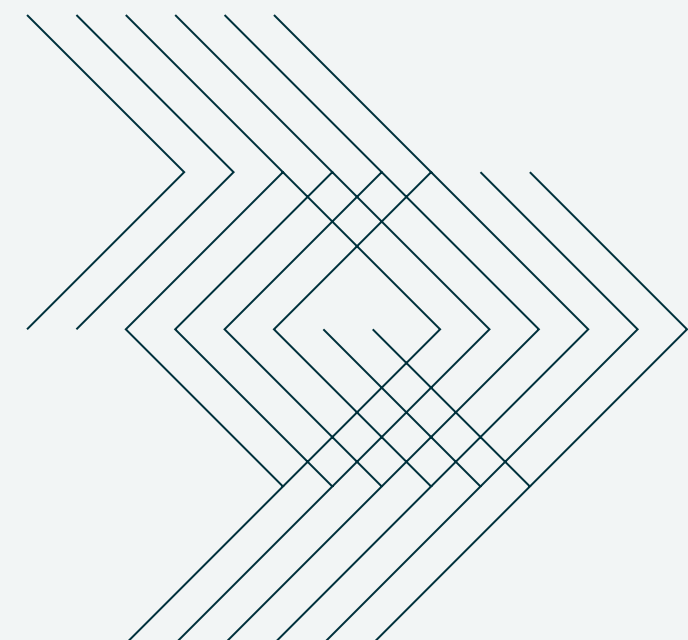
Comparison of ammonia prices (€/t)



Sources: H2Global, EHB

Case Study: H2Global's first auction (2/2)

Key challenges/risks



1 Nascent supply chains networks

H2Global focuses on hydrogen derivatives that can be transported more easily than hydrogen itself (e.g. green ammonia, methanol and e-SAF, which can leverage existing infrastructure). Nevertheless, access to port infrastructure has been a challenge for some bidders. Ultimately, all but one bidder proposed to import derivatives through the same port (Rotterdam) suggesting potential limitations on infrastructure elsewhere. Hintco will try to address this through the contractual arrangements and facilitate transport in future auctions.

2 Complexity of compliance requirements

Overall, the auction process took [two years](#) to conclude and required compliance with extensive sustainability criteria. This included meeting the EU's green hydrogen definitions, protection of arid regions, sustainable land use, and more.

3 Market uncertainty with little precedence

Given the nascency of this market, there are still uncertainties of the demand, supply and pricing that could hinder potential bidders. As such, H2Global has focused on providing transparency and information from its bids as price signals to the market. This means future bidders/industry players can rely on this information to make business decisions.

4 Difficulty securing e-SAF bids

H2Global's auction allocated funding to separate auctions for ammonia, methanol and e-SAF. The pilot e-SAF auction [did not result in final offers from bidders](#), which has been attributed to two factors:

- **Regulatory uncertainty:** ambiguity and nuances regarding whether/how the imported e-SAF would count towards the targets set under the EU's hydrogen goals
- **Contract value:** given the high cost and project development timescales for e-SAF production.

3.7

Carbon Pricing

Overview: Carbon Pricing

Carbon pricing applies a cost to CO₂ emissions and other greenhouse gases. The cost reflects the external damages of these emissions. There are two overarching mechanisms for implementing carbon pricing:

- **Cap and trade system:** which caps the total amount of emissions allowed. Emitters need to procure permits for each tonne of CO₂ they emit, which can be traded. This creates a market for emission permits and incentivises reductions

- **Carbon taxes:** this directly sets a price per tonne of CO₂ emitted. Emitters must pay this tax, which incentivises them to reduce emissions to lower the resulting tax burden. While some carbon taxes are explicit (e.g. based directly on GHG emissions) others are implicit (e.g. applied to each unit of a given fossil fuel sold).

Some sectors, such as international maritime and aviation, will soon be (in the case of maritime) or are (in the case of aviation) subject to forms of international pricing systems.

Green demand creation potential by sector

We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand this lever can apply to, and its potential impact on a business case. Depending on local or national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. We assess carbon pricing as an especially high priority for the aluminium, cement and steel sectors, as it can bridge the green premium more effectively than in aviation, maritime and chemicals. Nevertheless, carbon pricing can be effective in aviation, and maritime, especially paired with other measures such as demand-side subsidies to create a bigger impact on the business case.

Demand creation potential rating by sector

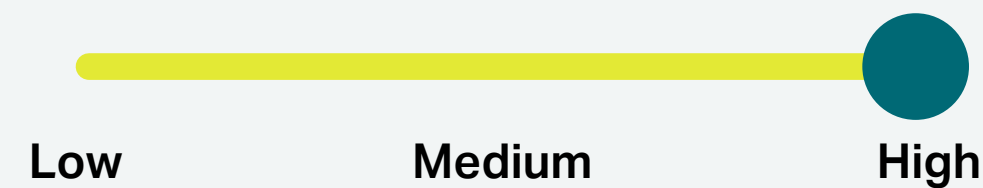
Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Demand creation potential	Medium	Medium	Medium	High	High	High

Note: a multilateral measure for a GHG pricing mechanism is currently under development at IMO, which international shipping would be subject to and should be prioritised. Domestic systems could be applied to domestic shipping. A global market based mechanism ([Carbon Offsetting and Reduction Scheme](#)) applies to aviation.

Included for deep dive in this report

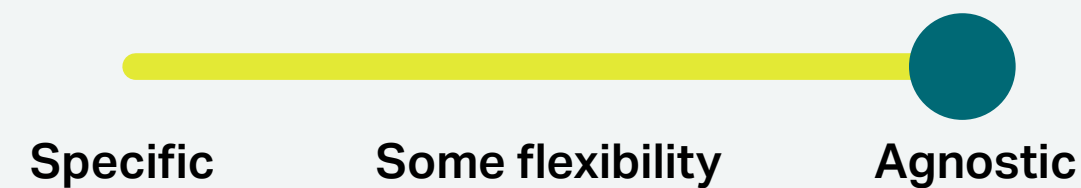
Key Attributes: Carbon Pricing

Carbon leakage risk



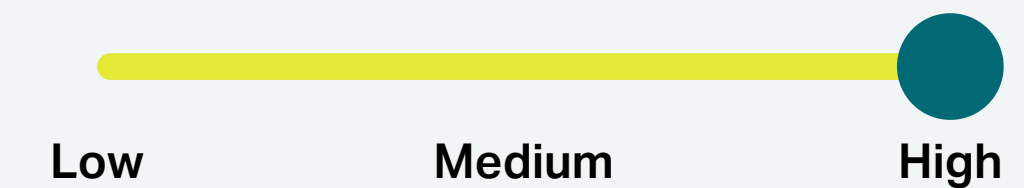
Heavy industry and international transportation sectors are subject to global competition and are at risk of carbon leakage. To mitigate this, these sectors are often shielded from carbon pricing systems. New models, like global carbon pricing systems in some sectors (e.g. aviation and shipping) and carbon border tariffs, are emerging to apply carbon prices while mitigating this risk.

Technology agnostic



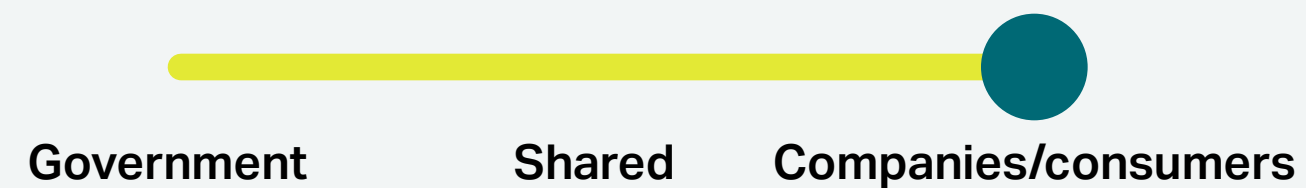
Carbon pricing systems are often applied across multiple sectors. In a cap-and-trade system, emissions can be traded between sectors. This incentivises the cheapest and most near-term efficient ways to reduce emissions.

Ability to ramp up over time



As technologies mature, and underpinning infrastructure is put in place, it should be possible to set increasingly stringent carbon pricing mechanisms. However, higher carbon prices may meet political backlash and pose competitive challenges without complementary measures.

Burden of cost



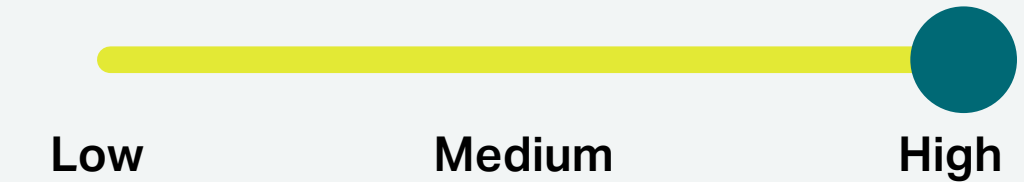
The costs of carbon pricing would be borne by industry. Many governments redistribute the revenues raised from carbon pricing to support the transition through subsidies for green industrial players (e.g. funds from the EU ETS are recycled into the [Innovation Fund](#)).

Long-term stability



Carbon prices, especially market-based systems, can fluctuate depending on economic conditions, policy changes and technological improvements. Measures like price floors and ceilings can prevent extreme fluctuations. Long-term commitments, with progressively higher, stringent prices/more stringent limits on emissions, can create a stable trajectory.

Complexity

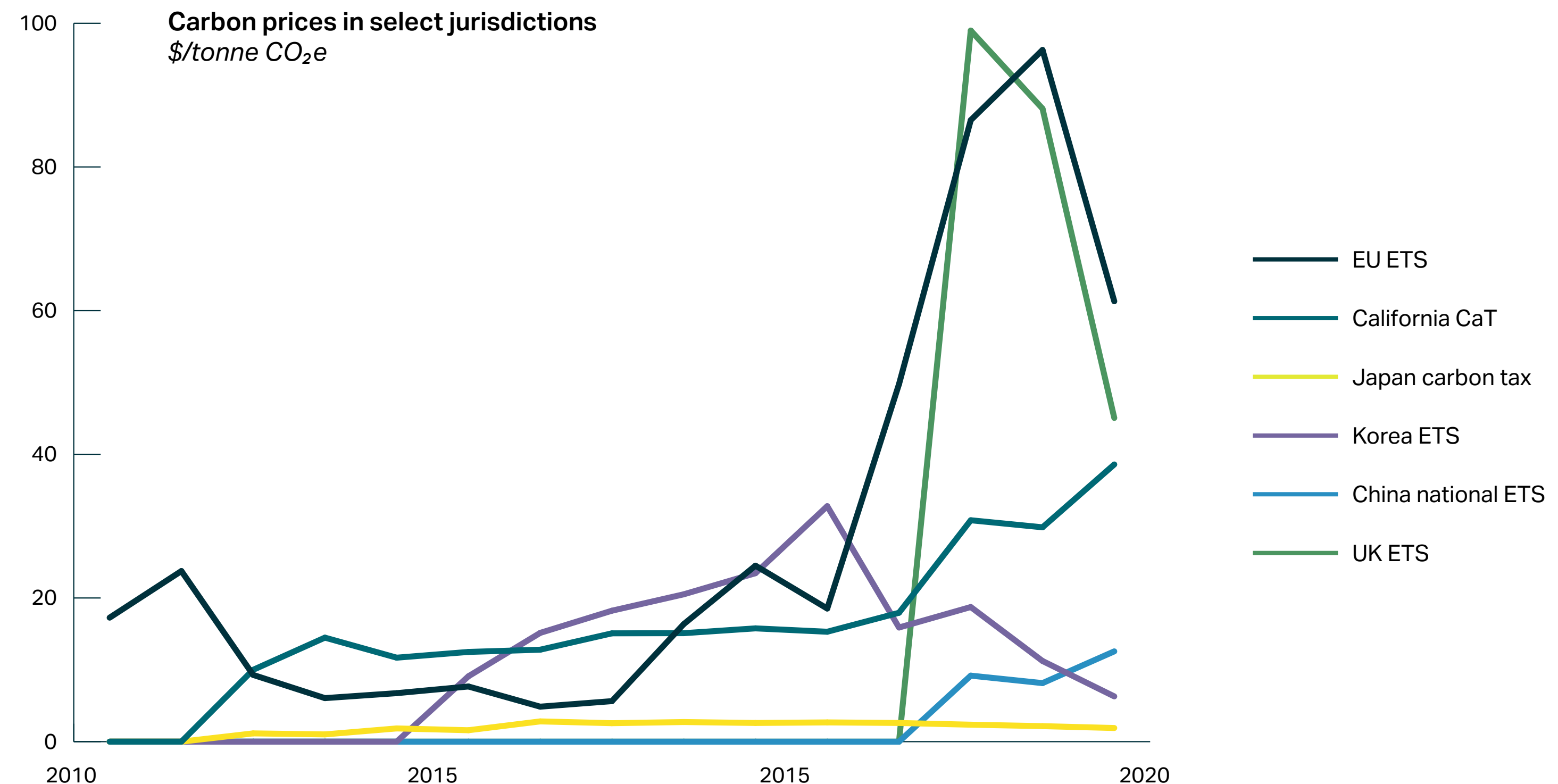


Carbon pricing is relatively complex to implement given: the broad scope; potential impacts on economic competitiveness; the need for integration with existing policies; the need to mitigate carbon leakage; and the risk of carbon price volatility.

Deep Dive: Carbon pricing in heavy industry sectors

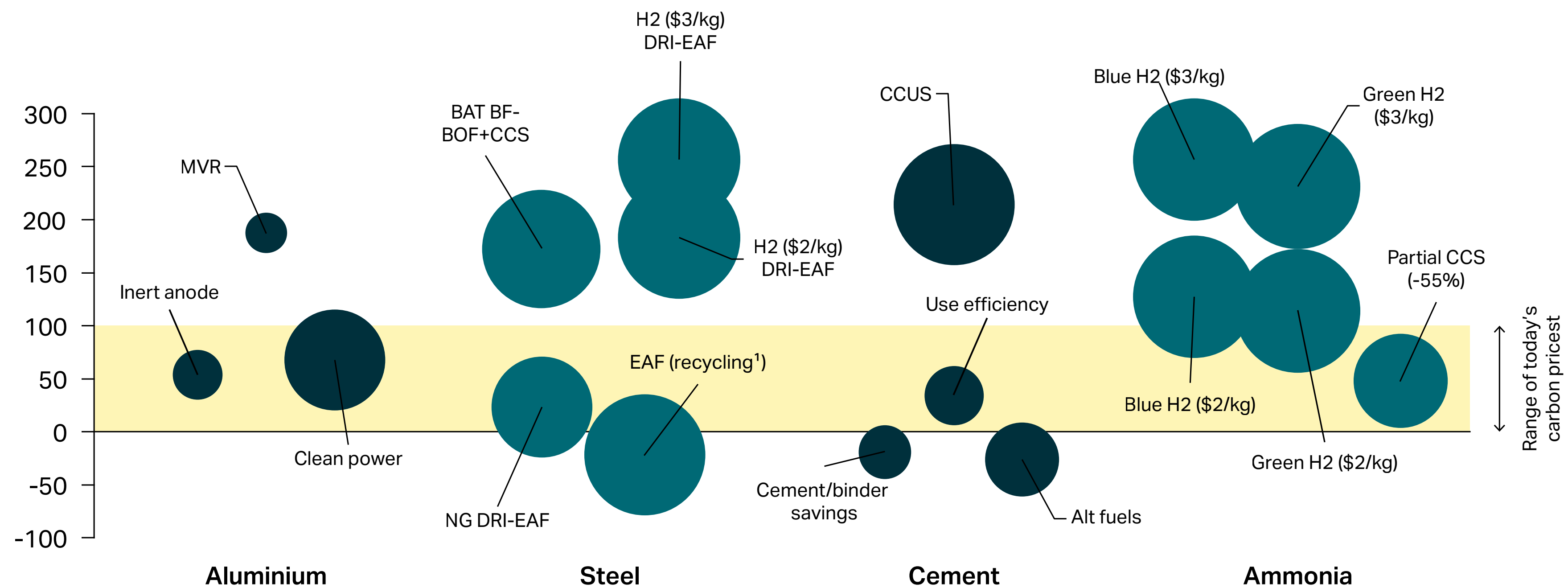
- Historically, carbon pricing has been instrumental in the decarbonisation of the electricity sector. However, due to competitiveness concerns, it has been challenging to fully implement carbon pricing in sectors exposed to global competition.
- We estimate for the aluminium, cement and steel sectors, a carbon price of up to approximately \$200/tonne CO₂e would be necessary to close the gap with fossil products for most decarbonisation levers (though many levers are well below this cost). If aggressive cost reductions in key cross-cutting energy solutions (e.g. green hydrogen and CCUS) can be achieved, this may be lower (e.g. approximately \$120/tonne CO₂e to \$160/tonne CO₂e).
- Carbon prices in the systems with the highest prices today are currently below circa \$100/tonne CO₂e.

Note, the carbon price in most materials sectors is primarily applied on the supply-side (e.g. at the point of steel or cement production, where most emissions are released). However, by increasing the costs of carbon intensive products, it can indirectly catalyse demand for low and near-zero carbon products.



Deep Dive: carbon pricing in heavy industry sectors (2/2)

Indicative carbon prices to bridge GP for decarbonisation levers in 2030



● Complementary measures
(i.e. measures that can be implemented in parallel)

● Standalone measures
(i.e. implemented alone)



Indicative emissions reduction
potential versus current fossil average

1: although steel recycling is a low cost decarbonisation option with very high emission reduction potential, its scalability is limited by the supply of scrap and the potential need for virgin steel for certain cases
Sources: [World Bank Carbon Pricing Dashboard](#), [Agora Industry \(2024\)](#), MPP Making net zero steel/aluminium/cement possible

Deep Dive: Carbon pricing in heavy industry sectors

- **Risk of carbon leakage:** a key challenge to implementing carbon pricing in heavy industry is that many of the sectors involved are subject to global competition. In particular, there is a risk that if commodities are internationally traded, producers could relocate to regions with a lower (or no) carbon price. This may result in higher emissions for creating these products, which could be imported back to the region with a carbon price - resulting in a loss of competitiveness and higher emissions. Potential options to mitigate this risk include global pricing schemes (e.g. WTO is initiating a [taskforce](#) on international co-operation on carbon pricing) and carbon border adjustments (see next section). If comparable carbon pricing schemes become more common, such measures may become less necessary.
- **Economic competitiveness:** because carbon prices increase the cost of commodities, they can make exports less competitive. Where a jurisdiction's production of commodities are largely for domestic consumption, this may be a limited problem. One option to mitigate this risk could be rebates of carbon taxes for exporters.
- **Carbon price stability:** heavy industry is characterised by high upfront investment costs, and requires a degree of predictability of future cashflows to enable investment decisions. Carbon prices would need to be both sufficiently high and stable to enable emission reductions. Measures to stabilise carbon prices for heavy industry could include: tightening overall caps on emissions over time; introducing price floors for emission trading systems; and/or carbon price indexed subsidy mechanisms (see [CCFDs](#) section).
- **System scope:** the scope of a carbon pricing system needs to be carefully designed to avoid disadvantaging novel technologies. Depending on system scope, it may be difficult to monetise specific emission reduction levers (e.g. carbon dioxide removal via recarbonation of cement which takes place over long periods of time). Where free allocations are provided, the detailed rules around their provision have sometimes [disadvantaged low carbon options](#).
- **Efficiency:** carbon taxes may be set by governments on an economy wide or sector-by-sector basis. Cap-and-trade systems are market-based measures designed to maximise efficiency - ensuring the cheapest emission reductions are unlocked as prices progressively increase. Although this may yield economic efficiency in the near term, it may miss opportunities (e.g. to rapidly scale up low nascent technologies and achieve cost reductions) and risks carbon lock in (e.g. from fossil-based plants with long lifetimes). Complementary measures (like subsidies and regulations) can be used alongside carbon pricing to achieve this.
- **Revenue recycling:** the proceeds of carbon pricing systems can be recycled into subsidy schemes to support low carbon technologies.

Implementation examples of carbon pricing in industrial sectors

Examples of carbon pricing policies

Jurisdiction		Policy description	Status	Sectors
UK		Emissions Trading System (ETS) has been implemented together with a carbon border adjustment mechanism (CBAM) , which is currently under consultation in 2024 with a planned timeline for it to be activated in 2027. Free allocations are maintained until 2026.		Steel Aluminium Concrete
European Union		ETS implemented together with CBAM . Currently heavy free allocations will phase out by 2034.		
Canada		ETS includes steel and cement with free allocations. CBAMs are under consideration .		
South Korea		ETS includes steel and cement with free allocations.		
Australia		CBAM under consideration to complement its Safeguard Mechanism , which sets emission limits on industrial facilities. The Australian Carbon Credit Unit (ACCU) Scheme currently allows industry players to earn an ACCU per tonne of CO ₂ e avoided, which can be sold for income.		
India		India is putting in place a carbon market , which will have a compliance and voluntary offset mechanism. It is expected to include steel and cement.		
China		ETS covers power sector and is expected to include aluminium, steel and cement in the future.		
 Covers ≥10% demand			 In place (and enforced)  Under consideration	

Examples of key enabling initiatives/detailed studies

- [WTO](#) has launched a taskforce exploring an international approach to carbon pricing.
- In the maritime sector, the [IMO](#) is developing an international GHG pricing mechanism.
- In aviation, the [ICAO](#) has developed an international market-based measure (CORSIA) to offset emissions.

Case Study: EU ETS and CBAM (1/2)



Adopted: 2005

Applies to: power, industry, aviation, maritime

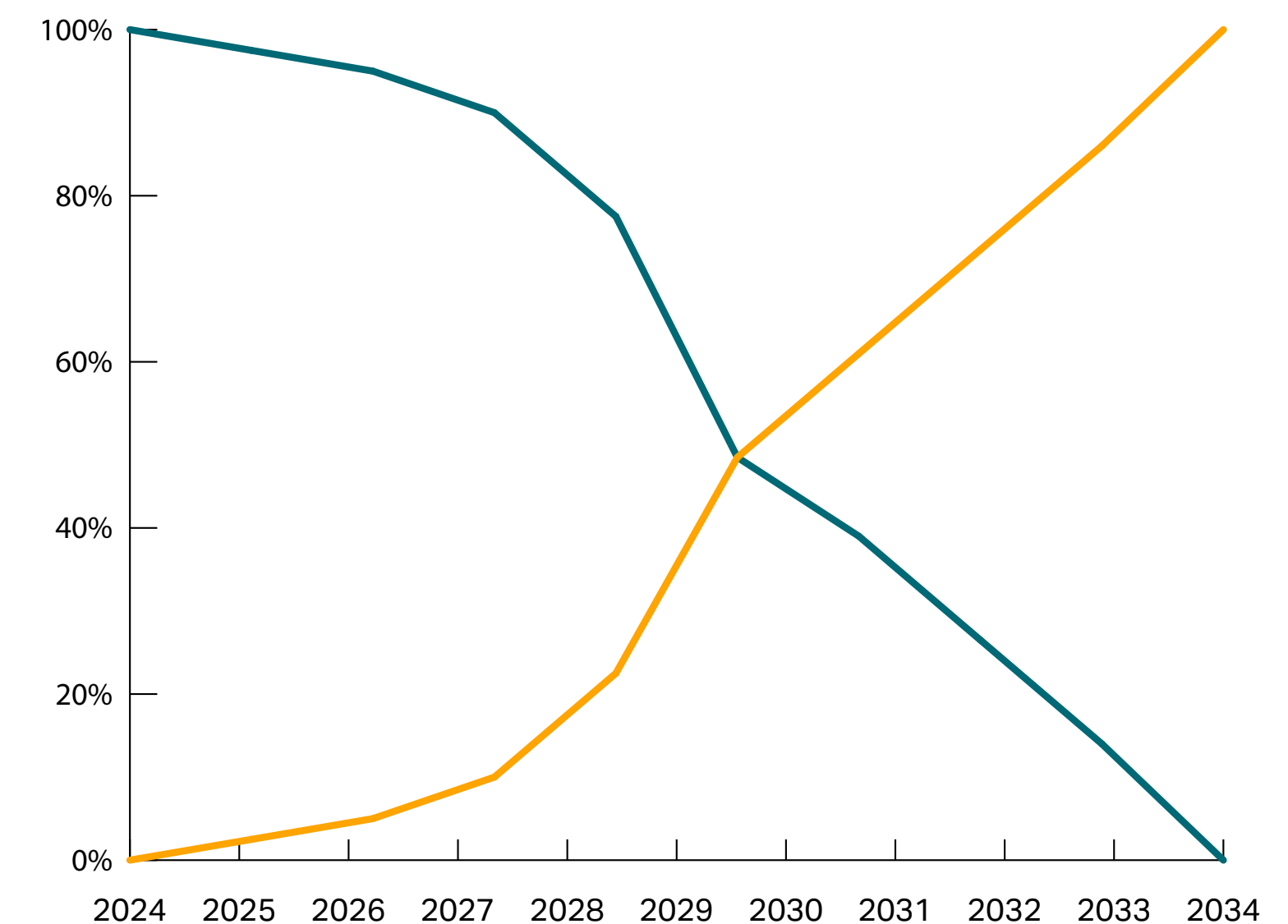
The EU ETS is the world's largest carbon pricing system. It works by issuing a capped number of emission allowances (EUAs) that represent one tonne of CO₂e emissions. These are either auctioned or given to specific emitters (e.g. in sectors deemed at risk of carbon leakage) for free - a process called free allocation. Emitters in scope of the ETS need to surrender EUAs to match their emissions. In order to incentivise increasing reductions, the number of EUAs issued is reduced over time. A share of the proceeds are used by member states and the EU to subsidise low carbon technologies (e.g. via the [Innovation Fund](#)).

The EU ETS is being tightened over time in three key ways:

- The number of **EUAs are gradually being reduced over time to limit** the emissions from the sectors in scope
- Sectors exposed to risks of carbon leakage are currently provided with free allocations. However, **free allocation will be phased out between 2026 and 2034**, currently a European Commission proposal to extend this to 2038 is under consideration) and these sectors will increasingly be exposed to the carbon price.

- **From 2026, the EU will fully implement a Carbon Border Adjustment Mechanism (CBAM).** This will require importers to the EU¹ of some goods (iron, steel, aluminium, cement, fertilisers, hydrogen and electricity) to buy and surrender CBAM certificates² to match the (scope 1, 2, and a limited share of scope 3) emissions embodied in the goods, with the equivalent value to EUAs (phased in before 2034 - see graph on the right). If importers can demonstrate a carbon price has already been levied on the relevant goods, this amount can be deducted. If importers can demonstrate a carbon price has already been levied on the relevant goods, this amount can be deducted. The EU is currently in the process of extending CBAM to a range of downstream projects (especially those with containing high volumes of steel and aluminium).
- Until 2025 a transitional period is in place, where relevant importers need to report the quantity of imports, their embedded/indirect emissions, and carbon prices already paid on goods in their country of origin.

Phase out of free allocations and phase in of CBAM



— % of embodied emissions that will need to covered by CBAM certificates

— % of free allowances relative to 2024

1: excluding some countries that are part of the EU ETS/have a linked ETS

2: the number of certificates needed will be phased in from 2026 to 2034

Sources: BloombergNEF (2023) [Scaling Technologies for Greening Heavy Industry](#), European Commission, [PtX Hub](#)

Case study: EU ETS and CBAM (2/2)

Impact

- The impact of an EU ETS with no free allocation on heavy industry is yet to be seen. It may be that to effectively drive demand, carbon pricing on its own will need to be complemented with other measures like subsidies and regulations.
- Analyses¹ suggest that with sufficiently low clean energy costs (e.g. for hydrogen costs of €2-3/kg), stable carbon prices between approximately \$120/tonne to \$200/tonne and effective measures to combat carbon leakage, production of commodities such as green steel could become competitive on a cost basis with steel produced through the BF-BOF route.
- Other countries are now considering similar measures. The UK has adopted a CBAM and measures are under consideration in Australia and Canada.

Key challenges/risks

1 Potential gaps in the CBAM

Potential gaps: the initial scope of the CBAM focuses on commodities that may be at risk of carbon leakage. However, it only extends to some finished products. Although hydrogen and ammonia are covered by the CBAM, hydrogen derivatives such as e-methanol and e-kerosene are not subject to the CBAM. This will be reviewed at the end of the transitional period. The CBAM may also face challenges when accounting for upstream emissions (e.g. embodied emissions in post-consumer [metal scrap](#) are not currently included in CBAM, which may disincentivise primary production in the EU).

2 Carbon leakage risk and additionality

Some of the sectors in scope of the CBAM are currently subject to overcapacity (e.g. steel). In the case of steel, the global fleet contains both lower carbon steel plants and carbon intensive plants. This creates a risk of 'resource shuffling' where green steel that would have been used in third countries is instead sold in the EU, and displaced by carbon intensive steel. This would result in reduced EU emissions, but the reductions would not be additional. Wider adoption of carbon prices in other jurisdictions and measures to tackle carbon leakage could mitigate this.

3 Impact on developing countries

There is a risk that the CBAM impacts imports from developing countries and small companies that may not have the resources to decarbonise rapidly. Options to mitigate this could include financial support for industrial decarbonisation in developing countries.

1: for example, [Energy Transitions Commission \(2023\): Unlocking the First Wave of Breakthrough Steel Investments](#)
Sources: BloombergNEF, European Commission

3.8

Demand-Side Subsidies & Tax Credits

Overview: Demand-Side Subsidies & Tax Credits (1/2)

These are payments given to buyers and consumers, reducing the price they pay for materials or fuels. Tax credits are financial benefits that reduce the amount of tax owed for producing or procuring a lower carbon material or fuel. They can be applied at the demand- or supply-side. This lowers post-tax costs and stimulates demand. In some cases, these can be higher than the tax paid initially - resulting in either a net rebate or limit on the tax credit provided.

A key limit on the scalability or potential impact of subsidies is ensuring sufficient funding can be made available. Funds can be raised via general taxation, or the proceeds of carbon pricing systems. Furthermore, significant subsidies are currently provided for the production and use of fossil fuels or fossil-based products.

There are opportunities to redistribute such subsidies towards lower carbon products. For example, in India, approximately [\\$30bn](#) of subsidies were allocated to the fertiliser sector (FY 22-2023). Redistributing, or introducing requirements to use clean commodities into, such subsidies could be one way of incentivising green fertiliser use without an additional cost to governments. A similar structure has been proposed under the EU Industrial Accelerator Act which proposed to introduce requirements to use low carbon steel and aluminium to select public support schemes. Subsidies could also be leveraged to achieve other strategic aims (e.g. building domestic capabilities in green markets, improving the national balance of payments for fossil importers, and reducing exposure to the volatility of global energy prices). Supply-side subsidies, (e.g. results based payments or for reducing capital expenditure) can also be leveraged to reduce production costs over the lifespan of production facilities.

Green demand creation potential by sector

We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand it can apply to, and its potential impact on a business case. Depending on local or national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. Demand-Side Subsidies are most critical for sectors where the green premium is especially high, and where certain consumers may not have the ability to afford to pay the green premium (e.g. fertilisers for farmers). Subsidies are especially important in certain segments of sectors to avoid adverse distributive impacts (e.g. subsidising shipping fuel for small island developing states that are heavily dependent on imports).

Demand creation potential rating by sector

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Demand creation potential	Medium	Medium	High	Medium	Medium	Medium

Included for deep dive in this report

Overview: Demand-Side Subsidies & Tax Credits (2/2)

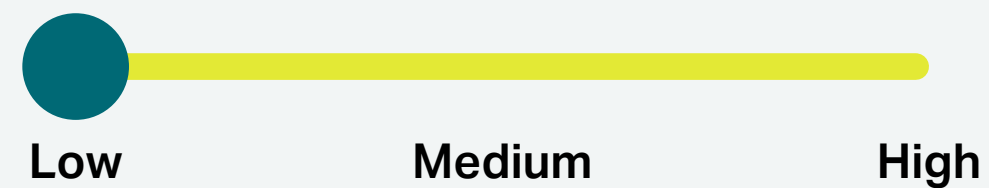
There are many different models to provide Demand-Side Subsidies and Tax Credits to suppliers and users of deeply decarbonised commodities. A non-exhaustive set of models, many of which can be applied either on the demand- or supply-side, are set out below:

Subsidy model	Description	Examples
Incorporation of clean commodity subsidies into existing schemes	Where end products are already subject to subsidy schemes (e.g. fertilisers or cars), existing subsidies could be made conditional on using clean inputs, or additional subsidies could be administered as a bonus	Proposed EU Industrial Accelerator Act measures on public support schemes
Upfront grants	Paid upfront on a one-off basis or according to a payment schedule. Because these are one-off, they are particularly well suited to research and development (R&D) projects.	Grant funding via the EU innovation fund
Tax credits	Reduction of tax liability for producing low carbon materials or fuels, which effectively decreases the costs incurred for procuring these products.	Brazilian Hydrogen tax credits
Fixed premium subsidies	Provide a fixed payment per unit output over a set period of time to all users of low carbon or near-zero commodities that meet a given standard. These subsidies can also be auctioned and awarded on a competitive basis (e.g. based on lowest subsidy needs).	European Hydrogen Bank
Contract for difference	Provides subsidies that cover the difference between a fixed strike price and the price the commodity is sold at. If the reference price is lower than the strike price, there could be an obligation to pay the government back.	UK Hydrogen production Business Model, India SIGHT programme
Carbon contracts for difference (CCFDs)	Can only be implemented in conjunction with an emission trading system. Provides a contract for difference based on a pre-agreed carbon price reference, which is indexed to energy costs.	German Carbon Contracts for Difference
Indirect subsidies	Subsidies provided on an indirect basis (e.g. by crediting the use of low carbon fuels with allowances in an emission trading system, or allowing the use of sustainable fuels to opt in to a fuel standard programme).	EU provision of free ETS allowances for airlines using SAF

The list above is not exhaustive. The use of [state-backed intermediaries](#) can provide a means to both subsidise and derisk offtake and the production of decarbonised commodities. Furthermore, other forms of tax relief and incentives could be provided in return for the use of low and near-zero commodities.

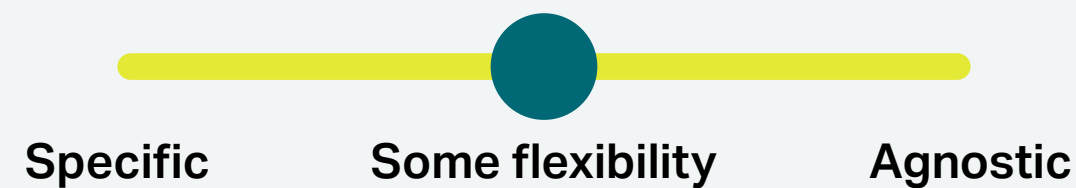
Key Attributes: Demand-Side Subsidies & Tax Credits

Carbon leakage risk



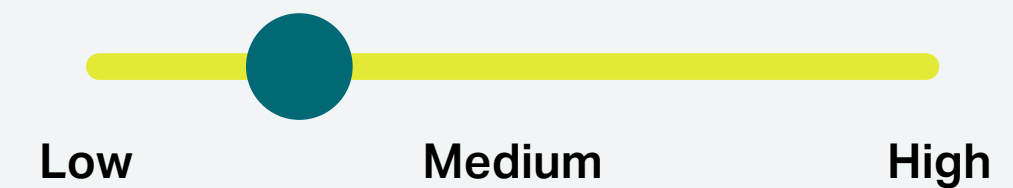
Since subsidies and tax credits reduce the cost of using low and near-zero commodities, they do not pose significant carbon leakage risks. They can be used to mitigate the competitive risks associated with mandatory measures and carbon pricing.

Technology agnostic



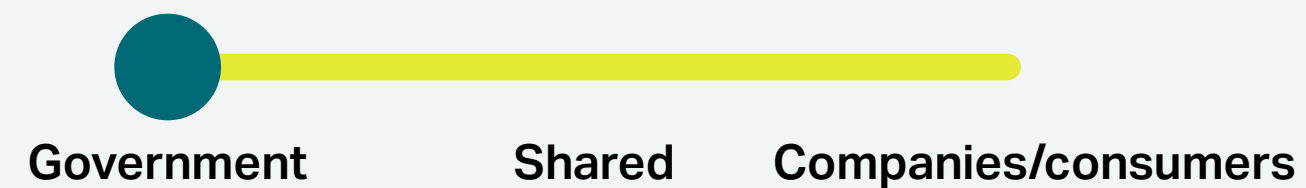
Subsidies and tax credits can either be targeted at specific sectors or technologies, or be applied based on a technology neutral basis.

Ability to ramp up over time



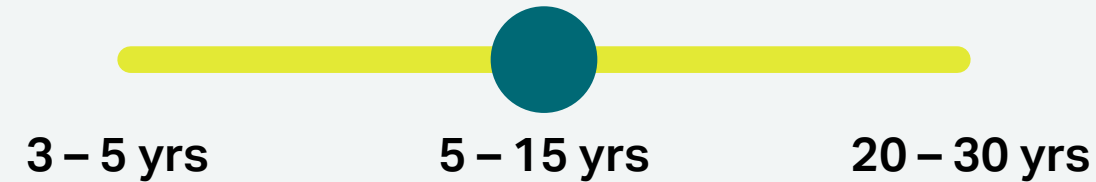
As the supply of decarbonised commodities increases and costs drop, subsidy programmes can be calibrated to account for greater coverage - and creates the potential for reduced levels of subsidies.

Burden of cost



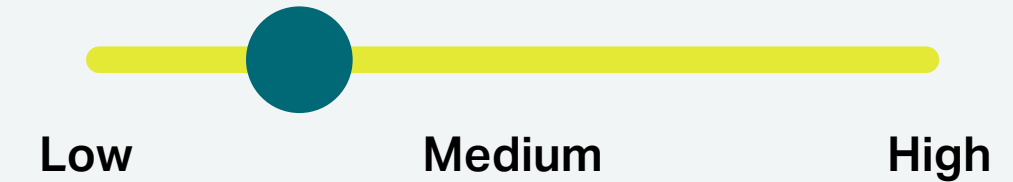
They would need to be funded by governments, and this could amount to a significant sum. Allocation of funds could be made more efficient by running competitive processes for support - see next slide. Additionally, where subsidies are currently being applied for fossil-based products and fuels, these could be redistributed to lower carbon options.

Long-term stability



Current subsidy programmes offer incentives either upfront or over 10-15 years. However, renewing and capitalising these programmes is subject to government budget cycles, which can be significantly shorter. This makes it difficult to be certain whether subsidies will be in place for the long term.

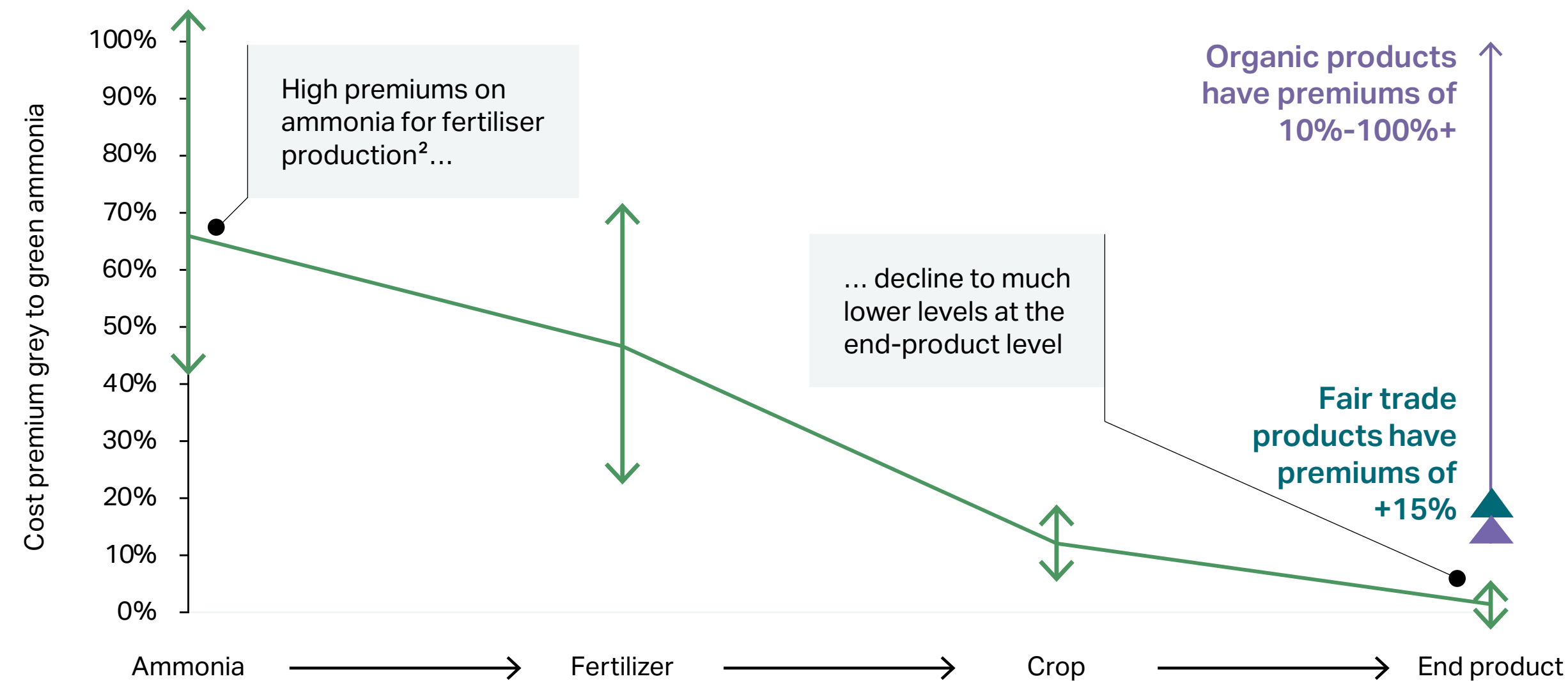
Complexity



Given the low competitive distortion risks associated with subsidy programmes and tax credits, these are likely to be less complex to implement.

Demand-side subsidies may be needed to help stakeholders who are less able to afford the green premium

Indicative green premium across different segments of the fertiliser value chain¹



Stakeholder and their indicative ability to manage green premium

Fertiliser producers: Difficult in a commodity market, but may be able to develop differentiated market

Farmers: Tight margins, especially for small holders and in developing economies

Processing and retail: Varies widely by market, product and company size

Consumers: Varies, depending on product, country and household finances

Cost impact on end product³



+ €0.01 (0.5%)
for a loaf of bread



+ €0.001 (0.06%)
for a can of beer



+ €0.005 (0.3%)
for a bag of rice



+ €0.005 (0.3%)
for a carton of milk

+ €0.01
maximum on price tags

1: premium cascade estimates based on estimated percentage contribution of ammonia to fertiliser cost, fertiliser to crop cost and crop to end product cost

2: displayed premium is based on modelling of a 0.5MT plant placed in a region with affordable renewable energy to produce hydrogen (i.e. Sweden), starting operation in 2027, and fossil energy market price outlooks

3: based on approximate crop input volume to produce the end product

Sources: MPP analysis, [Global Agriculture](#), BloombergNEF: [Scaling up hydrogen: the case for low carbon ammonia](#), IEA: [Global Hydrogen Review 2024](#)

Deep Dive: Demand-side subsidies in materials sectors

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

 Steel	 Efficiency of use ¹
	 Recycling
	 CCUS/H ₂ DRI
 Cement	 Efficiency of use ¹
	 Low carbon production (e.g. via SCMs, CCUS)
 Aluminium	 Efficiency of use ¹
	 Recycling
	 Low/near-zero carbon primary production ²

Key

 Directly incentivised  Indirectly incentivised  Not incentivised

Key considerations

- **Stage of the value chain:** subsidies for the use of green materials could be applied at various stages of the value chain. To administer them efficiently, it may be prudent to ensure demand-side subsidies are applied at a large enough scale to support new supply. Therefore, demand-side subsidies may need to be provided to a) very large offtakers b) consortia of end users c) to localised hubs d) disbursed via existing subsidy schemes.
- **Technology pathways:** subsidies can either target the procurement of material using specific production pathways (e.g. use of CCUS in production) or be technology neutral, targeting the carbon intensity of a material - see example of CCFDs. The former is especially useful if policymakers wish to scale specific nascent technologies and meet broader goals such as developing new green markets and supply chains. However, policymakers may risk artificially selecting technology ‘winners’ and may not allocate funding to the most efficient technologies in the near term.
- **Implementation over time:** the criteria for products eligible for such subsidies can be tightened over time, as costs of new solutions reduce, and as more novel technologies that can achieve deeper emission reductions mature.
- **Complementary policies:** subsidies can be paired with regulatory measures (e.g. mandatory quotas) to achieve a larger effect on emission reduction and reduce increased costs for end consumers. They can be applied at different parts of the value chain (e.g. subsidies for demand side and mandates for producers) or at the same stage. For subsidies, policymakers should assess the ability for various buyers to absorb the green premium across the value chain - and tailor the amount provided. Since they reduce the overall costs associated with green products, they can also help to mitigate carbon leakage risks. In the absence of sufficiently robust carbon pricing systems, subsidies can be key to help bridge the cost gap with carbon intensive goods.

1: optimising the use of material and reducing waste (depending on size of subsidy)
2: adopting production technologies with a lower carbon footprint (e.g. using clean power for aluminium smelting, inert anodes and/or mechanical vapor recompression (MVR))
Source: [BloombergNEF: Scaling Technologies for Greening Heavy Industry](#)

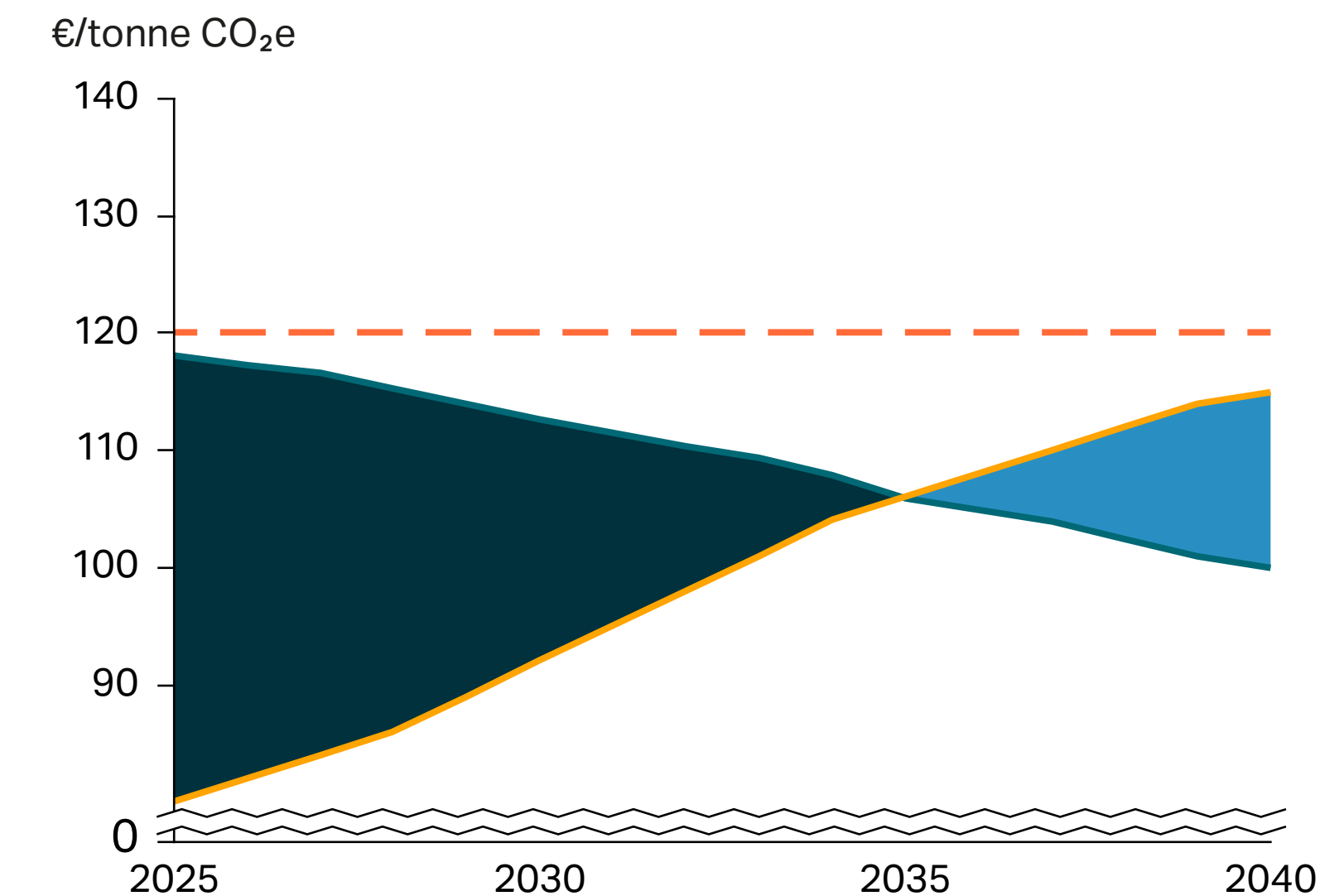
Case Study: Carbon Contracts for Difference (CCFDs) (1/2)



Applies to: heavy industry

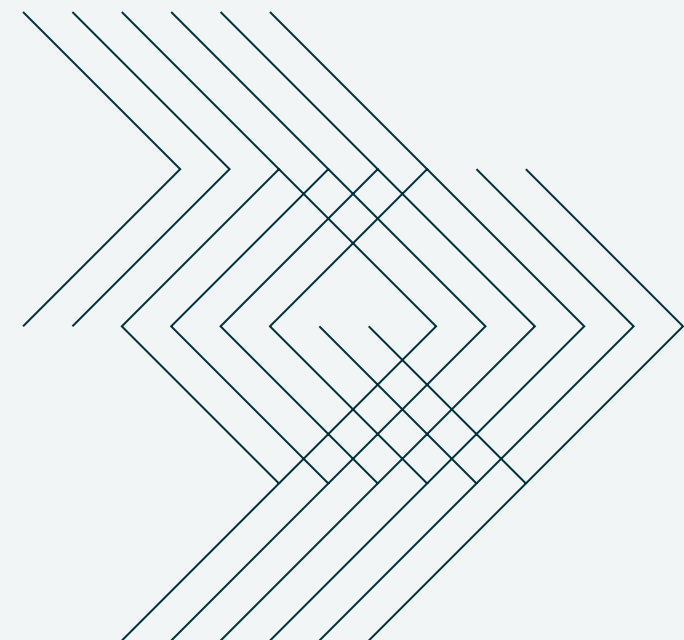
- Germany has launched a €4bn auction for [CCFDs](#) as the first step of a programme expected to ultimately be much larger. This supports the use of low carbon inputs such as green hydrogen. CCFDs work through three steps:
 - Bidding:** companies assess the cost and CO₂ emission delta between incumbent fossil and green plants. They use this to calculate a Euro per-tonne CO₂ **strike price** that would bridge the green premium, within given parameters (EU-ETS carbon price, energy price, caps on bids).
 - Adjustments:** where bids are successful, the base price is adjusted annually according to energy and carbon prices to calculate an **indexed CCFD strike price**. The **effective carbon price** is then subtracted from the **indexed CCFD price**.
 - Payments:** if the **effective carbon price** is **lower** than the **indexed CCFD strike price**, the difference is paid to the company from the government. If the **carbon price** is **higher** than the **indexed CCFD price**, the difference is paid to the government from the operator.
- This guarantees an effective carbon price that would give parity with an equivalent fossil good.
- Sectors in scope** include: oil refining; steel works; the production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp/paper, cardboard and acids and bulk organic chemicals. Projects would need to achieve at least a 90% emission reduction by the end of the funding period.
- Duration:** the contracts would last for up to 15 years, covering additional capex and opex.
- Competitive process:** companies will be selected competitively based on achieving the lowest cost emission reductions. The data from such bids may be able to be used to support price discovery in new markets - although this is not explicitly specified for the first auction.
- Other regions are now considering adopting CCFDs (e.g. Canada)

CCFD payment calculation: illustrative example



Case Study: Carbon Contracts for Difference (2/2)

Key challenges/risks



1 Need for large scale, prolonged funding

- A significant and steady amount of funding is needed; in Germany, the programme is envisaged to require tens of billions of Euros in funding. Initially, funds for the CCFD scheme were intended to be covered by leftover COVID-19 recovery funds that would be used to finance climate initiatives. A German court barred this route, which has raised issues with funding.
- Options to reduce the overall cost could include higher carbon prices and complementary regulations that increase willingness to pay for low carbon products.

2 Uncertain pricing information

- Due to a lack of accurate pricing information, it may be difficult to ascertain accurate base and indexed prices for the bidding. This could either lead to conservative bids being entered, or to increased uncertainty and bankability for projects down the line.

3 Competition across sectors

- Because the CCFDs are allocated across several industries, some are likely to have lower abatement costs than others - and therefore be more competitive in auctions for CCFDs. To ensure breakthrough technologies are incentivised in a wide range of sectors, separate buckets may be needed for different sectors.

4 Accessibility for small companies/facilities

- Larger facilities may be more competitive than smaller facilities in bids owing to economies of scale. To mitigate this, very large facilities (e.g. requiring €1bn+ in funding) are not included in the first pilot. Separate funding instruments may be needed for very small plants.

Deep Dive: Demand-side subsidies for low carbon hydrogen

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

 Steel	 Efficiency of use ¹
	 Recycling
	 CCUS/H ₂ DRI
 Aviation	 Efficiency of use ²
	 Bio-SAF
 Chemicals	 E-SAF
	 Efficiency of use ¹
	 Blue H ₂
 Maritime	 Green H ₂
	 Efficiency of use ²
	 SZE ³
Key  Directly incentivised  Indirectly incentivised  Not incentivised	

Key considerations

- Policy design:** a range of different subsidy instruments can be used to support projects depending on national priorities, government risk appetite, and the needs of industry. Given the differences between demand sectors, sector-specific subsidy programmes may need to be developed to ensure hydrogen consumption is scaled appropriately across different sectors (e.g. demand-side subsidies may be needed in the fertiliser sector to support farmers with tight profit margins to help buy green fertiliser, and to manage distributional impacts in other sectors like shipping).
- Co-ordination with other countries:** for global transportation sectors (e.g. international maritime) where hydrogen derivative-based fuels are not drop-in replacements for fossil fuels, subsidies may need to be co-ordinated between countries to build demand and enable infrastructure investments across international networks.
- Potential to offset social and distributional impacts:** although the costs of end products to end consumers in the value chain tend to be low, this could sometimes have a social or distributional impact. Increased food costs may be more difficult to absorb in emerging economies. Similarly, increased costs associated with low carbon shipping may distributional impacts effecting developing countries. Demand-side subsidies can be used to offset cost increases.
- Achieving scale and targeting different value chain stages:** several demand-side subsidy instruments are targeting localised hubs, comprising multiple hydrogen demand sources to provide a large enough signal to support new production facilities.
- Complementary policies:** demand-side subsidies could be used effectively in conjunction with a range of instruments (e.g. providing subsidies to reduce the cost of using green fertilisers could offset the impacts of regulatory measures such as mandatory quotas). In turn, leveraging mandates could increase the willingness to pay, reducing the government funding needed for subsidies.

1: improving fuel efficiency by optimising routes, speed, and other operational practices
2: optimal use of products to reduce associated emissions
3: scalable zero emission shipping fuel (SZE³) and includes zero or near-zero emissions methanol and ammonia
Source: IEA

Implementation examples of subsidies for low carbon hydrogen

Examples of hydrogen hub programmes

These programmes generally aim to develop hydrogen hubs, which are superclusters of demand for green hydrogen and derivatives. They tend to include grants and subsidies for both supply and demand.

Jurisdiction		Policy description	Status	Sectors
Australia		Regional Hydrogen Hubs Programme : under this programme AUD 490m (\$324m) has been allocated to seven hydrogen hubs, which are large clusters of demand for renewable hydrogen, targeting 2.8 MTPA of hydrogen production.		Chemicals Steel Maritime Aluminium ¹
India		National Green Hydrogen Mission : ₹400 crore (\$48m) up to FY2025-26 committed to building at least two green hubs producing at least 100,000 tonnes of H ₂ annually in the initial phase. Funding and subsidies cover infrastructure such as: pipelines and storage; compressors and liquefaction plants; and port upgrading.		
Spain		Public tender : launched for developing at least two hydrogen valleys by 2030, with €200m in funding per valley.		
Brazil		\$1.09 billion committed to developing clean hydrogen hubs in partnership with Climate Investment Funds, to support: hydrogen production; storage; transportation; and utilisation - including for low emission steelmaking.		
UAE		As part of the National Hydrogen Strategy , the policy on Low-Carbon Hydrogen sets out plans to develop low carbon hydrogen oases and clean energy precincts, with end use applications such as cement, aluminium, chemicals and steel.		
 Covers ≥10% demand		 In place (and enforced)  In place, but to be implemented		

Examples of key enabling initiatives/detailed studies

- [IEA Global Hydrogen Review 2024](#)
- [Global Maritime Forum's study](#) on national and regional policy for green shipping corridors includes detailed study of shipping specific support schemes for hydrogen derived shipping fuels

Implementation examples of demand-side subsidies for low carbon hydrogen

Examples of other subsidies supporting hydrogen consumption

Jurisdiction		Policy description	Status	Sectors
Chile		Up to USD 1m allocated for demand creation and the demonstration of new use cases, with up to 60% of costs covered. A total of \$1bn committed to foster domestic consumption and production of green H ₂ .		Chemicals Steel Maritime Aluminium ¹ Concrete ¹
India		National Green Hydrogen Mission : cumulative funding of ₹1,066 crore (\$126m) provided for pilot projects on the retrofitting or development of new infrastructure supporting green hydrogen consumption - initially targeting steel, mobility and shipping.		
Italy		Under the Temporary Crisis and Transition Framework (2023): €550m (\$603m) and €400m (\$438m) was allocated to support investments for hydrogen consumption in industrial processes and should be granted by 2026.		
Sweden		€265m (\$290m) grant to support the development of a 2.5MT low emission steel plant by Stegra. This includes developing a 690MW electrolyser, a DRI plant, two electric arc furnaces, and cold rolling and finishing facilities.		
United Kingdom		Industrial Energy Transformation Fund (Phase 3): £185m (\$240m) allocated for feasibility and engineering studies and deployment of decarbonisation projects - including the retrofitting or installation of equipment supporting the switch to low carbon fuels.		
Japan		A clusters support scheme has been announced, in conjunction with the supply chain subsidy, to support the industrial use of hydrogen and ammonia in Japan. The scheme was announced under the Hydrogen Society Promotion Act in May 2024 and is expected to be implemented soon.		
New Zealand		Interim Hydrogen Roadmap includes the Regional Hydrogen Industry Transition instrument, which offers a rebate for hydrogen consumption by companies in the heavy transport and industry sectors, to be implemented in 2025.		

Covers ≥10% demand

 In place (and enforced)  In place, but to be implemented

Case Study: National Green Hydrogen Mission – Pilot Projects (1/2)

India

Adopted: 2023

Applies to: industry and transport

- The **National Green Hydrogen Mission** was implemented with the aim of making India a global hub for the production, use and export of green hydrogen and derivatives, and to become self-reliant through increased use of domestic clean energy. The mission includes a mix of policies including: proposed mandatory quotas; competitive bidding processes for the production and procurement of hydrogen derivatives through the Strategic Interventions for Green Hydrogen Transition (SIGHT) programme; and the development of green hydrogen hubs supporting large scale production and utilisation.
 - As part of this, the Indian Government is supporting **pilot projects with targeted sectors** - steel, shipping and port infrastructure, long range heavy mobility, and hydrogen production through the provision of [grants for users](#):
- Low carbon steel projects: ₹455 crore (\$55m) up to FY2029-30

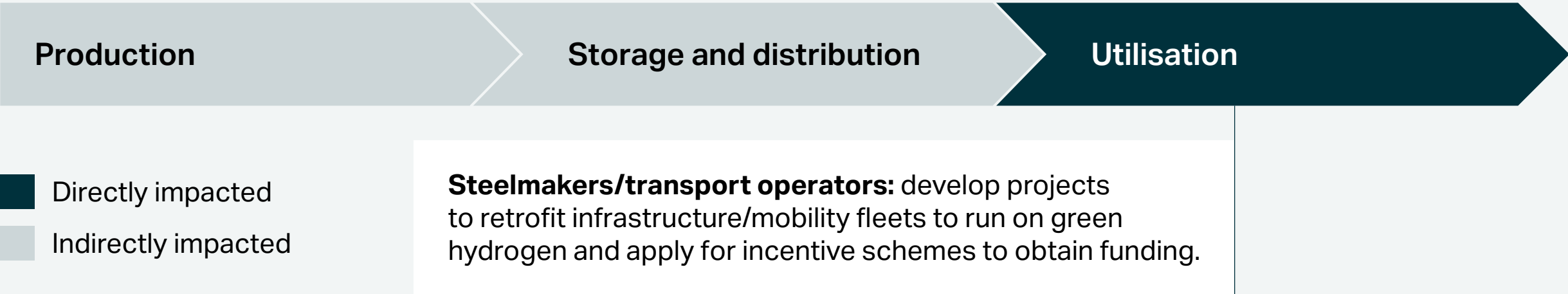
 - Eligible projects cover: 100% hydrogen in DRI using vertical shaft/kiln; use of hydrogen in blast furnaces; switching fossil fuels with hydrogen in DRI processes; and any other innovative use of hydrogen for reducing carbon emissions in iron and steel production
 - Funding is capped at 50% of the total project costs and will be used for capital equipment and preparing detailed project reports.

Shipping: ₹115 crore (\$14m) up to FY2025-26

 - Eligible projects cover: retrofitting ships to run on green hydrogen fuels; or developing bunkering and refuelling facilities at ports for such fuels
 - ₹80 crore (\$10m) allocated for the capex of vessels running on clean fuels, while the remaining funds will be used to develop refuelling infrastructure in at least one port by 2025.

Hydrogen value chain

Stakeholders impacted

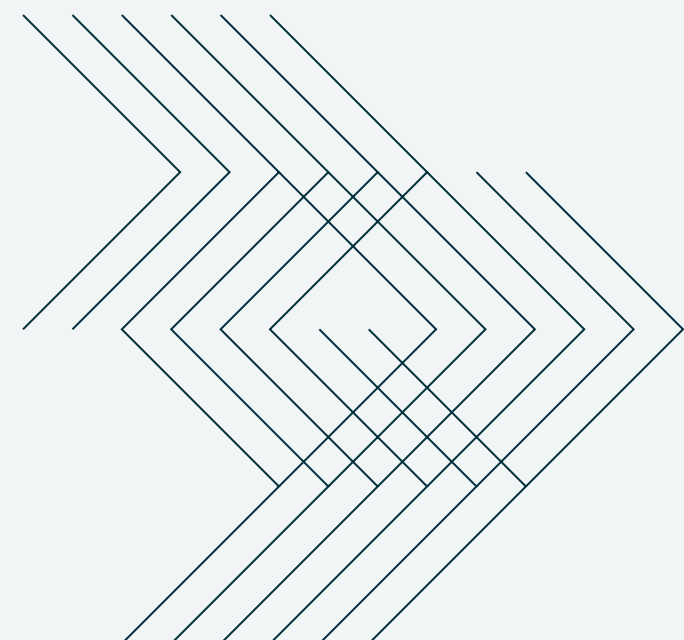


Impact

- **Low carbon steel:** India's Ministry of Steel, through its implementing agency, MECON, issued a Request for Proposal (RFP) in June – July 2024, calling for proposals for the use of hydrogen in steel. [Only one bid was received](#), submitted by a consortium led by the India Institute of Minerals and Materials Technology (IMMT), where they will use 100% hydrogen-based DRI.
- **Shipping:** A [scheme](#) was announced in February 2024 supporting the retrofitting of ocean-going and inland waterway vessels with green methanol, green ammonia or hydrogen fuel cell-based propulsion systems. This includes the conversion of at least two ships of the Shipping Corporation of India (SCI) to run on hydrogen derivatives by 2027.

Case Study: National Green Hydrogen Mission – Pilot Projects (2/2)

Key challenges/risks



1 Uncertainty of demand for the scheme

- The recent RFP launched for the steel sector only saw one bid for the fund, indicating some hesitation by steelmakers for adopting green hydrogen. In a recent survey conducted by [Ramboll and the Climate Group](#), steel and concrete buyers cited cost as the biggest barrier to large scale adoption of low emission steel. With cost a key concern for buyers, steelmakers may have more uncertainties on the return on investment for upgrading infrastructure to produce decarbonised emission steel - even with a subsidy scheme in place. As such, more complementary policies or technical advisory may be needed to increase the confidence of steelmakers and encourage them to apply for the scheme. Furthermore, with the implementation of one project demonstrating the success of low emission steel using hydrogen, more steelmakers may be encouraged to follow suit.

2 Limited impact on overall green premium

- Even with the subsidy for retrofitting/developing infrastructure to support hydrogen consumption in steelmaking or shipping, the steel and shipping companies would still need to finance part of the project. For steel, this is at least 50% of the total project costs. The companies would also need to finance the increased operational expenses, including the cost of green hydrogen (which is higher than its grey counterpart), land acquisition costs and any other costs associated with operational transformation (e.g. upskilling workforces to operate new equipment).
- States are developing their own demand-side support policies for green hydrogen consumption, to complement national policies. For instance, [Haryana](#) is planning to provide 50 rupees/kg (\$0.60) of green hydrogen used in industrial processes including steelmaking for five years. [Punjab](#) is also planning to provide a subsidy of 50 rupees/kg (\$0.60) for consuming green hydrogen in an initial shortlist of 10 industries - to be defined.

3.9

In-Kind Incentives For Use Of Decarbonised Products/Services

Overview: In-Kind Incentives for Use of Decarbonised Products/Services

These are non-financial benefits or advantages provided by public bodies to industry buyers for the uptake and use of low carbon materials. Incentives are rewarded in return for meeting an emissions threshold (e.g. an end product standard). In-kind incentives aim to improve the business case for using low and near-zero carbon materials and fuels without the use of public funds.

Examples of in-kind incentives that could be applied include: expediting permit approval processes/being granted additional areas in return for reducing whole life carbon in construction projects; or giving users of low emission shipping fuels priority access to ports. Many of these are likely to fall within the remits of **sub-national authorities** (e.g. municipal governments or port authorities).

Green demand creation potential by sector

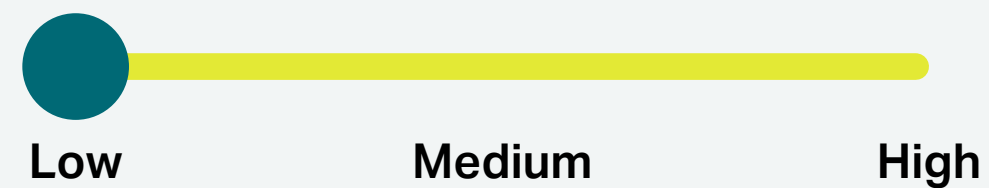
We have developed an indicative rating of the green demand creation potential of each policy by sector, based on the share of demand this lever can apply to, and its potential impact on a business case. Depending on local or national context this may be more or less impactful in different sectors. A full methodology is in [Annex 2](#) for each sector. In-kind incentives could be relevant across a range of sectors, but will likely play a supplementary role along with other demand stimulation policies discussed in this document.

Demand creation potential rating by sector

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	Low	Low	Low	Low	Low	Low
Included for deep dive in this report						

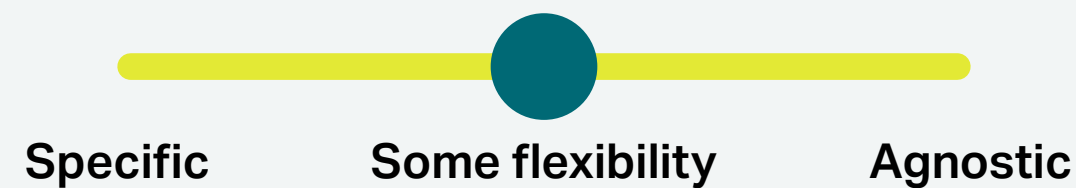
Key Attributes: In-Kind Incentives for Use of Decarbonised Products/Services

Carbon leakage risk



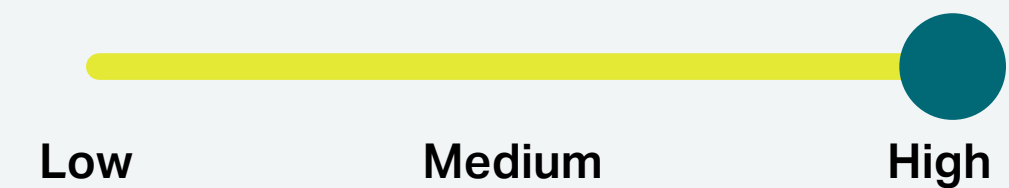
Incentive programmes are typically voluntary, so those who do not wish to meet the criteria of procuring/using lower carbon materials or fuels are not impacted financially. Therefore, carbon leakage risks are low.

Technology agnostic



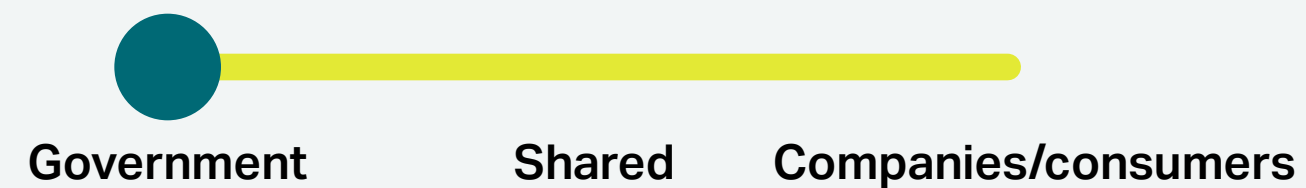
Depending on the sector these measures are applied to, they could either be applied to end products (e.g. based on whole life carbon for construction projects), or higher up value chains.

Ability to ramp up over time



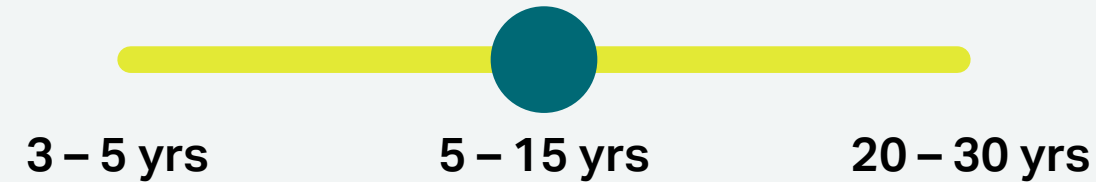
The eligibility criteria can be tightened over time to further incentivise emission reductions. The criteria can also be expanded across various categories of materials used. Over time, as the use of green materials becomes more widespread, there would be less need to incentivise it.

Burden of cost



Governments will need to allocate resources to process and disburse in-kind incentives (e.g. instance setting up a new department to oversee the programme). Additionally, they will need to fund the incentives or forego extra revenue that could have been earned from them.

Long-term stability



Non-financial programmes could be put in place over the long term, but would likely need to be adjusted over time, particularly as the supply of low or near-zero carbon commodities scales up, and more demand-side players become eligible.

Complexity



Sufficient government capabilities, expertise, and resources are needed to manage product standards, to ensure the right materials are used and applications are evaluated thoroughly.

Deep Dive: In-kind incentives in the construction sector

Decarbonisation levers incentivised by policy

(see lever details in [Annex 1](#))

	Steel	● Efficiency of use ¹
		● Recycling
		● CCUS/H ₂ DRI
	Cement	● Efficiency of use ¹
		● Low carbon production (e.g. via SCMs, CCUS)
	Aluminium	● Efficiency of use ¹
		● Recycling
		● Low/near-zero carbon primary production ²

Key

● Directly incentivised ● Indirectly incentivised ● Not incentivised

Key considerations

- **Type of incentive:** incentives would be provided in return for meeting a certain environmental standard or performance in their construction practices, such as the use of lower carbon construction materials for new buildings. There are various in-kind incentive options available, and selecting the right ones will depend on the key pain points or bottlenecks faced by project developers and building owners to increase the attractiveness of the programme. Some examples include: expedited permit approvals; permission to add additional floors or floor area ratios beyond standard zoning limits; technical assistance; and marketing support highlighting green building efforts.
- **Achieving scale:** many of the processes through which in-kind incentives could be provided are administered through sub-national authorities (e.g. municipal governments) and therefore co-operation between multiple authorities may be needed for in-kind incentives to have a significant impact on an industrial scale.
- **Scope and eligibility:** policymakers should determine the types of building this applies to (e.g. newbuilds versus retrofits, residential, commercial, and their various sub-categories) and the eligibility criteria (e.g. carbon limits for specific materials).
- **Market readiness:** lower carbon materials may cost more than conventional products and may be less readily available. Hence, the eligibility criteria must be realistic and achievable.
- **Administrative resourcing:** manpower resources and capabilities are needed to: oversee the standards and verification of projects; the implementation of the incentives; and reporting and monitoring of the effectiveness of the programme.

1: optimising the use of material and reducing waste
2: adopting production technologies with a lower carbon footprint (e.g. using clean power for aluminium smelting, inert anodes and/or mechanical vapor recompression (MVR))
Source: [GRESB](#)

Implementation examples of in-kind incentives in construction

Examples of in-kind incentives

Jurisdiction		Policy description	Status	Sectors
USA		Seattle Priority Green: projects receive priority for permit approval processes, saving at least three months (roughly 50%) from intake to issuance for meeting certain environmental criteria. This includes: using and advocating for Environmental Product Declarations; and obtaining green building certifications - the scoring criteria for which also includes goals for embodied carbon such as using at least 250ft ² of carbon negative material for town homes.		
Singapore		Built Environment Transformation Gross Floor Area (GFA): this scheme rewards developers/ building owners with 3% more GFA beyond the stipulated gross plot area if they meet certain outcomes - including criteria for whole life carbon and embodied carbon.		Steel Aluminium Concrete
Peru		Municipal Ordinance No. 610-MSB and Municipal Ordinance No. 496-MSB: municipal government schemes reward developers with additional one to four building storey allowances, if they meet certain green building certification requirements. Some of these certifications include criteria on life cycle assessments or offer credits for reducing embodied carbon.		
 Covers ≥10% demand		 In place (and enforced)		

Case Study: Seattle Priority Green Expedited Programme (1/2)

United States

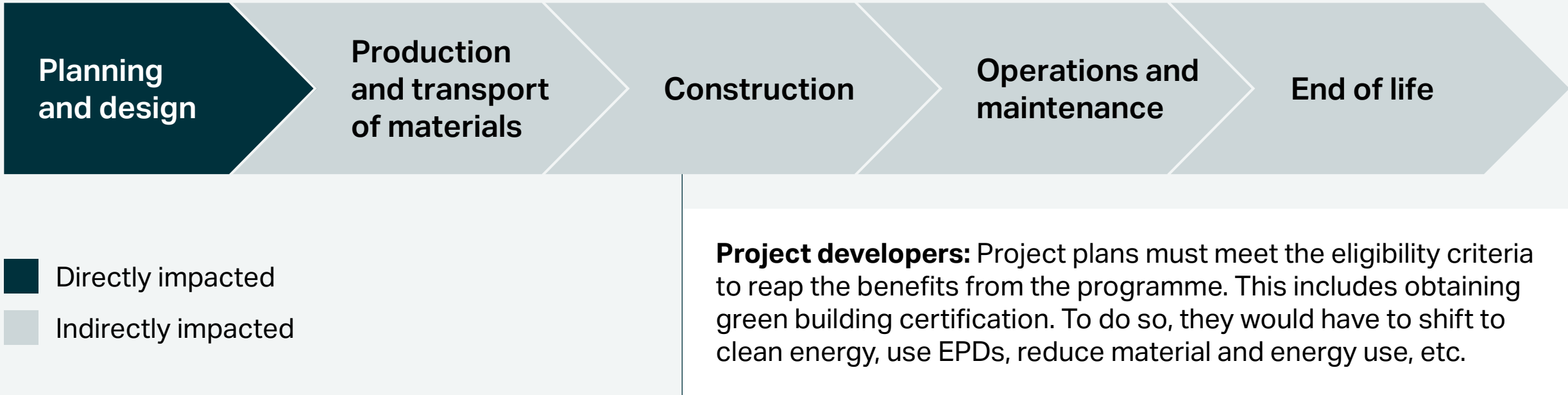
Adopted: 2009

Applies to: building materials

Seattle Priority Green is a voluntary programme where building projects receive in-kind incentives for meeting an environmental criteria. Developers can enjoy priority for permit approvals, saving at least three months (roughly 50%) from intake to issuance. The criteria includes exploring opportunities to reduce embodied carbon of materials by mainstreaming the use of Environmental Product Declarations and obtaining green building certification that includes goals for reduced embodied carbon.

Construction value chain

Stakeholders impacted

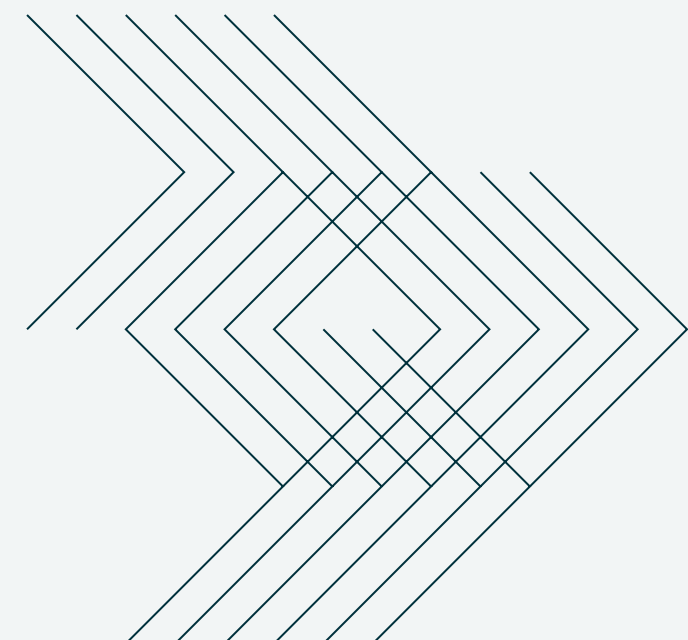


Impact

- Despite the voluntary nature of the programme, 52% of homes in Seattle obtained Built Green certification as of 2016. In 2022, 41% of Seattle’s office buildings were LEED-certified.
- The Seattle Storm Centre of Basketball Performance is a recent project that qualified for Priority Green. The 50,000ft² building uses lower carbon concrete for its exterior tilt-up concrete panels. They replaced cement with slag (a waste product of steel production) and were able to reduce cement use by up to 80% for some walls.
- The impact on GHG emission reductions over the policy remains unclear. A study by the Washington Policy Centre suggests that LEED-certified buildings only produced 5% fewer GHG emissions than uncertified buildings.
- The programme currently focuses on the disclosure of embodied carbon through Product Declaration (EPDs), as opposed to setting strict limits. Nevertheless, developers must meet the embodied carbon requirements under certifications (e.g. Built Green). As such, it currently may not create a significant impact in reducing the embodied carbon of buildings, although it could be expected to enforce limits in future.

Case Study: Seattle Priority Green Expedited Programme (2/2)

Key challenges/risks



1 May not achieve significant environmental impact

- To achieve embodied emission targets, developers may reduce material use or substitute with other low-cost materials but not actually make significant decarbonisation investments. Hence, the requirements must be stringent enough to ensure the uptake of low-carbon materials, and the overall package of incentives needs to be compelling enough to compensate for increased costs.

2 Increases strain on public agencies processing permits

- Increased manpower and resources are needed to approve projects for Priority Green to expedite the permit process (e.g. in 2018 there were 165 project applications). A new department was created within the Seattle Department of Construction and Inspections, along with an online self-help portal.

3 Managing the differences between third-party certifications

- Different third-party certification providers (e.g. Built Green, LEED, Evergreen) either do not address embodied carbon, or address it in different ways. As such, Seattle's Priority Green does not explicitly include embodied carbon limits, but instead focuses on disclosure through EPDs and demonstration of meeting third-party certification.

Join us in driving the new industrial revolution and fast-tracking clean industry this decade.

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4

Annex 1: Types of Decarbonisation Levers by Sector

Aviation decarbonisation levers

Decarbonisation lever	Efficiency	Drop-in Sustainable Aviation Fuel (SAF)		
		HEFA	Alcohol to Jet and Gasification/FT	Power-to-Liquid
Description	Upgrading aircrafts, using the most fuel-efficient jets, or improving fuel efficiency by optimising routes and other operational practices	SAF produced from waste and residue lipids, such as from cooking oil	SAF production from agricultural/ forestry residues, municipal solid waste and/or cellulosic energy crops	Alternative fuel produced from renewable energy sources, e.g. green hydrogen and carbon dioxide.
Technology maturity	Various	8-9	7-8	5-8
% life cycle reduction potential vs fossil incumbent	-15-40%	-73-84%	-85-94%	-99%

Note a range of other measures, such as modal shift and novel production aircraft are also expected to play a key role in decarbonisation of the aviation sector. Further details of these and other levers are set out in [Making Net Zero Aviation Possible](#). This analysis focuses on in sector decarbonisation levers that we expect to be most impactful before 2030.

Maritime decarbonisation levers

Decarbonisation lever	Efficiency	Novel propulsion ships	
		Ammonia-fuelled ships	Methanol-fuelled ships
Description	Optimising the speed, size and the technological specifications of vessels to drive energy efficiency	Vessels that are fuelled by using ammonia derived from clean hydrogen	Vessels that are fuelled by methanol, particularly those made from renewable sources: (1) bio-methanol, produced from biomass, and (2) green e-methanol, produced from bioenergy with carbon capture and storage (BECCS) or direct air capture (DAC), and green hydrogen.
Technology maturity	Various	TRL 7-9	TRL 9
% lifecycle reduction potential vs fossil incumbent	-25-30% ¹	Up to -100% ¹	Up to -100% ¹

1: High emissions reductions can be achieved if ammonia and methanol are produced using green hydrogen and in the case of methanol, using carbon dioxide that is carbon neutral (e.g. utilising direct air capture or carbon dioxide from a biological source). Otherwise, emissions reductions are typically much lower.

Ammonia decarbonisation levers

Decarbonisation lever	Demand efficiency	Blue ammonia	Green ammonia	Methane pyrolysis	Biomass-based ammonia
Description	Levers decreasing the amount of ammonia needed per output (e.g. improved nutrient use efficiency, dietary shifts)	Use of blue hydrogen (produced from fossil fuels with CCUS) to synthesise ammonia.	Use of green hydrogen (produced via electrolysis and renewable electricity) to synthesise ammonia.	Methane pyrolysis produces solid carbon and “turquoise” hydrogen from which ammonia is synthesized.	Biomethane and hydrogen are produced via biomass digestion or gasification. Resulting gas is fed to a reformer.
Technology maturity	Various	TRL 7-9	TRL 7-8	TL 6-7	TRL 3-7 ²
% lifecycle reduction potential vs fossil incumbent	-4% (indicative)	Up to -90% to -95% (scope 1) ¹	-100% (scope 1)	-100% (scope 1) ¹	-100% (scope 1)

1: Note that upstream emissions resulting from fossil fuel extraction and processing are left unmitigated with the blue ammonia or methane pyrolysis route. In 2020, these were estimated to approximately 25% of the global scope 1 emissions of ammonia production.
2: the TRL of biomass-based ammonia technologies refers to the maturity of producing biogas from digestion or gasification process integrated with a reformer and ammonia synthesis plant. The direct use of biomethane in substitution of fossil methane is not a technical challenge in itself and would be considered TRL 9.

Methanol decarbonisation levers

Decarbonisation lever	Blue methanol	E-Methanol with green electricity	Methane pyrolysis	Biomethanol
Description	CO ₂ generated during the synthesis of fossil-based methanol is captured and either stored or used.	Use of green hydrogen produced from renewables and an external source of CO ₂ to synthesise methanol.	Methane pyrolysis produces solid carbon and “turquoise” hydrogen from which methanol is synthetised with CO ₂ .	Biomass feedstock (e.g. biomethane, waste gasification) is converted into syngas used for methanol synthesis
Technology maturity	TRL 7-9	TRL 8-9	TRL 7	TRL 8
% lifecycle reduction potential vs fossil incumbent ¹	-20% ²	-37% (fossil CO ₂) -100% (biogenic CO ₂)	-21% (fossil CO ₂) -84% (biogenic CO ₂)	-70% to -100% (depending on biomass)

1: the life cycle perimeter considered here accounts for the feedstock production (e.g. natural gas extraction and processing), synthesis and combustion of methanol. Note that the carbon contained in methanol is not necessarily released shortly after production in the form of CO₂ and can have longer retention time depending on the final application of the product (e.g. fuels, plastics, textiles, coatings).

2: Assuming 95% CO₂ capture rate.

Steel decarbonisation levers

Decarbonisation lever	Material efficiency	Steel recycling	Primary steel production		
			H ₂ -DRI	Steel with CCUS	Direct electrolysis
Description	Levers decreasing the amount of steel needed per product (e.g. vehicle lightweighting, 3D printing).	Use of steel scrap in an Electric Arc Furnace (EAF) instead of primary steel produced in a blast furnace.	New primary steelmaking route based on the reduction of iron ores with 100% green hydrogen instead of coal.	Primary steelmaking route (including BF-BOF, DRI-EAF, DRI-Melt-BOF and Smelting) retrofitted with CO ₂ capture.	Direct electrolysis and electrowinning of iron ores are novel ironmaking technologies not yet available
Technology maturity	Various	TRL 9	TRL 5-7	TL 5-8	TRL 5-6
% lifecycle reduction potential vs fossil incumbent	-23% (based on the steel demand it can reduce)	-93% ¹	-97% to -98% (if based on low-carbon electricity)	-50% to -90% ²	-97% (if based on low-carbon electricity)

1: this emission reduction potential represents the switch from a BF-BOF to a 100% scrap-based EAF process. The figure does not account for constraints that may arise from the limited supply of scrap or the demand for higher grades of steel which is difficult to produce using 100% scrap.

2: for BF-BOF retrofitted with CCUS, emission reduction typically ranges between 50 and 70% depending on capture configuration. Although further emission reductions can be achieved in theory, the number of CO2 sources and variable flue gas compositions on an integrated steel plant makes it economically unattractive and technically challenging to capture 100% of CO2 emissions. Studies that have investigated carbon capture on a BF-BOF steel plant tend to focus on main emissions sources and preferably with higher CO2 concentration (e.g. coke oven, hot stoves, onsite power plant), leaving behind more diffuse and unstable sources (e.g. sintering, flares, ladle metallurgy). For DRI equipped with CCUS, expected emission reductions compared to conventional BF-BOF are typically higher (up to 90%). This is because the DRI route uses natural gas which is less emission-intensive than coal but also because CO2 is inherently easier to capture in a DRI furnace.

Aluminium decarbonisation levers

Decarbonisation lever	Material and resource efficiency	Recycling of Aluminium	Primary aluminium production		
			Low carbon electricity	Inert anodes	Low carbon refining
Description	Levers decreasing the amount of aluminium demand (e.g. lightweighting, reduced losses, increased lifetime).	Use of aluminium scrap in melting and casting instead of primary aluminium produced in a smelter.	Primary aluminium smelters running on 100% low carbon electricity (e.g. green Power Purchase Agreements (PPAs), CCS retrofit).	Replacement of conventional carbon anodes with innovative inert anode technology to cut process CO ₂ emissions.	Technologies to decarbonise alumina refining (e.g. Mechanical Vapour Recompression, electric boilers and hydrogen calcination).
Technology maturity	Various	TRL 9	TRL 8-9	TRL7	TRL 4-9 ⁴
% lifecycle reduction potential vs fossil incumbent ¹	-22%	-97% ²	-65%	-16% ³ (-95% direct emissions for a smelter)	Up to -16% (if low-carbon electricity)

1: except from recycling, the values presented are within the global aluminium value chain i.e. including bauxite mining, alumina refining and scope 2 emissions from electricity consumption.
2: this emission reduction potential represents the switch from a primary aluminium producer to a 100% aluminium recycling process. The figure does not account for constraints that may arise from the limited supply of scrap or the demand for high quality aluminium alloys which can be difficult to produce using 100% scrap.
3: from the perspective of a conventional aluminium smelter with on-site anode production, switching to inert anodes would reduce direct scope 1 emissions by approximately 95%.
4: electric and hydrogen calcination are at TRL 4-5, Mechanical Vapour Recompression (MVR) is at TRL 7, and electric and hydrogen boilers for digestion are at TRL 8-9.

Cement decarbonisation levers

Decarbonisation lever	More efficient use of concrete	Reduction of clinker content	Fuel switching to waste and biomass	Kiln electrification/ hydrogen	CCUS
Description	Reduction in concrete demand through optimisation measures (e.g. improved design, precast concrete).	Substitution of clinker (i.e. the CO ₂ bearing material) by use of Supplementary Cementitious Materials (SCMs).	Partial or full substitution of fossil fuels (typically coal and petcoke) by fuels derived from waste and biomass.	High temperature heat provided by electricity (e.g. plasma torch, resistance) or hydrogen combustion instead of fossil fuels.	Cement plant retrofitted with carbon capture, utilisation and storage.
Technology maturity	Various	TRL 9 (for most SCMs)	TRL 9	TRL 5-6	TRL 6-9
% lifecycle reduction potential vs fossil incumbent	-22% (indicative)	Up to -73% (depending on SCM) ¹	Up to -35% (if fuel is 100% biogenic)	Up to -35% (if low-carbon electricity)	Up to -95% (depending on capture rate)

1: compared an Ordinary Portland Cement (OPC) that contains 95% clinker. Some few cement types with very high substitution rates (i.e. more than 50%) generally incorporate high proportions of Ground Granulated Blast Furnace Slag (GGBFS) but most common blends (with e.g. GGBFS, fly ash, limestone, calcined clay, pozzolanas) achieve a clinker substitution rate in the order of 10 to 40%.

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Annex 2: Detailed Scoring of Policies' Green Demand Creation Potential by Sector

Green demand creation potential ratings of government policies by sector

This section rates the various government policies by sector according to 2 factors. This is an indicative rating only – detailed study, cost benefit analysis and stakeholder engagement is needed to underpin any government policy, and to ensure it is tailored to national contexts:

Factor	Definition	Rating	Assessment criteria
Demand coverage	What is the maximum share of demand in an illustrative industry that this government policy could apply to?	Low	Applicable to less than 10% of typical national demand
		Medium	Applicable to 10-40% of typical national demand
		High	Applicable to 40 – 100% of typical national demand
Impact on business case	What is the indicative impact on a hypothetical business case for a deep decarbonisation project?	Low	Marginal impact on business case
		Medium	Partially bridges the green premium/ supports green market pull
		High	Creates a differentiated market for near-zero emission products or can come close to bridging the full green premium

Based on the ratings, we provide an overall assessment on of the green demand creation potential policy by sector.

Example:

Government policies	Demand coverage (Rating and rationale)	Impact on business case (Rating and rationale)	Priority	Case Study
Green Public Procurement	Public procurement of steel accounts for approximately 25% of demand (with a much higher share in some countries e.g. India)	If emissions thresholds are sufficiently stringent, GPP can create a market for decarbonised steel. Many projects may involve a large share of recycled steel.	High	Buy Clean

Aviation fuel: green demand creation potential of government policies

Government policies	Demand coverage (rating and rationale)	Impact on business case (rating and rationale)	Demand creation potential ¹	Deep dive included	Case study
Mandatory Quotas	This could be set on an economy wide basis and cover up to 100% of the fuel pool, but it is limited by SAF supply and the cost to industry.	This sends a clear and stable signal to industry. When enforced with sufficient penalties or buyout fees, it could significantly impact a business case.	High	Deep dive	ReFUELEU
Transportation Fuel Standard Programs	This could be set on an economy wide basis and cover up to 100% of the fuel pool.	Typically part of a wider fuel standard programme with other sectors and may have limited impact due to the wide range of decarbonisation levers.	Medium		
Green Public Procurement	Public procurement accounts for only a small share of aviation fuel and is therefore likely supplementary to other measures.	This sends a direct signal to producers for the procurement of SAF but will likely be spread across multiple flights (e.g. for public officials' travel) or concentrated in e.g. military flights.	Low		
State Backed Intermediaries²	This can support the private sector in procuring SAF by absorbing cost and risk but is limited by government risk appetite and capitalisation.	This can bridge green premium and provide certainty of offtake to fuel producers over the lifetime of a contract.	High	Deep dive	H2Global³
Carbon Pricing	This could be set on an economy wide basis and cover up to 100% of the fuel pool.	This must be sufficiently high and stable to bridge the green premium for SAF. With indicative abatement costs of up to \$900/t in 2030, this has to be paired with other measures to drive SAF uptake.	Medium		
Demand-Side Subsidies & Tax Credits	This could be set on an economy wide basis and theoretically cover up to 100% of the fuel pool, but it is limited by government funding and SAF supply.	This can reduce the green premium for SAF, depending on the extent of the subsidy. One key drawback is the uncertainty over longevity of subsidy instruments.	Medium		
In-Kind Incentives	This could potentially cover a significant number of departing flights from a certain jurisdiction.	This is unlikely to match the value of the green premium.	Low		

1: based on rating assessment on demand coverage and impact on business case and overall qualitative assessment based on current policy landscape

2: in theory could also be a blended finance measure

3: H2Global applies only to Power-to-Liquids

Maritime fuel: green demand creation potential of government policies

Government policies	Demand coverage (rating and rationale)	Impact on business case (rating and rationale)	Demand creation potential ¹	Deep dive included	Case study
Mandatory Quotas	This is likely set only at the national or regional level, limiting the scale at which it could be taken up relative to global standards.	This sends a clear and stable demand signal. For international shipping, it may be complicated to implement together with global standards and may need to apply to suppliers.	High	Deep Dive	
Transportation Fuel Standard Programmes	National programmes could incentivise inland shipping and potentially be used to provide indirect subsidies to international shipping.	If based on a carbon intensity, this may incentivise not only SZE ² , but also blending of biofuels. In many standards, SZE ³ would compete with other fuels.	Medium		
Green Public Procurement	Public procurement accounts for only a small share of maritime routes. It is therefore likely supplementary to other measures.	Governments of zero emission ships and fuel can provide a clear signal on specific routes for the uptake of SZE.	Low		
State-Backed Intermediaries²	This supports private sector to procure SZE, but is limited by government risk appetite and capitalisation	This can bridge the green premium and provide certainty of offtake to fuel producers over the lifetime of a contract.	High	Deep Dive	H2Global
Carbon Pricing	National carbon pricing systems could be extended to inland shipping. An international GHG pricing mechanism is being developed by IMO with very large (international) potential coverage.	This must be sufficiently high and stable to bridge the green premium for SZE. With projected abatement costs of more than \$100/t in 2030, this must be coupled with other measures to drive SZE uptake.	Medium		
Demand-Side Subsidies & Tax Credits	This could be set on an economy wide basis and theoretically cover up to 100% of the fuel pool. However, it is limited by government funding and SZE supply.	This can bridge the green premium, but a key drawback is uncertainty over longevity of instrument. It could be particularly important to mitigate distributive impacts.	Medium	Deep Dive	
In-Kind Incentives	National policies can likely cover 100% of domestic ships.	The in-kind incentives offered will unlikely be able to match the value of the green premium.	Low		

1: based on rating assessment on demand coverage and impact on business case and overall qualitative assessment based on current policy landscape
2: Scalable zero emission shipping fuel (SZE), including zero/near-zero emissions methanol and ammonia
3: in theory could be a blended finance measure

These ratings apply for domestic implementation. For international shipping, a global fuel standard and Green House Gas price is under development by IMO, which international shipping will be subject to. The IMO measures are capable covering very high demand shares and not a focus of this work as they are multilateral. Supporting these should be treated as a priority for demand stimulation.

Chemicals (methanol & ammonia): green demand creation potential of government policies

Government policies	Demand coverage (rating and rationale)	Impact on business case (rating and rationale)	Demand creation potential ¹	Deep dive included	Case study
Mandatory Quotas	This could be set on an economy wide basis.	This sends a clear and stable signal to industry. When enforced with sufficient penalties or buyout fees, it can significantly impact a business case.	High	Deep dive	RED III
Embodied Carbon Limits for Basic Products	This could be set on an economy wide basis.	Life cycle emissions targets could support decarbonisation of bulk chemical uses.	Medium		
Embodied Carbon Limits on End Products	This could be set on an economy wide basis but will likely be challenging to implement in some sectors.	This will unlikely bridge the green premium as the cost is fully borne on the industry.	Medium		
Green Public Procurement	A significant number of countries have state-owned fertiliser companies that could either procure green ammonia or produce and use it themselves. ²	The government can leverage state owned enterprises to procure (or produce and use) low carbon H2 as a feedstock (e.g. SOE Sinopec built a 260MW electrolyser for the chemical industry).	Medium		
State-Backed Intermediaries³	This can support private sector in procuring decarbonised inputs (e.g. H2, NH3, CH3-OH), but will be limited by government risk appetite and capitalisation.	This can bridge green premium and provide certainty of offtake to fuel producers over the lifetime of a contract.	High	Deep dive	H2Global
Carbon Pricing	This could be set on an economy wide basis.	This will likely have some impact at moderate levels, but not bridge the cost gap for bulk chemicals such as methanol and ammonia until prices are more than \$100/tCO ₂ .	Medium		
Demand-Side Subsidies & Tax Credits	This could be set on an economy wide basis and theoretically cover up to 100% of decarbonised supply but is limited by government funding.	This is particularly effective for segments of the value chain with low ability to absorb the green premium due to small profit margins (e.g. subsidising green fertilisers for farmers).	High	Deep dive	National Green Hydrogen Mission
In-Kind Incentives	This could be set on an economy wide basis, depending on design.	This does not cover the green premium through monetary means, but may partially reward use of green chemicals through other in-kind benefits.	Low		

1: based on rating assessment on demand coverage and impact on business case and overall qualitative assessment based on current policy landscape

2: examples include National fertilisers (India), Sabic (Saudi Arabia)

3: in theory could also be a blended finance measure

Aluminium: green demand creation potential of government policies

Government policies	Demand coverage (rating and rationale)	Impact on business case (rating and rationale)	Demand creation potential ¹	Deep dive included	Case study
Mandatory Quotas	This could either be set at an economy wide basis or on individual sectors (e.g. automotive). It would likely start as a small share and increase over time.	This could create a differentiated green aluminium market and be targeted at sub-sectors with highest WtP (e.g. automotive). However, it may backfire by incentivising material substitution.	High	Deep dive	
Embodied Carbon Limits for Basic Products	This could be applied to all aluminium produced in a given jurisdiction.	Given such a standard would apply across a sector, it will be challenging to set aggressive carbon limit reduction rates before 2030.	Medium		
Embodied Carbon Limits on End Products	Product standards would likely be needed across several products (which may be more feasible for specific sectors than others).	Depending on the product, aluminium may make up a significant share of embodied carbon. The policy may drive material substitution instead of driving green aluminium demand.	High	Deep dive	RE2020
Green Public Procurement	Given the low share of aluminium usage in buildings relative to concrete/steel, demand coverage for aluminium is more moderate.	This may not successfully drive demand for aluminium as other materials (e.g. cement/concrete) make up a much larger share of emissions.	Medium		
State-Backed Intermediaries²	This could effectively cover 100% of the aluminium market or be applied at the sector level (e.g. automotive).	This could be an efficient method of reducing green premium, with competitive mechanisms in place.	Medium		
Carbon Pricing	This could be applied at an economy wide level to create an effective pool of demand, but it will likely need to be coupled with other measures to avoid carbon leakage.	Carbon prices of ~\$100/t CO ₂ are expected to support driving aluminium decarbonisation.	High	Deep dive	EU ETS
Demand-Side Subsidies & Tax Credits	This could be applied at an economy wide level but is constrained by public finances made available.	This reduces the green premium, but a key drawback is the uncertainty over longevity of subsidy instruments.	Medium		
In-Kind Incentives	The consumers for aluminium comprise several, relatively fragmented sectors, making it complex to develop sector specific in-kind incentives to cover all aluminium market.	This does not cover the green premium through monetary means but compensates through other in-kind benefits.	Low		

1: based on rating assessment on demand coverage and impact on business case and overall qualitative assessment based on current policy landscape

2: in theory could also be a blended finance measure

Cement & Concrete: green demand creation potential of government policies

Government policies	Demand coverage (rating and rationale)	Impact on business case (rating and rationale)	Demand creation potential ¹	Deep dive included	Case study
Mandatory Quotas	This could cover up to 100% of cement/concrete use in a given region (and would become more stringent over time). It would likely start as a small share and increase over time.	This could create a differentiated market for decarbonised cement (particularly given limited alternatives).	High	Deep dive	
Embodied Carbon Limits for Basic Products	This could be applied to all cement/concrete produced in a given jurisdiction.	Given such a standard would apply across a sector, it will be challenging to set aggressive carbon limit reduction rates before 2030.	Medium		
Embodied Carbon Limits on End Products	This could be applied in the housing and construction sector which accounts for almost all concrete consumption.	Limits are likely to be set on buildings. Since concrete and steel are key contributors to embodied carbon in buildings, limits will likely support a low carbon cement market too.	High	Deep dive	RE2020
Green Public Procurement	The public sector accounts for 40 – 60% of concrete sales.	If emissions thresholds are sufficiently stringent, they can create a market for decarbonised concrete/cement.	High	Deep dive	Canadian policy on green public procurement
State-Backed Intermediaries²	Depending on the share of demand from the private sector, this measure may cover a majority of the demand.	This is an efficient method of disbursing subsidies when leveraging competitive mechanisms. It can ensure the minimum amount of funding is paid.	Medium		
Carbon Pricing	This could cover up to 100% of cement/concrete use in a given region and be applied to imports if the materials are subjected to a carbon border tariff.	Carbon prices of approximately \$100-160/t CO2 are expected to substantially support driving several cement decarbonisation levers.	High	Deep dive	EU ETS
Demand-Side Subsidies & Tax Credits	This could be applied at an economy wide level, constrained by public finances made available.	This reduces the green premium between green and conventional inputs, but a key drawback is the uncertainty over longevity of subsidy instruments.	Medium	Deep dive	CCFD
In-Kind Incentives	This could be applied to all cement/concrete used in an economy.	This does not cover the green premium through monetary means, but compensates through other in-kind benefits.	Low	Deep dive	Priority Green

1: based on rating assessment on demand coverage and impact on business case and overall qualitative assessment based on current policy landscape

2: in theory could also be a blended finance measure

Iron & Steel: green demand creation potential of government policies

Government policies	Demand coverage (rating and rationale)	Impact on business case (rating and rationale)	Demand creation potential ¹	Deep dive included	Case study
Mandatory Quotas	This could either be set at a sector wide basis or set at sub-sector level (e.g. automotive). It would likely start as a small share and increase over time.	This can create a differentiated market for steel and targeted at sub-sectors with the highest WtP (e.g. automotive). However, it may backfire by incentivising material substitution instead.	High	Deep dive	
Embodied Carbon Limits for Basic Products	This could be applied to all iron/steel produced in a given jurisdiction.	Challenges include setting aggressive carbon intensity reduction rates across a sector before 2030.	Medium		
Embodied Carbon Limits on End Products	This may be difficult to create for specific products but could be possible in some sectors (e.g. automotive).	Given that steel is a key contributor to embodied carbon in construction and automotive, carbon limits can enable a green steel market. Some sectors may prefer recycled steel.	High	Deep dive	RE2020
Green Public Procurement	Public procurement of steel accounts for approximately 25% of demand (with a much higher share in some countries, e.g. India).	If emissions thresholds are sufficiently stringent, GPP can create a market for decarbonised steel. Many projects may involve a large share of recycled steel.	High	Deep dive	Canadian policy on green public procurement
State-Backed Intermediaries²	This could theoretically scale to cover all private sector supply and demand, but it is limited by government funding and risk appetite.	This is an efficient method of reducing green premium as it uses competitive mechanisms.	Medium		
Carbon Pricing	This could be set on an economy wide basis and applied to imports and exports alike if steel were subject to a carbon border tariff.	Carbon prices of approximately \$100-200/t with sufficiently low H ₂ /CCUS costs (e.g. \$2-3/kg) and a modest increase thereafter could make virgin green steel affordable.	High	Deep dive	EU ETS
Demand-Side Subsidies & Tax Credits	This could be applied at an economy wide level but constrained by public finances made available.	This reduces up to 100% of the green premium between green and conventional inputs. A key drawback is uncertainty over longevity of subsidy instruments.	Medium	Deep dive	CCFD
In-Kind Incentives	This could be applied at a sector or sub-sector level as incentives typically differ between sectors.	This does not bridge the green premium from a financial perspective but compensates through non-monetary benefits.	Low	Deep dive	Priority Green

1: based on rating assessment on demand coverage and impact on business case and overall qualitative assessment based on current policy landscape

2: in theory could also be a blended finance measure

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Annex 3: Glossary

Key terms

Binder

A material, such as ordinary Portland cement, used in cement production that binds materials together through a chemical process to create a hardened, cohesive structure.

Carbon leakage

The increase in greenhouse gas emissions in one country as a result of government policies in another country that lead to the relocation of production to regions with less stringent environmental regulations.

E-fuels

E-fuels are synthetic fuels such as e-methane and e-methanol that serve as alternatives to fossil fuels and can be used in heavy transport sectors such as aviation and maritime.

Efficiency of Use

Reducing emissions through increasing energy efficiency by improving operational practices.

Embodied carbon

The amount of GHG emissions associated with upstream (extraction, production, transport, and manufacturing) stages of a product’s life, as well as its end of life.

Environmental Product Declaration (EPD)

A standardised document that details the life-cycle environmental impact of a product. Other examples of similar documents exist.

Emissions Trading System (ETS)

A “cap and trade” system where an emissions cap is imposed by government on given sectors, actors within scope are allowed to trade emissions credits to meet the cap.

Final Investment Decision

The commitment to allocate capital resources to a project and move from the planning stages to the execution phase (including construction and operations).

Feedstock

The raw materials used to produce materials or fuels.

Fugitive emissions

Fugitive emissions are greenhouse gas emissions that arise from leaks and other irregular releases, usually associated with industry and fossil fuel extraction.

Green premium

The cost difference between lower carbon materials/fuels compared to less environmentally friendly alternatives that are typically made using fossil fuels.

Greenhouse Gas (GHG)

Greenhouse gas (GHG), which can include carbon dioxide, nitrous oxide, methane, are gases that trap heat in the Earth’s atmosphere, contributing to climate change.

Grey materials or fuels

Materials or fuels that are produced with the use of fossil fuels.

Key terms

Hydrogen-based direct reduced iron (H₂-DRI)
H2-DRI is a low-carbon iron produced using iron obtained by removing oxygen from iron ore using low-carbon hydrogen and carbon monoxide.

Life Cycle Assessment (LCA)
Climate mitigation and adaptation plans submitted by national governments under the Paris Agreement.

Mechanical vapor recompression (MVR)
An energy recovery process that uses electricity to power mechanical compression to recycle waste heat from industrial processes, such as aluminium making, and improve energy efficiency and reduce the environmental impact.

Nationally Determined Contributions (NDCs)
Climate mitigation and adaptation plans submitted by national governments under the Paris Agreement.

Power-to-Liquid (PtL)
PtL is a process for producing synthetic fuels by using renewable energy, water and carbon dioxide. These fuels can be used in combustion engines used in transport vehicles such as airplanes, ships, trucks, etc.

Scope 1 emissions
The greenhouse gas emissions that are directly produced and emitted by a company from operational processes that it controls.

Scope 2 emissions
The greenhouse gas emissions associated with the energy or electricity used by a company and supplied by a utility provider.

Supplementary Cementitious Materials (SCMs)
SCMs are byproducts or natural materials that are used with portland cement to create concrete. They improve concrete properties while reducing the amount of portland cement required in the cement mixture.

Strike Price
A reference price that is calculated based on the differences in cost and CO2 emissions between green materials/fuels and their fossil fuel-based alternative.

Scalable zero-emission fuels (SZEf)
SZEfS are fuels such as green methanol and green ammonia that can be produced in large quantities whilst generating little to no GHG emissions. They can replace fossil fuels in transport sectors, especially maritime.

Technology Agnostic
This is an attribute of a policy that targets a specific material/fuel, regardless of the technology or pathway in which it was produced.

Virgin Steel
Steel that is produced using new raw materials such as iron ore, as opposed to recycled materials.

Willingness to pay (WtP)
WtP is the highest price that customers can afford and are willing to pay for a good or service.