Demand Stimulation Policy Playbook

Working draft for review – October, 2024

ITA
INDUSTRIAL TRANSITION ACCELERATOR

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Introduction

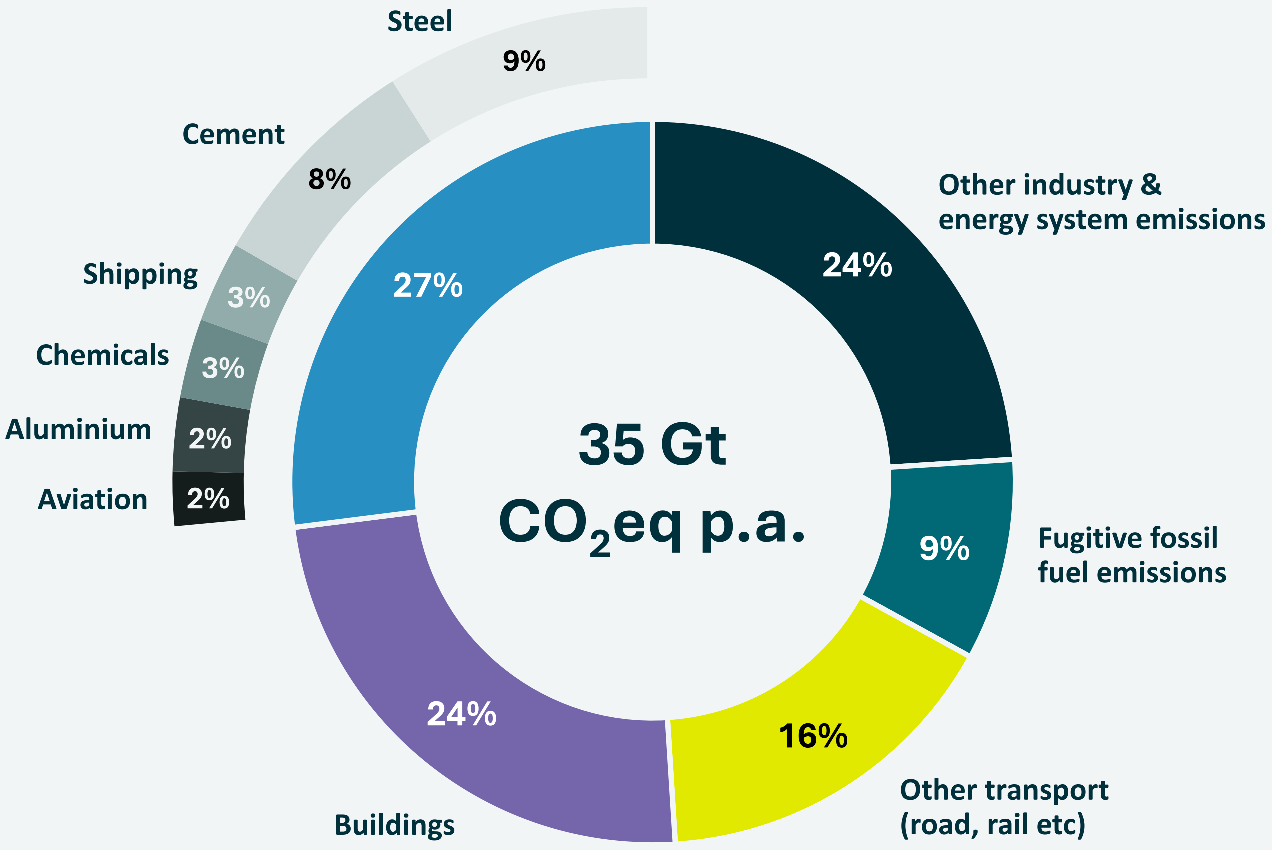
Motivation and use

- The ITA is developing this demand stimulation playbook in collaboration with organisations represented on its Leadership Council, other non-state actors and real economy players (companies involved in the relevant value chains).
- It is intended to provide:
  - **A. A set of policy options,** highlighting particularly critical measures, that can be used by regional, national and subnational governments to stimulate demand for near zero emissions goods and services across the sectors that the ITA focuses on: heavy industry (aluminium, cement/concrete, chemicals, iron/steel) and transportation (aviation, shipping).
  - **B. A mapping** showing key examples of implementation to date from diverse economies across the world.
  - **C. Deep dives and 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 much more detailed studies and organisations that can assist in implementation of key policies.
- As set out in MPP's Sector Transition Strategies, the full range of actors have an important role to play in the transition, and supply-side and market enabling government policies also have a critical role to play. This work focuses on the need for governments to accelerate the introduction of demand stimulating policies to unlock the next wave of investments in large commercial scale industrial projects.
- The guidance is intended to inform and support domestic policy making processes. This report should be used as an introduction and signposting to key policy levers, where possible we have highlighted organisations and initiatives that can support implementation. All government policies should be underpinned by detailed impact assessments and stakeholder consultation.
- Furthermore, the implementation examples we intend to include in this document do not represent a full endorsement of these Governments' policies. Exerted action from all Governments and stakeholders is needed to close the wide gap between today and a 1.5C pathway in these sectors.

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

Scope 1 & 2 greenhouse gas emissions

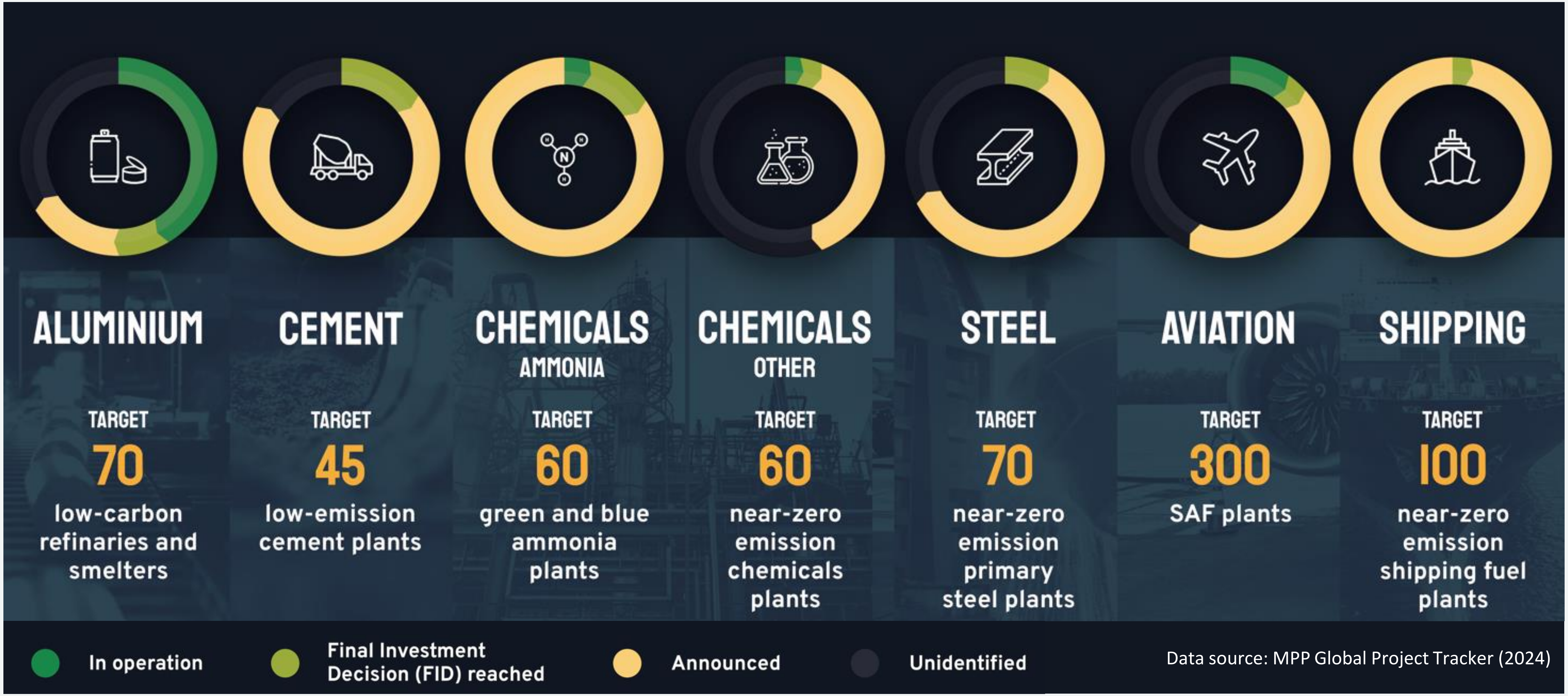
Allocated to energy and industrial sectors in 2020



- Hard to abate sectors are responsible for nearly 30% of global CO2 emissions*
- We are progressing towards a world where scope 3 emissions are under scrutiny and need to be addressed.

Note: Global Scope 1&2 emissions shown with GWP 100 used for non-CO2 emissions.
Sources: IEA (2022), GHG Emissions from Energy; Mission Possible Partnership (2020), *excludes agriculture, forestry and land use emissions

To keep on track to achieve net zero emissions by 2050, some 700 industrial production facilities need to be up and running by 2030



Progress towards this goal is mixed: The pipeline of announced projects has grown tremendously and represents roughly 70% of our 2030 targets, with significant variations between sectors. However, announced projects struggle to reach FID, and we're seeing little progress on this critical indicator.

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… in addition, increased energy and material efficiency, including greater circularity, will also be needed

Energy efficiency
Reduction in average energy use per vehicle

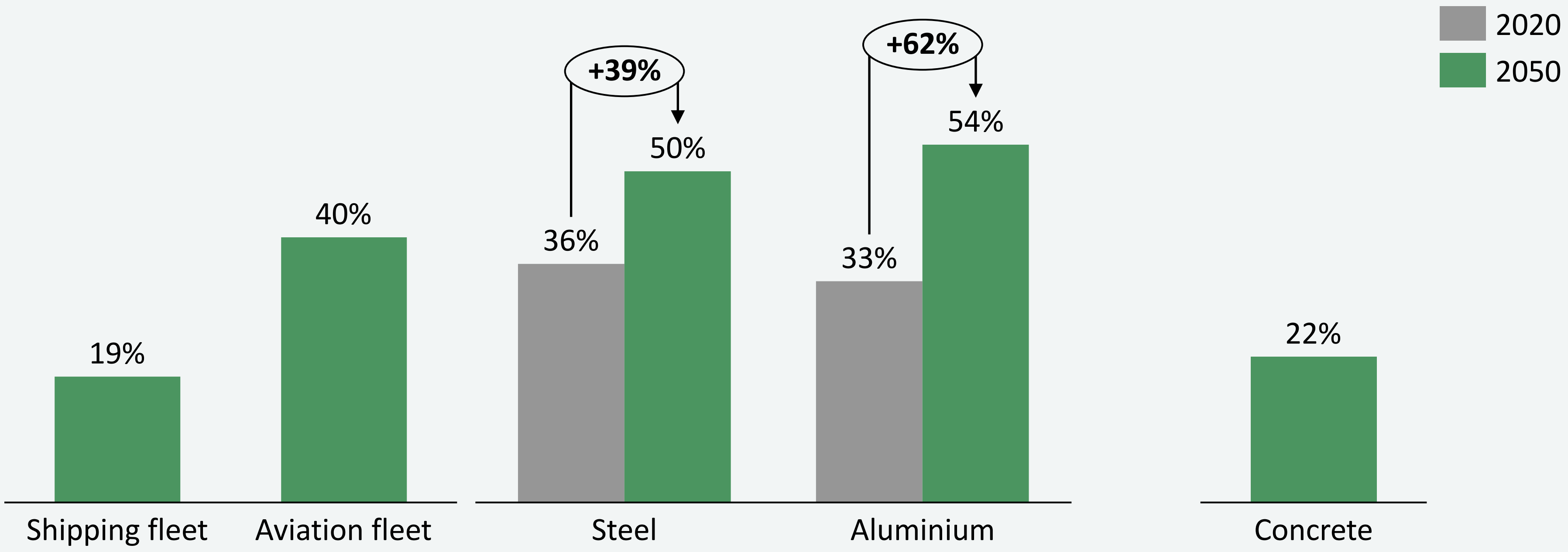
Increased fleet fuel efficiency vs. today

Circularity
Reduced primary demand via increased recycling

Recycled content in final product

Material use efficiency
Reduced demand via lower material input per final product

Increased construction efficiency vs. today



Increasing efficiency has three beneficial impacts:

1) **Lower size of the challenge** by reducing number of assets that require transformation
2) **Decreased investment costs**
3) **Reduced negative impacts** on other planetary boundaries (e.g. microplastics leakage)

Note:
Sources: Mission Possible Partnership Analysis (2023), based on MPP Sector Transition Strategies; IRENA (2021), A pathway to decarbonise the shipping sector by 2050; IMO (2022); Systemiq (2022), Planet Positive Chemicals;

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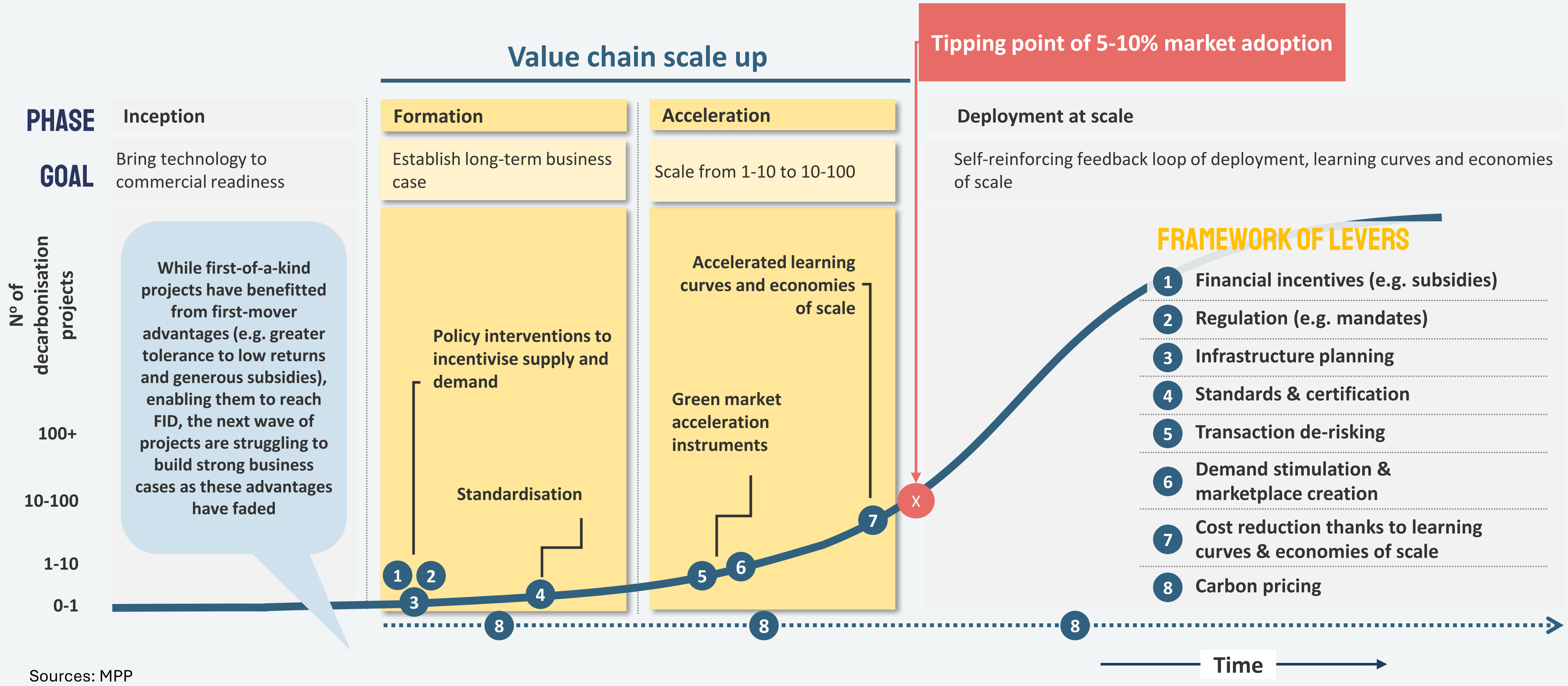
First-of-a-kind projects have benefited from first-mover advantages, but these have faded for the next wave of projects; demand stimulation is key to unlock supply



Sources: MPP

Government policies are required to stimulate and structurally embed higher demand, implemented to complement supply side support and other interventions

Framework of government policies – examples of policies

Demand stimulation

★ Focus of the playbook

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)

Today, there are limited cases of demand stimulating policies in these sectors. Carbon pricing schemes are often limited in application to industry.

Supply stimulation

Examples
- Providing financial support and low interest loans to scale up supply capacity
- Expediting planning and permitting for energy supply
- Prioritising use of and reducing cost of low carbon energy supply for heavy industry

There are important examples of supply-side support emerging (e.g. US Inflation Reduction Act)

Critical enablers

Examples
- Robust standards for low and near-zero emission products are needed to underpin policies. The ITA Standards Map charts the international landscape for six key industrial products / transport fuels.
- Scaling up underpinning energy infrastructure (e.g. power networks, CO_2 and hydrogen transportation)

Research and Development

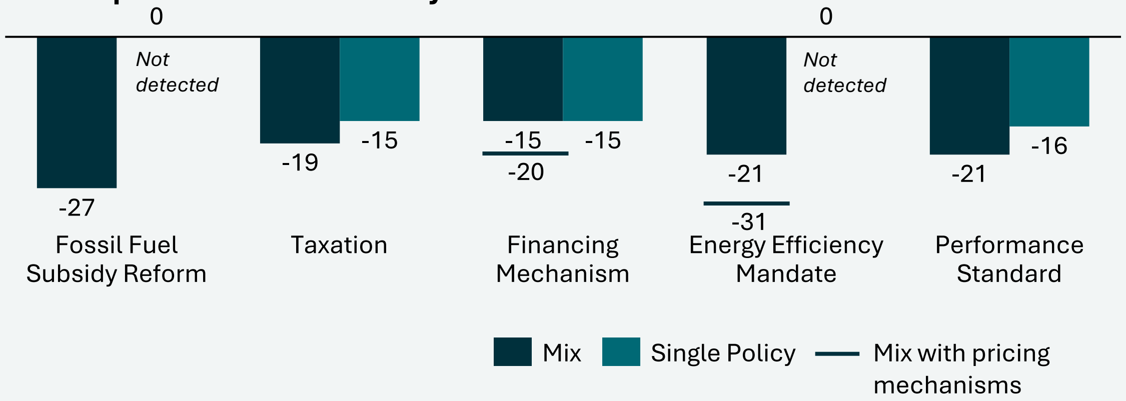
Examples
- Funding early-stage trials and demonstration projects to advance new technologies towards commercial deployments

Many demonstration projects underway for key technologies

Carbon pricing and/or complementary subsidies and regulations have proven to be effective emissions 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, have a larger effect on emissions reductions when combined with other policies, than when implemented alone.
- Furthermore, when non-pricing mechanisms were combined with pricing mechanisms (namely taxation or reduced fossil fuel subsidies), a larger impact is achieved.
- Using a mix of policies have proven to be successful in other sectors, e.g. with zero emission vehicle adoption in California, USA.

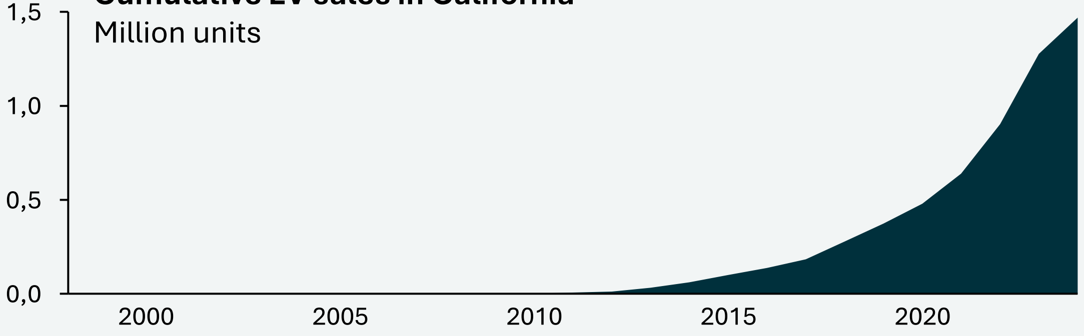
Average effect size (%)[1] on emissions reductions for single policy vs in a mix of policies in the Industry sector



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

- Since 1990, California pioneered a mandate for ZEVs, requiring manufacturers to annually surrender tradable credits gained by selling ZEVs. Manufacturers that generate more credits than needed can sell them to manufacturers with a deficit. The overall % of ZEV (and in practice hybrids) out of total vehicles sold was progressively increased and ranged from 4.5% in 2018 to 22% in 2025. Since the share started low, this had only a small knock-on cost to conventional vehicles. The ZEV mandate was accompanied by state funded rebates to subsidise EV purchases.
- As such, early movers could enter and create an additional revenue stream. Between 2012 - 2017, almost all ZEV credits traded were generated by Tesla and Nissan. The ZEV program 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).

Cumulative EV sales in California
Million units

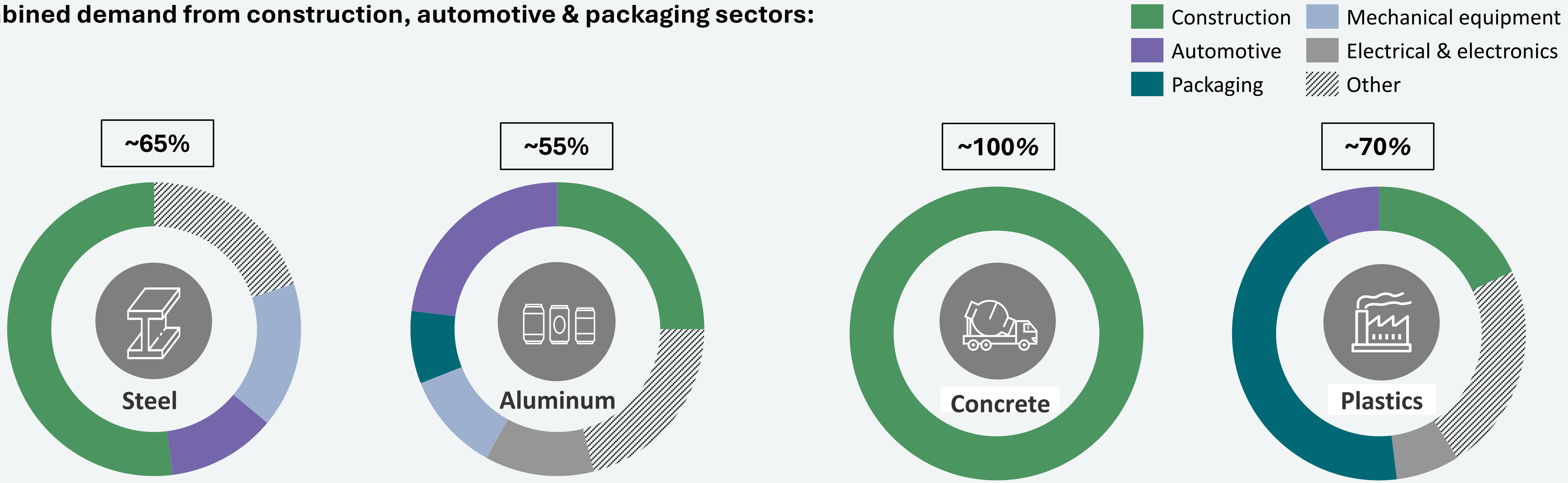


Sources: Stechemesser, A., Koch, N., Mark, E., Dilger, E., Klösel, P., Menicacci, L., Nachtigall, D., Pretis, F., Ritter, N., Schwarz, M., Vossen, H., & Wenzel, A. (2024). Climate policies that achieved major emission reductions: Global evidence from two decades. *Science (New York, N.Y.)*, *385*(6711), 884–892. https://doi.org/10.1126/science.adl6547; Meckling, Jonas & Sterner, Thomas & Wagner, Gernot. (2017). Policy sequencing toward decarbonisation. Nature Energy. 2. 10.1038/s41560-017-0025-8; Columbia Center on Global Energy Policy (2024: Triggering Investment in First of a kind and early near zero emissions industrial facilities 1 – Effect size is a statistical indicator on the strength of a relationship between the policy and significant emission reductions

Policies are highly synergistic across sectors: triggering demand further down in the value chain can drive decarbonisation for multiple upstream sectors

Global market share of end-user industries per material

Combined demand from construction, automotive & packaging sectors:

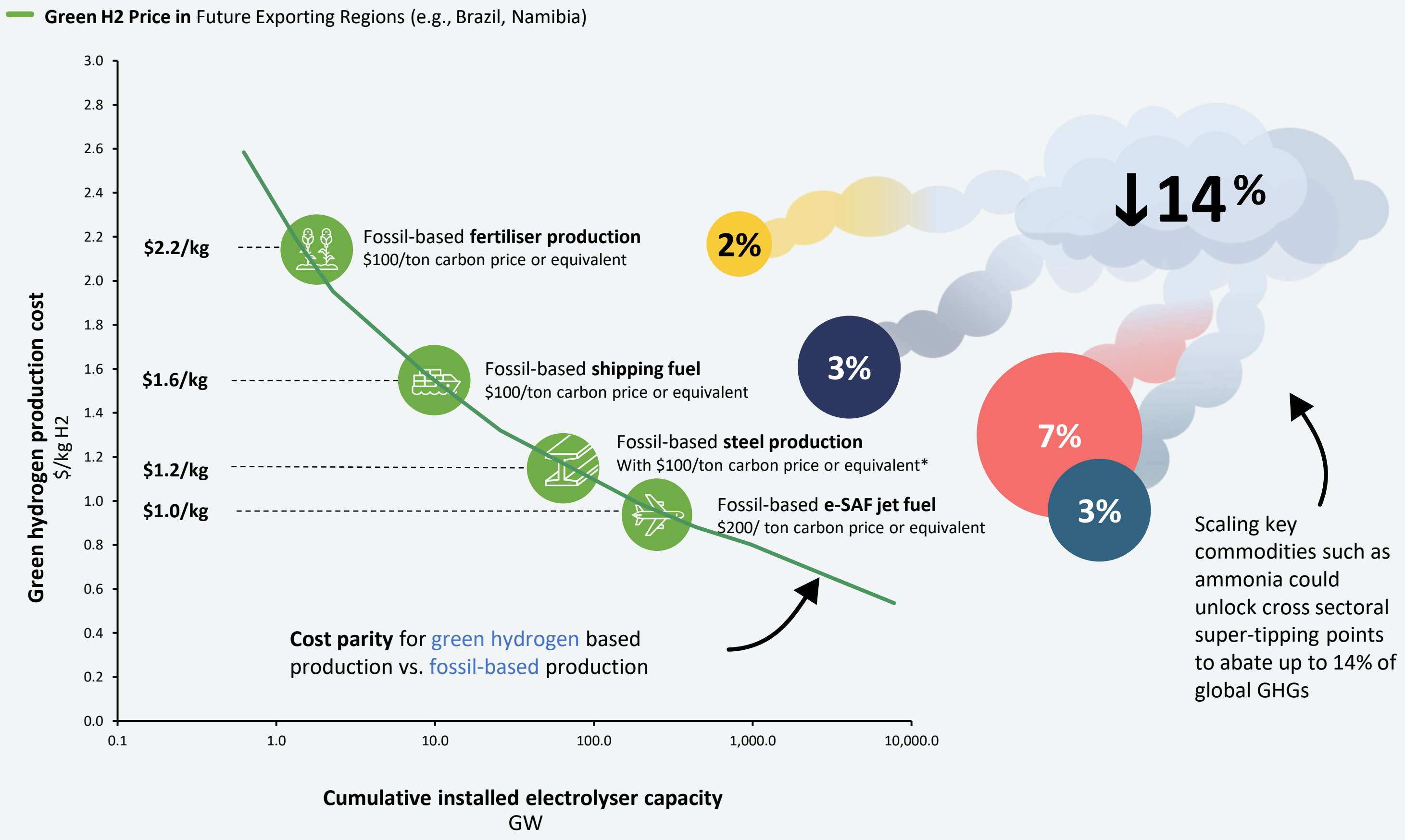


Stimulating demand in downstream sectors, e.g. construction, will simultaneously **drive the production of green materials upstream** across several hard-to-abate sectors (steel, aluminum, plastics and concrete) and reduce the market share of grey materials, thereby triggering decarbonisation

Note: market shares of each sector are approximations, as exact numbers differ per year and sector definition.
Sources: World Steel Association; International Aluminium institute (2022), Opportunities For Aluminium In A Post-Covid Economy; Plastics Europe (2022). Plastics - the Facts 2022; Material Economics (2019), Industrial Transformation 2050; Criteria based on Agora Industry (2024): Creating markets for climate-friendly basic materials. Potentials and policy options

Similarly, driving demand for green commodities in one sector can lead to lower production costs, benefitting other sectors and further stimulating demand

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



- **Driving demand and production for key commodities,** e.g. green ammonia for fertilisers, **will increase economies of scale and reduce production costs of green commodities.**
- **The cost reduction benefits could further stimulate demand in other sectors for green products,** e.g. shipping fuel, synthetic jet fuels, and steel derived via H_2 DRI.

Sources: The Breakthrough Effect, Systemiq (2022)

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Although it is high at specific stages of the value chain, the green premium in most of these sectors is manageable at end product or service level

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

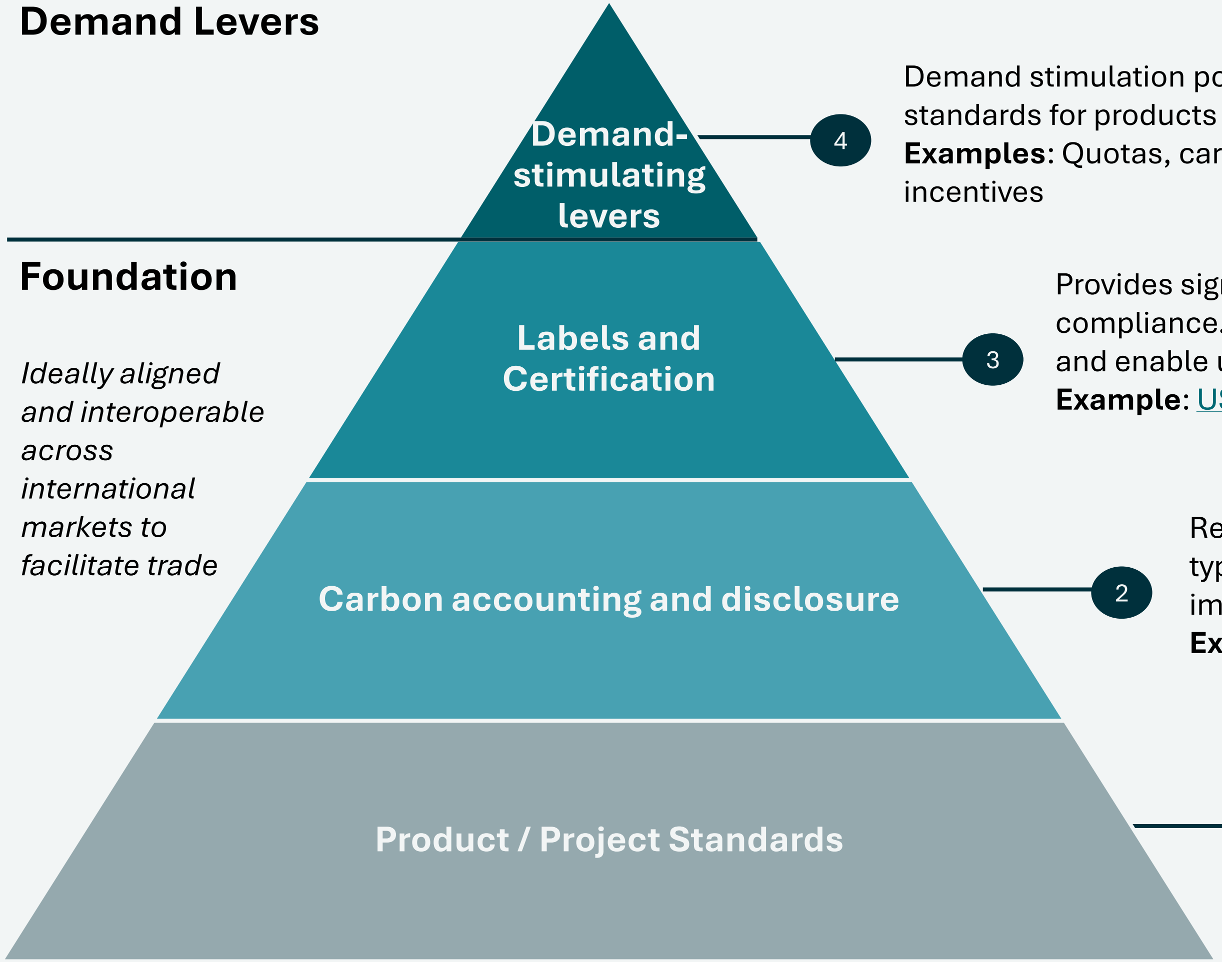
Notes on materials: Premiums are based on estimates of LevelisedCosts of the relevant commodity per production technology without carbon pricing, weighted by the market share of green vs. fossil-based technologies in 2030 to reach net zero by 2050. Upstream premiums are approximations rounded to the nearest 5%. An average car is assumed to weigh 1860 kg and to contain approximately 900kg steel, 180kg aluminium and 180kg plastic. An average washing machine is assumed to weigh 70 kg and to contain approximately 30kg steel, 3 kg aluminium, 4 kg plastic and 25kg concrete. A 2000 square feet house is assumed to weigh 124000 kg and to contain 8000kg steel and require 40,000kg of cement. Notes on fuels chemicals: SAF assumes fuel makes up 25-30% of a ticket price.
Costs are indicative and based on literature estimates. Sources: World Steel Association

02

Overview of Policy Levers

The policies in this document need to be underpinned by a foundation of accounting methodologies, definitions and disclosure

Demand Levers



4. Demand stimulation policy levers are based on eligibility criteria that includes sustainability standards for products
Examples: Quotas, carbon intensity targets, green public procurement, and financial and in-kind incentives

Foundation

Ideally aligned and interoperable across international markets to facilitate trade

3. Provides signals indicating that products meet a standard of environmental quality or compliance. Labels can follow a tiered system according to environmental performance and enable users of products to understand their environmental performance.
Example: US Label Program for Low Embodied Carbon Construction, CertifHy

2. Require the measurement and disclosure of GHG emissions, which are typically based on a whole life / lifecycle or embodied carbon assessment to improve the ability of identifying scope 3 emissions within value chains.
Example: Environmental Product Declaration and ISO 14044

1. Technical specifications or guidelines that set the baseline requirements for products or projects to ensure quality, safety, and environmental performance. Additionally, voluntary standards set higher environmental requirements.
Example: (baseline) ISO 115:2003 or EN 546:2006 for Aluminium, (voluntary) Responsible Steel standards

Based on - 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

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This playbook focusses on 9 demand-stimulation policy categories

These measures are best used in a complementary fashion because they have different key features. Some measures pose a risk of carbon leakage that other measures can help mitigate, some place a burden of cost on government, some provide a long-term, increasing market signal, while others are more impactful in in the near term.

Category	Government policies	Definition	Features: Risk of Carbon Leakage	Features: Burden of cost	Features: Technology agnostic vs specific	Features: Long-term stability	Features: Ability to ramp up over time	Key Function
Government procurement mechanism	Green Public procurement	Public sector procurement of goods and services based on their environmental impact	Low	Government	Agnostic	Long-term	High	Creates a differentiated low / near-zero carbon market
Government procurement mechanism	State backed intermediaries	State-backed entity buys a commodity from private sector producers and sells it on to private sector buyers, absorbing price differential and risk	Low	Government	Some flexibility	Mid-term	Medium	Creates a differentiated low / near-zero carbon market
Mandatory mechanism	Mandatory quotas	Obligating one or more parties in a value chain to procure decarbonised materials or fuels	High	Industry	Specific	Long-term	High	Creates a differentiated low / near-zero carbon market
Mandatory mechanism	Transportation fuel standard programs	Limits on the carbon intensity of fuels used in transportation systems	Low	Industry	Agnostic	Long-term	Medium	Creates a differentiated low / near-zero carbon market
Mandatory mechanism	Embodied carbon limits for basic materials	Limits set on the carbon intensity of input materials or intermediary products	High	Industry	Some flexibility	Long-term	High	Creates a differentiated low / near-zero carbon market
Mandatory mechanism	Embodied carbon limits on end products	Limits set on the carbon intensity of final products, thus lowering their embodied carbon	Low	Industry	Agnostic	Long-term	Medium	Creates a differentiated low / near-zero carbon market
Market based mechanism	Carbon pricing	Imposing a cost on GHG emissions by creating a market for capped emissions allowances or applying an explicit or implicit fixed price on emissions	High	Industry	Agnostic	Long-term	High	Increases fossil costs
Market based mechanism	Demand side subsidies	Providing financial support to make using green fuels and materials cheaper and more competitive	Low	Government	Specific	Short to mid-term	Low - Medium	Makes using low / near-zero products and fuels cheaper, more convenient, and/or less risky
Non-financial incentives	In-kind incentives	Providing non-financial incentives (e.g. expedited permit approvals) to the users of deeply decarbonised materials and services	Low	Government	Specific	Mid-term	High	Makes using low / near-zero products and fuels cheaper, more convenient, and/or less risky

Note: policies are not mutually exclusive, and can often by implemented in a complementary manner, with each other and other levers. List may not be exhaustive.

Different policy levers are better suited critical to different heavy industrial and transportation sectors

Government policies	Aviation Fuel (Transport)	Maritime Fuel (Transport)	Chemicals (Heavy Industry)	Steel (Heavy Industry)	Aluminium (Heavy Industry)	Cement (Heavy Industry)	Examples / case studies
Green public procurement	◐	◐	◐	●	◐	●	US buy clean
State backed intermediaries[2]	●	●	●	◐	◐	◐	H2Global
Mandatory quotas for use of decarbonised materials / fuels	●	●	●	●	●	●	REFUELEU, RED III
Transportation fuel standard programs	◐	🟡 ◐	○	○	○	○	UK RTFO
Embodied carbon limits for basic materials	○	○	◐	◐	◐	◐	No examples identified
Embodied carbon limits on end products	○	○	◐	●	●	●	RE2020
Carbon pricing	🟡 ◐	🟡 ◐	◐	●	●	●	EU ETS + CBAM
Demand side subsidies	●	●	●	◐	◐	◐	CCFDs
In-kind incentives	◐	◐	◐	◐	◐	◐	Priority Green, Seattle

● High priority sub-national / national / regional measure

◐ Sub-national / national / regional measure

○ Limited/no relevance

🟡 Multilateral measure (not a focus of this work)

Government procurement mechanism (Green public procurement; State backed intermediaries)

Mandatory mechanism (Mandatory quotas for use of decarbonised materials / fuels; Transportation fuel standard programs; Embodied carbon limits for basic materials; Embodied carbon limits on end products)

Market based mechanism (Carbon pricing; Demand side subsidies)

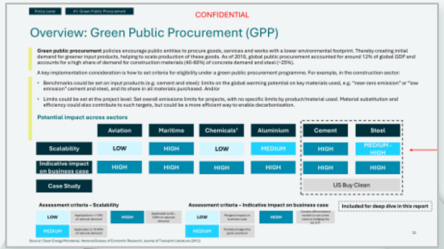
Non-financial incentives (In-kind incentives)

1 – Focussing on ammonia (particularly for fertilisers) and methanol

2 - Alternatively, these could also be based on a blended finance model with a mix of public and private funds

Using this playbook

The following chapters in the playbook describe each policy lever in detail. Each chapter contains a consistent sequence of slides:



1

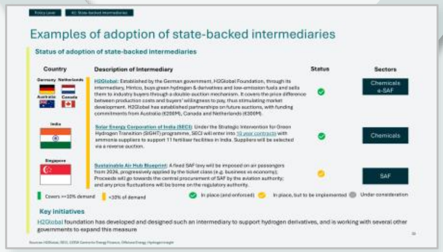
Overview descriptions of each lever, with an indicative assessment of applicability for given sectors

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



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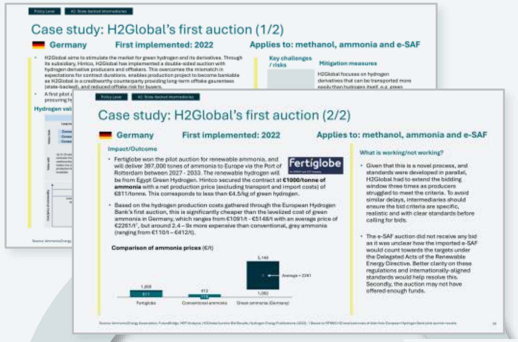
Identified **examples** of uptake from across the world



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Case studies of implementation

3.1

Green Public Procurement (GPP)

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Overview: Green Public Procurement (GPP)

Green public procurement policies encourage public entities to procure goods, services and 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 ~25% for steel. This creates huge potential for GPP of green building materials. In the transport sector, the majority of the world's major ports and many airports are publicly owned (though government demand for aviation/shipping services is a much lower share) providing opportunities to support the development of enabling infrastructure via GPP. Some countries have large state owned fertilizer companies that could procure or produce green ammonia as a chemical feedstock.

Priority for implementation by sector

We have developed an indicative prioritisation of each policy lever 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/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 demand.

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	Medium	Medium	Medium	Medium	High	High

Included for deep dive in this report

Sources: Mission Possible Partnership, World Resources Institute, OECD, Aviation Learnings, Bloomberg NEF

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Key Features: Green Public Procurement

Carbon leakage risk

Low | Medium | High

Public procurement policies are typically accompanied by a set of product or project requirements that would determine eligibility. There is 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.

Burden of cost

Government | Shared | Industry

As some low/near-zero carbon products and services are more costly than their grey substitutes, the burden of cost falls on the government to increase spending in order to afford these products.

Technology Agnostic

Specific | Some flexibility | 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 emissions 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.

Long term stability

3-5 yrs | 5 – 15 yrs | 20 – 30 yrs

GPP policies are dependent on public funding, but have shown longevity as instruments (e.g. over 10 years). For example Japan's Act on Promoting Green Purchasing was first established in 2001 and remains in force today.

Ability to ramp up over time

Low | Medium | High

GPP policies can be reviewed over time and be made more stringent as the cost and availability of low and near-zero products and services become more available.

Complexity

Low | Medium | High

To ensure the success of these policies, governments need to ensure there is adequate funding to procure green materials, and that a strong foundation of standards, emissions accounting methodologies and certification is in place. Furthermore, responsibility for decarbonisation and procurement is often split across different departments and bodies requiring coordination.

Sources: World Bank , WRI , Japan Ministry of the Environment

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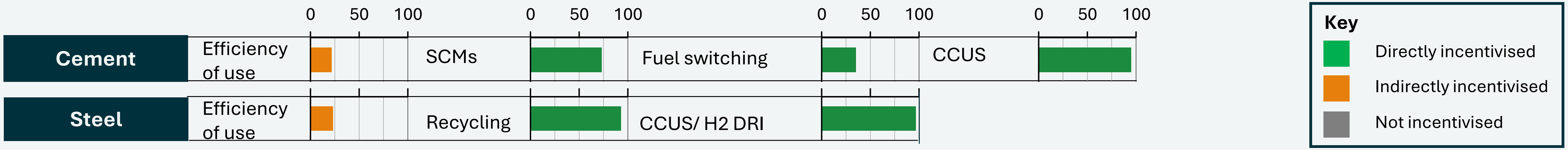
Government procurement mechanism

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

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



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 mainstreamed 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).
- **Scope of emissions included:** ideally, GPP programs should consider emissions over 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 the overall resilience of the project when evaluating a project's carbon footprint. This avoids the risks of increasing emissions inadvertently (e.g. via inappropriate material substitutions).
- **Eligibility criteria** is a key design feature. Benchmarks could be set on basic materials (e.g. cement and steel): limits on the global warming potential on key materials used, e.g. "near-zero emission" or "low emission" cement and steel. And/or Limits could be set at the project level, with overall emissions limits for projects, with no specific limits by product/material used.
- **Financial cost to the government**: Green materials are expected to command a premium. Hence, the government must allocate extra budget to finance GPP programmes, to incentivise future job growth and the creation of new industries.
- **Implementation over time**: GPP programmes can be gradually phased in. Initially beginning with 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 green products targeted, or increasing the scope of materials, projects and 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 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 more impact in countries where public procurement accounts for a larger share of demand, which is often the case in developing and emerging economies.

Sources: BloombergNEF, Stockholm Environment Institute, European Commission, Breakthrough Energy, Rocky Mountain Institute, WEF, Sustainability by Numbers, GCCA EPD tool

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Government procurement mechanism

Implementation examples of GPP programmes

Key examples of policies adopted by countries

Jurisdiction	Description of GPP Policy	Status	Sectors
USA	**Federal Buy Clean Initiative**: Promotes the use of low-carbon steel, concrete, asphalt and flat glass, which comprises 98% of purchased construction materials[1].	In place (and enforced)	Steel, Cement
Netherlands	**Sustainable Public Procurement**: Mapped out criteria database to measure the environmental impact of projects, one of which is low CO2 impact materials for construction. However, more detailed standards are yet to be published.	In place, but to be implemented	Steel, Cement
Canada	**Policy on Green Procurement**: which it requires disclosing and reducing the carbon footprint of materials in major construction projects. This sets limits e.g. that 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.	In place (and enforced)	Cement

Several other countries have or are developing relevant GPP programs, including UK, Germany, Japan, Sweden, China, Saudi Arabia, and the UAE[2]. India is exploring a potential GPP programme including steel and cement.

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Examples of key enabling initiatives / detailed studies

- The Industrial Deep Decarbonisation Initiative: 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 pledge and has developed Green Public Procurement guidelines that can assist governments in setting bold objectives for purchasing low-carbon materials for construction projects.

Sources: SECI, CEEW Centre for Energy Finance, US Government website

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Government procurement mechanism

Case study: Federal Buy Clean Initiative (1/2)

United States

Adopted: 2023

Summary

The Federal Buy Clean Initiative aims to reduce the carbon footprint of federal construction projects by prioritising procurement of low-carbon construction materials (focusing on steel, cement/concrete, asphalt and flat glass). To support this, the Inflation Reduction Act (IRA) makes $2.15bn available for public procurement of low embodied carbon building materials in specific projects. It sets limits for the procurement of basic materials (rather than at project level), requiring suppliers to verify these through EPDs.

Government construction value chain

Stakeholders impacted

Material manufacturers: Required to obtain EPDs for material products sold to federal projects; incentivised to produce low/near-zero carbon materials to meet federal procurement requirements.

Developers/contractors: Perform construction / installation using low carbon materials

Product manufacturers → Procurement → Developers/contractors

Project owners/developers, procurement officers: Develop tender requirements and evaluate proposals in accordance with Buy Clean (and/or other state level programmes) criteria, e.g. embodied carbon levels

Directly Impacted
Indirectly Impacted

Impact

- A 6-month pilot launch of lower embodied carbon construction material requirements in US General Services Administration has been concluded. This piloted the limits for use of procurement of building materials in 11 construction projects. Following the pilot, the programme has expanded to over 150 federal projects.
- Over 17,000 new EPDs across concrete, asphalt, steel and glass have been made since the programme started, including a 15% increase in the total number of relevant EPDs in North America relating to concrete. This indicates increasing readiness to meet market demands for lower-carbon products.
- Since its inception, many states and agencies have developed their internal programmes, in line with the Buy Clean Initiative, such as California Buy Clean Act, Buy Clean Oregon Act, Department of Transportation's Lower Carbon Procurement Pilot.
- When implemented at large scale, green public procurement could result in very significant emissions reductions. Based on a study by Global Efficiency Intelligence, the annual estimated impact of reducing the overall emissions intensity of public cement and steel procurement in the US by 10% compared to the industry average 5.6 $MtCO_2$ and 28$MtCO_2$/yr based on a 50% reduction. Factoring in spillover effects into the private sector, the reductions could double for cement and increase five-fold for steel.

Sources: One Click LCA, American Economic Association, Clean Energy Canada, Third Way, Global Efficiency Intelligence

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Case study: Federal Buy Clean Initiative (2/2)

Key challenges/risks

Lack of product standards data	• Buy Clean has been implemented in stages, focusing first on increasing the use of EPDs by material producers, implementing pilots and allowing government to gauge appropriate limits by gathering data on products in the market.
Complexities in managing breadth of scope	• Public construction projects use a wide variety of materials, each with varying, emerging definitions of "low-carbon". To manage the scope, the initial scope focused on a few materials. They also piloted the requirements within a limited number of projects before expanding them more widely.
Limits alone only encourage innovation to a certain degree	• Although embodied carbon caps are effective in encouraging the production of lower carbon products, once products meet the threshold, there is little incentive for manufacturers to keep innovating and lowering the embodied carbon in products. Limits can be complemented with incentives like improved scores in bidding processes or allocating budget for the top 10% lowest carbon products to incentivise innovation. Such options are being considered after the trial.
Administrative barriers to small businesses	• Small businesses that lack the manpower and resources to develop EPDs or switch production to lower carbon materials may become redundant in the market. Hence, the EPA has made available $160 million of grants to support businesses to develop EPDs.
Product vs project level approach	• Buy Clean focuses on emissions limits on materials, which helps to reduce the emissions associated with cement and steel production. However, it does not directly incentivise other decarbonisation levers such as more efficient use of materials across the life-cycle of projects, nor increasing the lifetime/resiliency of projects. Considering whole life carbon emissions would allow incorporation of these factors.

Source: industrial Deep Decarbonisation, One Click LCA, US Government Website, American Economic Association, Clean Energy Canada, Third Way, US Environmental Protection Agency

3.2

State-backed Intermediaries

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Overview: State-backed Intermediaries

State-backed intermediaries 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 off-takers and intermediaries. 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 premia (e.g. of ~300% relative to a grey product), e.g. Ammonia and Methanol, but has proven more challenging when applied to earlier stage green commodities with a higher green premium (e.g. synthetic kerosene at ~700-800%).

There are several choices that can be made when designing a state backed intermediary: the commodities in scope and the stage of the value chain to focus on; where can 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).

Priority for implementation by sector

We have developed an indicative prioritisation of this policy lever by sector, based on the share of demand this lever 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. Based on this analysis, state backed intermediaries have been assessed as particularly impactful for heavy transportation fuels and chemical feedstocks.

Sector	Aviation Fuel	Maritime Fuel	Chemicals	Aluminium	Cement	Steel
Prioritisation	High	High	High	Medium	Low	Medium

Included for deep dive in this report

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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, thereby reducing the risk of carbon leakage associated with their use.

Burden of cost

The burden of risk and cost falls on the intermediary, and hence the state that supports the intermediary. 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.

Technology Agnostic

State-backed intermediaries could either focus on one or a few critical products. For example, Hintco, focuses on clean hydrogen and its derivatives.

Long term stability

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

Ability to ramp up over time

The ability to scale up the use of an intermediary is constrained by the overall money made available and risk-reward assessed by governments. Over time, state backed intermediaries may become less necessary as decarbonized options become more competitive

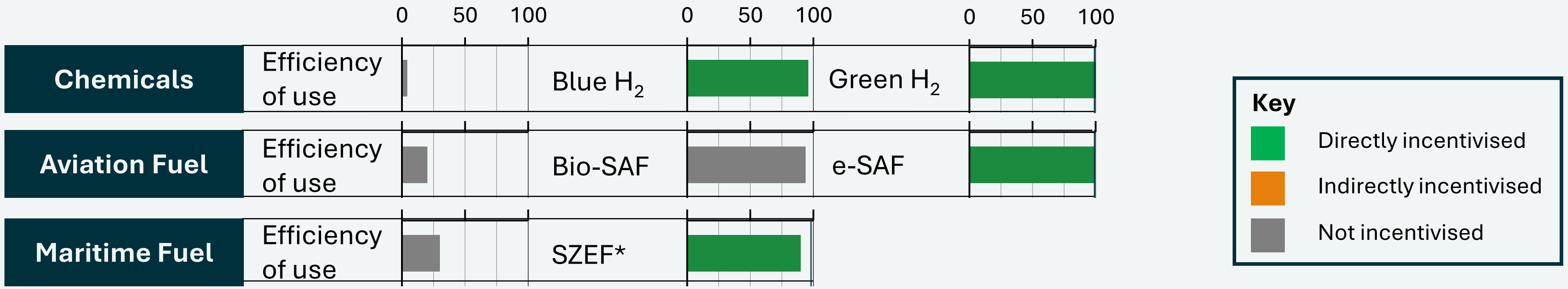
Complexity

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

Deep Dive – State-backed intermediaries for H_2 derivatives

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



Key considerations

- **Value for money**: in order 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, it is likely that a large amount of funding is needed. One example is a two-sided auction, where one auction is conducted with the producer to select the most competitive bid. A separate auction is conducted for buyers who then procures the commodity from the intermediary. Consequently, the intermediary bridges the price gap between the producer and buyer.
- **Price discovery:** over time, the intermediary can gather and where appropriate 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 to the extent possible while ensuring that the high ambition of decarbonisation is achieve.
- **Availability of infrastructure**: where potential suppliers and off-takers 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. In order to ensure specific sectors are incentivised,
- **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 concessional finance will be required to support the state backed 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 off-take risks from projects, intermediaries could be used to support projects in other countries (for example, H2Global supports the production and import of hydrogen derivatives from outside the EU into the EU).

SZEF = scalable zero emission shipping fuel and includes zero/near-zero emissions methanol and ammonia

Sources: H2Global, SECI, CEEW Centre for Energy Finance

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Government procurement mechanism

Implementation examples of state-backed intermediaries

Status of adoption of state-backed intermediaries

Country	Description of Intermediary	Status	Sectors
Germany, Netherlands, Australia, Canada	H2Global: Established by the German government, H2Global Foundation, through its intermediary, Hintco, buys green hydrogen & derivatives and low-emission fuels and sells them to industry buyers through a double-auction mechanism. It covers the price difference between production costs and buyers' willingness to pay, thus stimulating market development. H2Global has established partnerships on future auctions, with funding commitments from Australia (€200M), Canada and Netherlands (€300M).	In place (and enforced)	Maritime, Chemicals, Aviation
India	Solar Energy Corporation of India (SECI): Under the Strategic Intervention for Green Hydrogen Transition (SIGHT) programme, SECI is entering into long-term contracts with suppliers of green hydrogen and derivatives, selected via a reverse auction mechanism where the lowest offer price wins. The agency will also call for bids for the procurement of the chemicals.	In place (and enforced)	Chemicals
Singapore	Sustainable Air Hub Blueprint: A fixed SAF levy will be imposed on air passengers from 2026, progressively applied by the ticket class (e.g. business vs 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.	In place, but to be implemented	Aviation

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Under consideration

Examples of key enabling initiatives / detailed studies

- H2Global foundation has developed and designed such an intermediary to support hydrogen derivatives, and is working with several other governments to expand this measure.

Sources: CEEW Centre for Energy Finance, Offshore Energy, Hydrogen Insight

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Government procurement mechanism

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

Germany First implemented: 2022 Applies to: e-methanol, e-ammonia & 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 the mismatch in expectations for contract durations, and enables production projects to become bankable, as H2Global is a creditworthy counterparty providing long-term offtake guarantees (state-backed), and reduced offtake risk for buyers.

A first pilot auction has taken place, with results announced in 2024. This focussed on procuring hydrogen derivatives from outside of the EU and importing them into the EU.

Hydrogen value chain - Stakeholders impacted

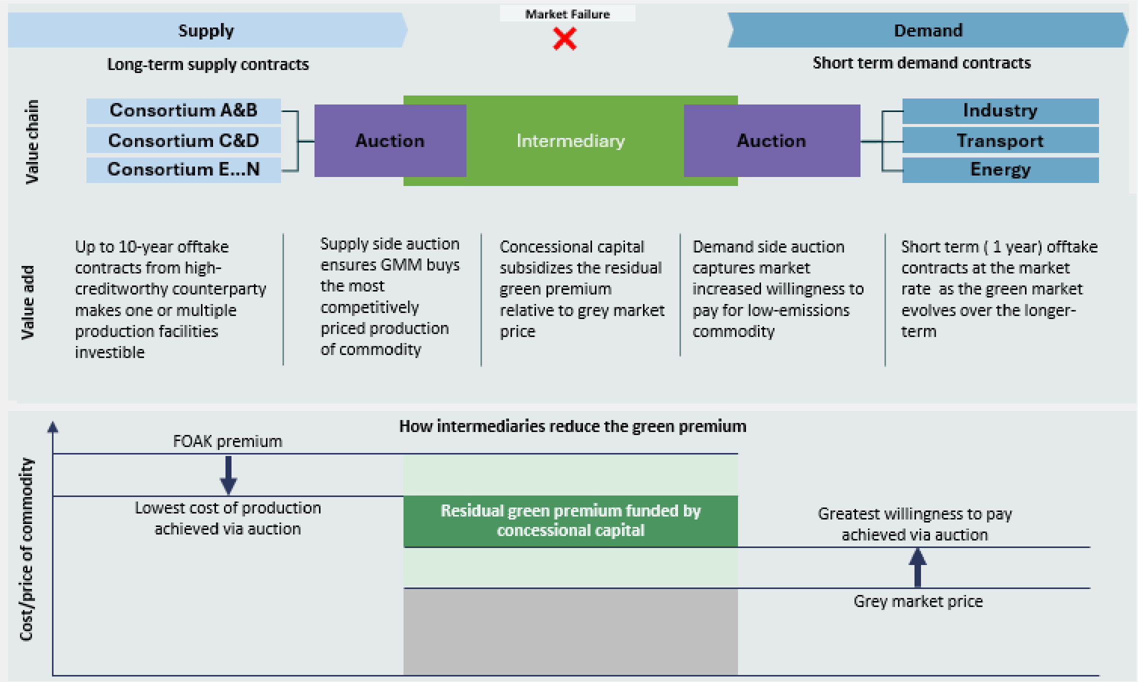
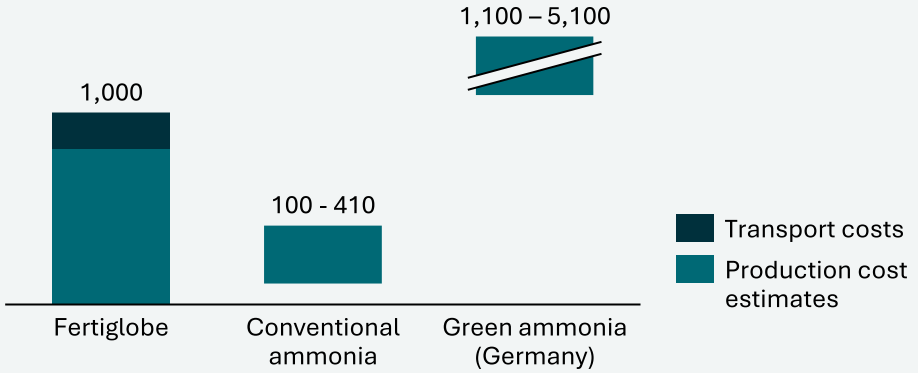


Figure adapted from MPP: Unleashing Market Forces to Scale Green Industry (2024)

Impact

- Fertiglobe won the pilot auction for renewable ammonia and will deliver 397,000 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 from the European Hydrogen Bank's first auction, this is significantly cheaper than the estimated levelized cost of green ammonia in Germany, ranging from €1100/t - €5100/t with an average price of €2300/t, but much more expensive than conventional, grey ammonia (ranging from €110/t – €410/t depending on geography).

Comparison of ammonia prices (€/t)



Source: Ammonia Energy Association: H2Global quadruples funding for low-carbon hydrogen and derivatives (2023) , Future Bridge – Green Ammonia – an Alternative Fuel, MPP Analysis, Hydrogen Energy Publications (2022)

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

Key challenges/risks

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. Access to port infrastructure has been a challenge for some bidders. Ultimately, all but one supplier proposed to import derivatives though the same port (Rotterdam) suggesting potential limitations on infrastructure elsewhere. Hintco will try to address this through the contractual arrangements to facilitate transport.
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 that future bidders / industry players can rely on to make business decisions.
Complexity of compliance requirements	• Overall, the auction process took 2 years to conclude, and required compliance with extensive sustainability criteria, including meeting the EU's green hydrogen definitions, but also protection of arid regions, sustainable land use, and others.
Difficulty securing e-SAF bids	• The pilot e-SAF auction did not result in final offers from bidders, which has been attributed to two reasons: ○ **Regulatory uncertainty**: Ambiguity and nuances regarding whether/how the imported e-SAF would count towards the targets set under the EU's hydrogen targets. ○ **Contract value:** given the high cost and project development timescales for e-SAF production.

Source: ammonia energy association, H2Global

3.3
Mandatory Quotas

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Mandatory mechanism

Overview: Mandatory quotas

Mandatory quotas are binding targets set on industry requiring a specified uptake of low and near zero carbon commodities, thereby increasing demand. They can start relatively low and ramp up over time as low / near zero carbon options scale and become cheaper. Quotas can be set as a percentage of total consumption of the commodity (%), or by volume (e.g. Mt). These measures have been applied successfully 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-fueled domestic flights by 2030. Bans could be implemented following a progressive tightening of mandatory quotas on green products, giving the industry time to adapt to the new requirements.

At least initially, it is likely to be challenging for all stakeholders effected 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 important 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 could be issued. The regulator overseeing the quota would define a compliance window, at the end of which companies would need to surrender a corresponding number of certificates to their overall consumption or pay a fine for non-compliance and/or a buyout. This would allow companies that use a surplus of low carbon or near zero carbon commodities to monetize this by trading certificates with companies that fall short.

Priority for implementation by sector

We have developed an indicative prioritisation of this policy lever 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. Based on these criteria, quotas are deemed as a high priority lever across all sectors.

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	High	High	High	High	High	High

Included for deep dive in this report

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Mandatory mechanism

Key Attributes: Mandatory quotas

Carbon leakage risk

Low | Medium | High

International transport and heavy industry are subject to global competition. In the transport sector, risks include tankering for aviation[1] and relocation of trips or stop overs to ports/ airports outside of the mandate's reach. For materials, value chains could shift to regions with less stringent regulations. Complementary measures would be needed to avoid these risks.

Burden of cost

Government | Shared | Industry

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.

Technology Agnostic

Specific | Some flexibility | Agnostic

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

Long term stability

3-5 yrs | 5 – 15 yrs | 20 – 30 yrs

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

Ability to ramp up over time

Low | Medium | High

The mandated percentage or volume of decarbonized commodities can start at a manageable level (while costs are high and supply is limited) and be gradually increased over time as low carbon options reduce in cost.

Complexity

Low | Medium | High

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

1 - Tankering is the practice of carrying extra fuel on to avoid paying higher prices on arrival.

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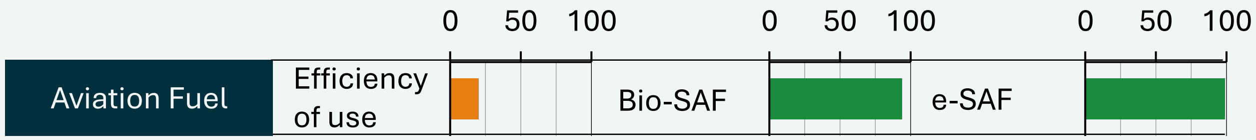
Mandatory mechanism

Deep Dive – SAF blending mandates

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



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 sustainable aviation fuel that increases over time. Given SAF is currently 2-5 times more expensive than conventional jet fuel, blending levels are typically starting at or below 10% and ramping up over time. Quotas for SAF should ensure that sufficient lead times are given to allow scale up of SAF pipeline. It may take 4-7 years, or more for SAF plants to reach operations following final investment decision. 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 of 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** may be required needed to ensure compliance, with penalties / buy outs 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 and may result in market distortions that could result in carbon leakage (e.g. tankering practices). Measures should be put in place to compensate for 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. Supply side incentives for SAF (for example, prioritising bio-feedstocks for use in aviation, low-cost loans and 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 bio-genic 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.

Sources: UK SAF mandate, S&P Global, Reuters, WEF Clean Skies for Tomorrow, MPP Making Net Zero Aviation Possible. 1 - Efficiency is indirectly incentivised due to SAF blending increasing the overall cost of fuel, 2 – assuming a 2% annual efficiency improvement rate between 2025 and 2030

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Mandatory mechanism

Implementation examples of SAF blending mandates

Examples of Adoption of SAF mandates

Jurisdiction	Legislation (Blending level)	Status	Sectors
UK	SAF Mandate: 10% of all jet fuel in flights departing UK by 2030 to be SAF	In place (and enforced)	Aviation
Japan	Basic Guidelines for Promoting Decarbonisation of Aviation: 10% of its jet fuel demand met by SAF by 2030	In place (and enforced)	Aviation
EU	Fit for 55 & Refuel EU: 6% of jet fuel in flights departing EU by 2030 (including 1.2% e-SAF sub quota)	In place (and enforced)	Aviation
Malaysia	National Energy Transition Roadmap: 1% SAF mandate in 2026; 47% in 2050	In place (and enforced)	Aviation
Indonesia	National Roadmap: 5% SAF mandate by 2025	~	Aviation
Singapore	Sustainable Air Hub Blueprint: 1% SAF mandate in 2026, rising to 3-5% by 2030	In place (and enforced)	Aviation
Turkey	Considering 5% SAF mandate for 2030	Under consideration	Aviation

Covers >=10% demand (UK, Japan) | <10% of demand (EU, Malaysia, Indonesia, Singapore, Turkey) | Demand coverage uncertain

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

Sources: UK SAF mandate, S&P Global, Reuters, WEF Clean Skies for Tomorrow, MPP Making Net Zero Aviation Possible.

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Mandatory mechanism

Case Study: REFUEL EU Aviation (1/2)

Jurisdiction: European Union   Adopted: 2023   Applies to: Flights departing EU airports

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

Aviation Value Chain

Stakeholders impacted

Fuel suppliers are required to:
- Supply the required volumes of SAF within a given period
- If they don't, pay a fine of at least 2x the price difference between SAF and conventional fuel[1], and make up the shortfall in the next period

Airlines are required to:
- Uplift at least 90% of the required aviation fuel at EU airports
- If they don't[2], then pay a fine of at least 2x the cost of the non-tanked fuel, reducing the risk of carbon leakage due to increased fuel purchase at airports beyond scope

Fuel suppliers → Airports → Airlines → Customers

Airport operators are required to:
- Take necessary steps to facilitate access of SAF by aircraft operators
- Member states set fines for airports that fail to take adequate measures

Directly Impacted
Indirectly Impacted

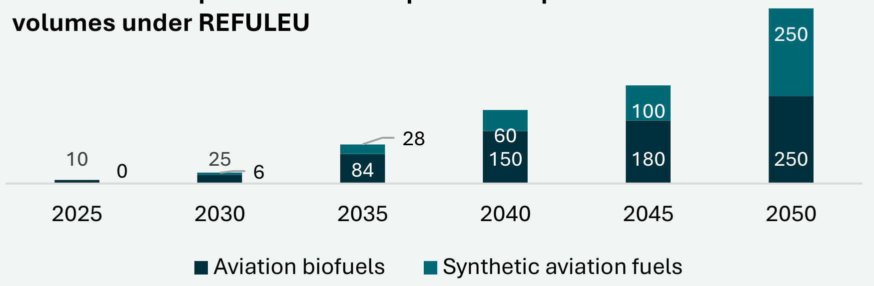
Impact

- 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. 2 out of the top 5 largest disclosed deals involve European airlines:

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

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

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



Assumed plant sizes: SAF output capacities of 0.18 Mt/y

Source: ICAO, NOW-GmbH, European Commission, Ishka Sustainable Aviation Intelligence; 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

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Mandatory mechanism

Case Study: REFUEL EU Aviation (2/2)

Key challenges/risks

Carbon leakage	• One of the key carbon leakage risks associated with the policy are tankering practices, which would involve airlines taking in additional (potentially cheaper) fuel in jurisdictions outside of the mandate, reducing flight efficiency. • The policy includes requirements for uplifting 90% of necessary fuel at EU airports are a key method to avoid airlines circumventing the mandate.
Variations in ability to meet targets across the EU	• ReFUELEU includes a flexibility mechanism that allows the blending of SAF to be averaged across EU airports in the period before 2035, with further flexibility granted to peripheral airports. • Because 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.
Establishing fines	• The fines set under REFUELEU need to be sufficient to ensure that compliance is the cheapest option. To do this, 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 where no commercial scale plants yet operate in Europe). This will likely improve over time as SAF scales in the market.
Regulatory uncertainty	• The legislation include a revision clause stating that the legislation will be reiviewed in 2027 that may lead to adjustments to the definition of SAF, fuels permitted, fine levels and mandated blending percentages. • The review clause reduces the certainty of the demand signal sent by the legislation, and may thereby 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.
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 deployment.

Source: ICAO, NOW-GmbH, European Commission, Ishka Sustainable Aviation Intelligence

1 For the Power-to-Liquids sub-quota, the fine is at least twice price difference between fuel derived via e-SAF and conventional jet fuel; 2- barring exceptional circumstances

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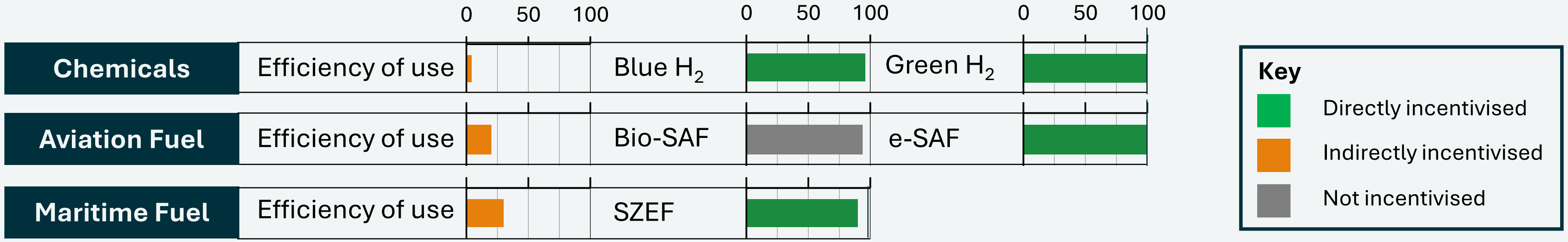
Mandatory mechanism

Deep Dive – Mandatory quotas for use of decarbonised hydrogen and hydrogen derivatives

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



Key considerations

- **Ramp up over time:** quotas should increase in over time, depending on country's climate goals, and may include sub-mandates by sector. The cost of hydrogen is expected to decrease over time, so a gradual ramp-up can balance the impact of costs further down the value chain.
- **Timeframe:** quotas should be signposted well in advance ensure that sufficient lead times are given to allow scale up of green hydrogen supply. For example, it may take 4-7 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, vs sectors that will transition to using hydrogen, such as steel), as well as the impact on end consumers. For instance, agricultural supply chains often operate with tight margins, so it may be more difficult for them to absorb the green premium associated with green fertilisers. Furthermore, the knock-on costs of using green fertilisers could impact downstream sectors, e.g. competitiveness in the food industry. Additional support mechanisms may be needed in parallel.
- **Enforcement:** An enforcement body may be required needed to ensure compliance, with penalties/buy outs set at a high enough level to make green hydrogen adoption the most attractive option. Given the nascency of the clean 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, and therefore any quotas should ensure imports are properly included in the quota and accounted for to create a level playing field and avoid carbon leakage. At present there are a limited number of (for example) ammonia terminals worldwide so monitoring imports effectively may be feasible.
- **Complementary policies** may be necessary to support underpinning hydrogen/derivative transportation infrastructure, support downstream users and to ensure reduce the risk of carbon leakage.
- 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 / a dependence on imports (e.g. India is seeking to displace all ammonia based fertiliser imports by 2034-5).

Sources: India National Green Hydrogen Mission, European Union Renewable Energy Directive.

Implementation of mandates & quotas for decarbonised hydrogen

Examples of mandates and quotas by jurisdiction

Jurisdiction	Description of policy	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 can set mandatory quotas of their own to achieve this or use other measures (e.g. increased subsidies or alternative demand side measures). FuelEU Maritime and ReFuelEU Aviation also set quotas for hydrogen derivatives (or suggest they may come into force).	In place, but to be implemented	Chemicals, Maritime, Aviation
India	National Green Hydrogen Mission: Overall objective of producing at least 5Mtpa of green hydrogen by 2030[1]; Proposals to specify a minimum share of consumption of green hydrogen or derivatives in specific energy-intensive industries have been under consideration	Under consideration	Chemicals

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Examples of key enabling initiatives / detailed studies

- CEEW and Climate Finance Leadership Initiative – Financing Green Hydrogen In India
- Hydrogen for Net Zero (2021), Hydrogen Council & McKinsey

Sources: India National Green Hydrogen Mission, European Union Renewable Energy Directive.

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Mandatory mechanism

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

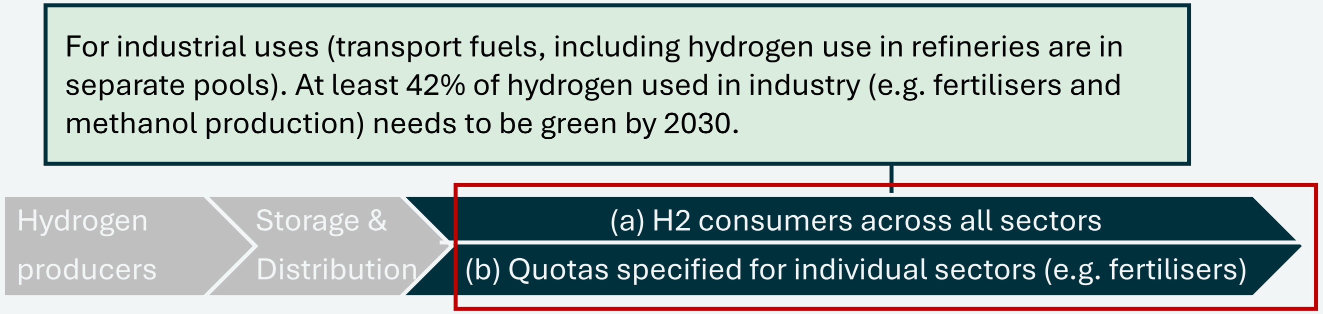
European Union   Adopted: 2023   Applies to: Industrial hydrogen users

RED requires Member States to ensure that at least 42% of hydrogen used in 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 CCS) these targets could be reduced. By 2025, Member States must 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 other incentives and demand side measures to spur uptake. Here we consider options (a) and (b) in detail.

Industrial hydrogen value chain

Stakeholders impacted by option (a) & (b)

Directly Impacted
Indirectly Impacted

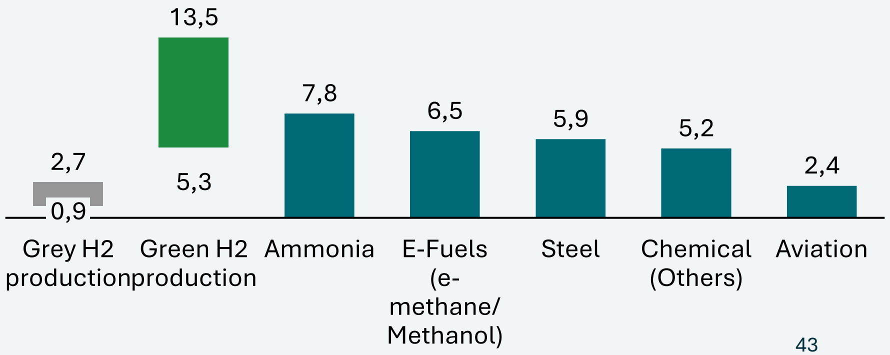


Note: many industrial players produce their own hydrogen on site, so these stakeholders may not be distinct

Details on next slide

- **Demand creation:** if achieved, the RED targets could drive consumption of renewable hydrogen of 1.6 – 4 million metric tonnes (Mt) by 2030, and 2.3 – 7.5Mt by 2035. (Estimates vary depending on forecasted total hydrogen demand[1]).
- **Impact on willingness to pay:** although states have yet to implement 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 sectoral offtake prices identified through its pilot auction**.** Average offtake prices ranged from €5.7 – 8.3/kg H2 (depending on sector), which are significantly higher than grey H2 levelized costs.

Grey and green hydrogen production costs (€/kg H_2) vs average offtake bid prices by sector (EHB) (non-exhaustive)



Source: TUV Sud, European Commission, European Environment Agency, Hydrogen Europe, Bloomberg NEF, S&P Global Commodity Insights, NOW gmbh, H2Global Pilot Auction Results – Bid insights 1 BNEF, European Hydrogen Observatory

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Mandatory mechanism

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 industry, 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 1: Applying the mandate across ALL sectors	**Option 2: 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	• 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	• 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 if the update 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.

Sources: Hydrogen Europe Position Paper , European Commission

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Mandatory mechanism

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

Key challenges/risks

Carbon leakage risks	• Member states are encouraged by the EC to coordinate their policies in order to reduce intra-EU carbon leakage risks. • The rules regarding how imported fossil-based hydrogen derivatives (e.g. as methanol, ammonia) are accounted for through the quota are currently not clear. To avoid carbon leakage, and ensure a level playing field, it is important that the quota apply fairly to imports as well as domestic production.
Means to reduce targets	• 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) produced via means other than electrolysis may be excluded from the quota.
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 sufficient high penalties/buy outs for non-compliance. Setting these may be a challenge due to lack of market data.
Managing the green premium and increased risks	• The increased costs of green hydrogen for downstream industries need to be managed alongside the mandate. Additional funding to support green hydrogen producers and offtakers could be used to 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).
Need for flexibility	• 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 quota. • This is particularly important in the case of industrial use of hydrogen / hydrogen derivatives, where distribution infrastructure is currently very nascent, and the use of such commodities is likely to be predominantly concentrated a handful of large industrial facilities (e.g. chemical/DRI-steel plants and refineries).

Source: TUV Sud, European Commission, European Environment Agency, Hydrogen Europe, Bloomberg NEF, S&P Global Commodity Insights, NOW gmbh, H2Global Pilot Auction Results – Bid insights; 1 For more information, see the European Commission's Guidance on targets;

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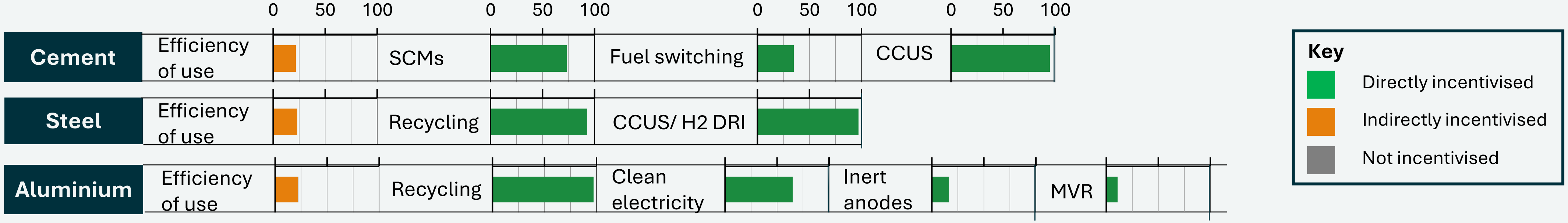
Mandatory mechanism

Deep Dive – Quotas for Low/Zero Emissions Materials

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



Key considerations

- **Novel instrument:** though these have not yet been implemented in these sectors, quotas for the use of low/near zero emissions materials could work in a similar way to blending-mandates set for biofuels and quotas for zero emissions 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. 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 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 monetize this by trading certificates with companies that fall short, creating a valuable revenue stream for early plants.
- **Ramp up over time:** quotas should increase in 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 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 procure certificates. Where downstream products containing the commodities are imported further measures on embodied content may be necessary. For widely traded commodities, this may be challenging to implement.
- **Substitution:** such quotas would increase the overall costs of the relevant commodity(ies). 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.
- **Scale of jurisdiction:** the more facilities that are within scope of the regulation, the easier it will 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.

Sources: Colombia Centre for Energy Policy, Centre for European Policy Studies (CEPS)

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Mandatory mechanism

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 sectors. 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

3.4

Transportation fuel standard programs

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Mandatory mechanism

Overview: Transportation fuel standard programs

Transportation fuel standard programs are instruments that incentivise the adoption of decarbonised fuels by imposing a limit on the carbon intensity on fuels used in transportation. These 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.
- Requirement that suppliers need sufficient credits to represent their overall fossil supply.
- Suppliers that have a deficit of credits can procure them from suppliers with a surplus, creating a revenue stream for the use of low carbon fuels.

Priority for implementation by sector

We have developed an indicative prioritisation of this policy lever by sector, based on the share of demand this lever 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. Based on this analysis, domestic fuel standards programmes can be applied to the aviation and maritime sectors in different ways. In the international maritime sector, these would need to be carefully coordinated with the regulatory measures currently under development by the IMO.

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	Medium	Medium	N/A	N/A	N/A	N/A

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.

Included for deep dive in this report

Source:

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Mandatory mechanism

Key Attributes: Transportation fuel standard programs

Carbon leakage risk

Low | Medium | High

Depending on how a fuel standard incentivizes transportation fuels, it could increase costs and expose internationally exposed transportation sectors to a risk of carbon leakage, however, because the cost is likely to be shared with more localized transport services (e.g. road transport) this is likely to be relatively low.

Burden of cost

Government | Shared | Industry

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 with less resources to absorb the cost.

Technology Agnostic

Specific | Some flexibility | Agnostic

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

Long term stability

3-5 yrs | 5 – 15 yrs | 20 – 30 yrs

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.

Ability to ramp up over time

Low | Medium | High

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.

Complexity

Low | Medium | High

To ensure the success of these policies, governments need robust systems in place, supporting emissions reporting, measurement, monitoring, and enforcement. Important trade-offs between different sub-sectors also need to be considered.

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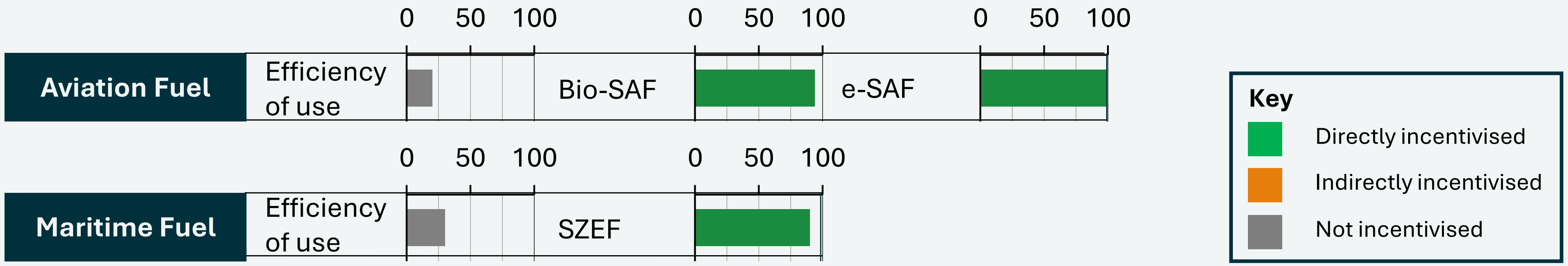
Mandatory mechanism

Deep Dive – Fuel standards for heavy transport fuels

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



Key considerations

- **Inclusion of more nascent fuels:** for less mature / more expensive fuels (e.g. hydrogen derivatives & advanced biofuels) governments can consider awarding additional credits to further incentivise such fuels ("mulitpliers"). When determining multipliers trade-offs between the decarbonisation of different sub-sectors needs to be considered carefully. Alternatively limits for specific fuels in subsectors can be implemented (e.g. to 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 near-zero/zero emission 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 sub-sectors (e.g. road transport) may reduce demand for credits in heavy transport sectors.
- **Method of inclusion:** How a fuel standard is applied to different fuels and sectors is a key consideration. For maritime and aviation fuels, there are three main ways these are reflected:
  1. Not in scope of programmes – programmes do not include maritime or aviation, but focus on other sectors (e.g. road transportation
  2. Allowed to "opt in" to programme – 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 maritime or aviation fuels receive credits and sale of fossil aviation or maritime fuels generates deficits
- **Verification & Evaluation:** Manpower resources and capabilities are needed to verify the use of near-zero/zero emission fuels and to accurately reward or penalise industry players according to obligations met.
- **Need for coordination with other instruments/regulations:** the international maritime sector is globally regulated by the IMO, which is soon expected to adopt a mandatory Global Fuel Standard and GHG pricing mechanism. 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 maritime fuels to opt in and receive credits.

Sources: RMI

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Mandatory mechanism

Case study: Renewable Transport Fuels Obligation

United Kingdom Adopted: 2008 Applies to: Maritime and aviation (until 2025)

The RTFO sets two obligations on fuel suppliers – (1) 13% of total equivalent fuel supply should be sustainable fuels (inc biodiesel and bioethanol) by 2023, increasing to 14.6% in 2032 (2) a subtarget for more nascent development fuels (inc hydrogen derivatives for use in transport) of 1.1% in 2023. The use of sustainable fuels generates tradable certificates called RTFCs. Some sectors are fully covered by the obligation (e.g. road transport and aviation [until 2025]), but the use of fossil fuels in international shipping are not covered and sustainable shipping fuels are able to "opt in" to receive credits.

Fuel value chain

Stakeholders impacted

- Fuel suppliers in the road, non-road, aviation and maritime sectors who supply at least 450,000 litres of relevant fuel for transport within an obligation period must register under RFTO and report their annual volume and share of renewable fuels produced.
- They can either obtain RTFCs for their share of renewable fuel produced or buy/trade RTFCs to meet their obligations
- If the obligation is not met, suppliers pay ~$0.7/l buyouts per RTFC for standard fuel, and ~$1.1/l for advanced fuels. The $1.1/l is equivalent to ~$9/kg hydrogen, $1,400/t for ammonia and $1,500/l for methanol.

Production → Storage & Distribution → **Fuel supplier** → End consumer

Directly Impacted

Indirectly Impacted

Key challenges/risks

Inter-sectoral competition	By crediting low carbon fuels on an "opt in" basis, the cost of decarbonisation of a sector is partially transferred to another sector. Such mechansisms could lead to distortions of the original instruments and slow down decarbonisation of other sectors.
Difficulty meeting compliance requirements	Because production of green hydrogen and its deriviatives is electricity intensive, the green hydrogen definitions that underpin the RTFO include stringent criteria for additionality and temporal / geographical correlation of the electricity used. Meeting these requirements may be complex for industry
Guardrails	The RTFO is also based on detailed sustainability criteria regarding qualifying biogenic feedstocks. The RTFO also limits the use of biofuels derived from certain crops associated with food production through a "crop cap".

Impact

- RTFCs could represent a significant revenue stream for zero emission shipping fuels - overall, the maximum incentives corresponding to buyout payments represent ~$1,400/t ammonia and $1500 / l methanol.
- The RTFO places a requirement on suppliers to provide a share of fuel, and currently exempts fuel supplied to the international maritime sector.
- As mandatory measures are introduced in international shipping (e.g. via the IMO's Mid-term measures), it may be possible to expand such obligations to incentivise ports to supply SZEF to international shipping.

Source: UK Department for Transport, RTFO compliance guidance (2024), ElectroMobility UK

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Mandatory mechanism

Examples of fuel standards programmes incentivising heavy transport fuels

Examples of credits

Jurisdiction	Description of policy	Status	Sectors
UK	Renewable Transport Fuel Obligation: SZEFs for international shipping are allowed to opt in to 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.	In place (and enforced)	Maritime
US	SAF is permitted to opt in under state level Low Carbon Fuel Standards in California, Washington and Oregon in the US.	In place (and enforced)	Aviation
Netherlands	Renewable Energy for Transport:[1] Fuel distributers 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. Intenrational maritime and aviation fuel suppliers are allowed to opt in. Inland maritime is fully covered[2].	In place (and enforced)	Maritime, Aviation

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Examples of key enabling initiatives / detailed studies

- RMI: How States Can Use Low-Carbon Fuel Standards to Incentivise Clean Hydrogen-Derived Fuels

Sources: US Department of Energy, Dutch Energy for Transport, lhyfe-heroes 1 – To apply to inland ships from 2025 2 – CEM Biofuture Platform – Policy Blueprint Country Profile Netherlands

3.5 Embodied carbon limits for basic materials

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Mandatory mechanism

Overview: Embodied carbon limits for basic materials/chemicals

Embodied carbon limits for basic materials are restrictions set on the carbon intensity associated with the use of input materials/chemicals (e.g. steel or concrete), 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. 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-near zero solutions, it is likely such limits would need to be set close to current emissions levels, and gradually reduced.

Priority for implementation by sector

We have developed an indicative prioritisation of this policy lever 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 lever could be applied in the chemicals, aluminium, cement and steel sectors.

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	N/A	NA	Medium	Medium	Medium	Medium

Included for deep dive in this report: Chemicals, Aluminium, Cement, Steel

Source: Agora Industry (2024): Creating markets for climate-friendly basic materials. Potentials and policy options

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Mandatory mechanism

Key Attributes: Embodied carbon limits for basic materials/chemicals

Carbon leakage risk

Low | Medium | High

Buyers may decide to source cheaper basic materials from jurisdictions with less stringent environmental regulations. To mitigate the risk of carbon leakage, governments would need to ensure imported basic materials and downstream products are also subject to the limits.

Burden of cost

Government | Shared | Industry

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

Technology Agnostic

Specific | Some flexibility | Agnostic

Embodied carbon limits would apply to specific categories of intermediary products, but wouldn't 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.

Long term stability

3-5 yrs | 5 – 15 yrs | 20 – 30 yrs

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.

Ability to ramp up over time

Low | Medium | High

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

Complexity

Low | Medium | High

To ensure the success of these policies, governments need robust systems in place, supporting 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.

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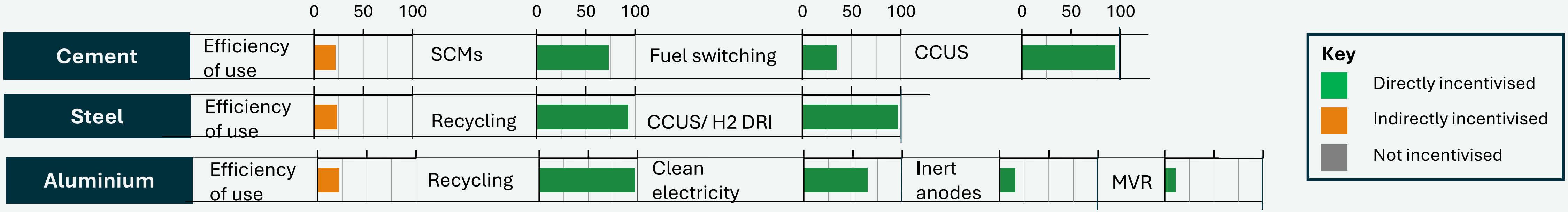
Mandatory mechanism

Deep Dive – Embodied carbon limits on basic materials

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



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 resulting in materials substation. These could result in emissions reductions or increases over the lifecycles of downstream products (e.g. they may be less recycle/durable and result in higher whole-life emissions for end products). It is important therefore that such policies are complemented by measures to ensure the lifecycle carbon of downstream products is also reduced.
- **Enforcement:** A regulatory body is needed to oversee the standards and compliance to 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 adapt to the carbon limits and reporting practices, and data on products become more available. Policymakers could first focus on mandatory disclosure, before enforcing limits, and 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 as well as those produced domestically, and for the materials in products down the value chain, the competitiveness of domestic industries could be impacted.

Sources: Agora Industry (2024): Creating markets for climate-friendly basic materials. Potentials and policy options

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Mandatory mechanism

Implementation examples of carbon limits on basic materials

Examples of carbon limits on 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 included on a non-mandatory basis into standards, labels and frameworks.

Jurisdiction	Description of policy	Status	Sectors
European Union	**Ecodesign for Sustainable Products Regulation (ESPR):** Sets out framework for ecodesign requirements for a list of products that is currently in the process of becoming published with steel and aluminium a priority	Under consideration	Steel, Aluminium
UK	**Mandatory Product Standards (MPS)**: This policy was under consideration by the UK Government in 2023, and if implemented, would set mandatory standards for embodied emissions for products (potentially including imports). Prioritised sectors would include steel, cement, concrete and chemicals.	Under consideration	Steel, Concrete, Chemicals

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Sources: European Commission, UK Department for Energy Security & Net Zero

3.6

Embodied carbon limits on end products

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Mandatory mechanism

Overview: Embodied carbon limits on end products

Carbon intensity limits on end products are thresholds on embodied carbon applied to consumer products (e.g. a car or a building) taking into account embodied carbon (or operational and embodied carbon) in the whole product. This policy is technologically neutral, allowing multiple 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 to absorb the green premium, and ideally have customers with a sufficient willingness to pay for a green product[1].
- How to define intensity limits: these could be set either against baselines of existing end products (e.g. a % reduction versus baseline at a given date) or be based on a threshold (e.g. limiting the $kgCO_2e/m^2$ emissions embodied in a new building).

Priority for implementation by sector

We have developed an indicative prioritisation of this policy lever by sector, based on the share of demand this lever 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 highest priority in the aluminium, cement and steel sectors.

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	NA	NA	Medium	High	High	High

Included for deep dive in this report

Sources: 1- Agora Industry (2024): Creating markets for climate-friendly basic materials. Potentials and policy options sets out criteria to identify lead markets in detail

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Mandatory mechanism

Key Attributes: Embodied carbon limits on end products

Carbon leakage risk	Low / Medium / High	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. This risk can be mitigated by applying limits to imported materials but may impact the competitiveness of exports of select products.
Burden of cost	Government / Shared / Industry	Businesses 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, that are less able to absorb these costs.
Technology Agnostic	Specific / Some flexibility / Agnostic	Because carbon intensity limits are set on end products in this case, there are various means in which the carbon limits could be achieved, e.g. by substituting intermediate products, using green input materials or using inputs more efficiently.
Long term stability	3-5 yrs / 5 – 15 yrs / 20 – 30 yrs	Regulations to set embodied carbon limits can be set with a long –term horizon, thus incentivizing long lasting changes in the industry as it switches to greener methods of production.
Ability to ramp up over time	Low / Medium / High	Limits on embodied carbon can be phased in and tightened over time as solutions for deep decarbonisation become more affordable and available.
Complexity	Low / Medium / High	To ensure the success of these policies, governments need robust systems in place, supporting emissions reporting, measurement, monitoring, and enforcement. Additionally, they would need to evaluate the impact on industrial competitiveness and other social objectives, e.g. housing costs, and potentially implement supporting measures to complement this policy.

Source: BloombergNEF, Agora Industry

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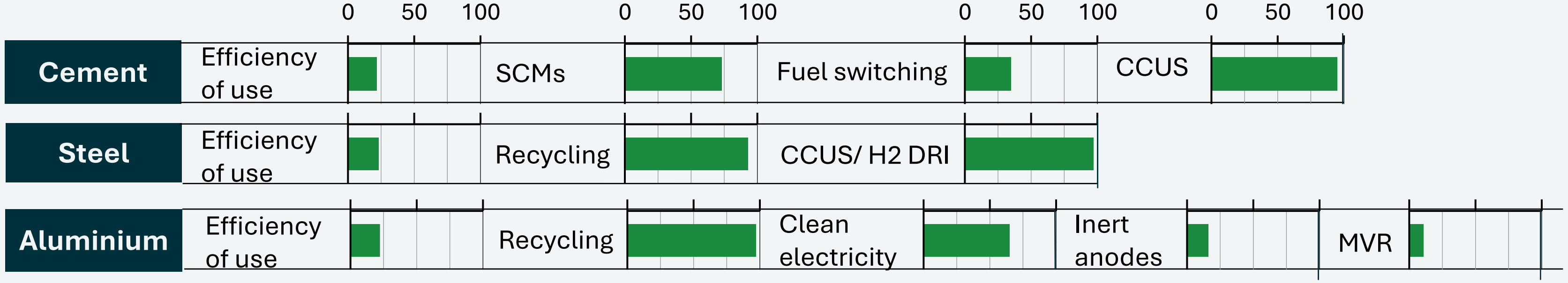
Mandatory mechanism

Deep Dive – Embodied carbon limits in the construction sector

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



Key considerations

Key: Directly incentivised | Indirectly incentivised | Not incentivised

- **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 projects overall resiliency. This can avoid unintended negative consequences (e.g. material substitution or reductions in overall lifetimes).
- **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. for housing). This could be in tension with social / housing objectives, particularly in markets where housing prices are already high.
- **Enforcement:** A regulatory body is needed to oversee the compliance to carbon limits by building developers/ owners. It may be costly/time consuming for some organisations (e.g. SMEs) in the construction value chain to demonstrate the environmental performance of their products, so tools to streamline these processes, or financial support may be necessary (e.g. to support the creation of EPDs).
- **Risk aversion:** It may be take time to develop new regulations in the construction sector, as important traditional criteria (e.g. strength, durability, safety) need to be maintained.
- **Product standards & certifications**: These are essential to support the procurement of lower-carbon raw materials (e.g. steel and concrete)

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

Metric tonnes CO_2e

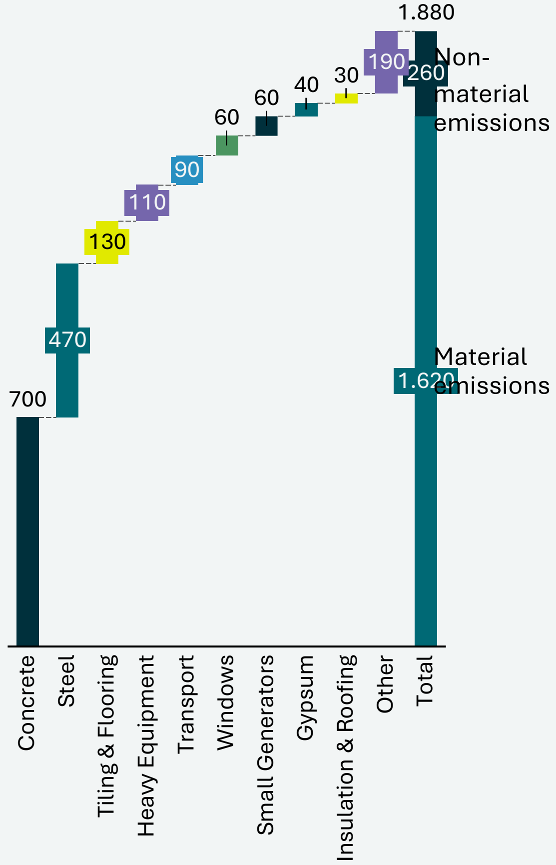


Figure adapted from McKinsey & Co and Energy Transitions Commission for MPP: Net-zero steel in construction: The way forward

Sources: BloombergNEF, European Commission, Agora Industry (2024): Creating markets for climate-friendly basic materials. Potentials and policy options McKinsey & Co

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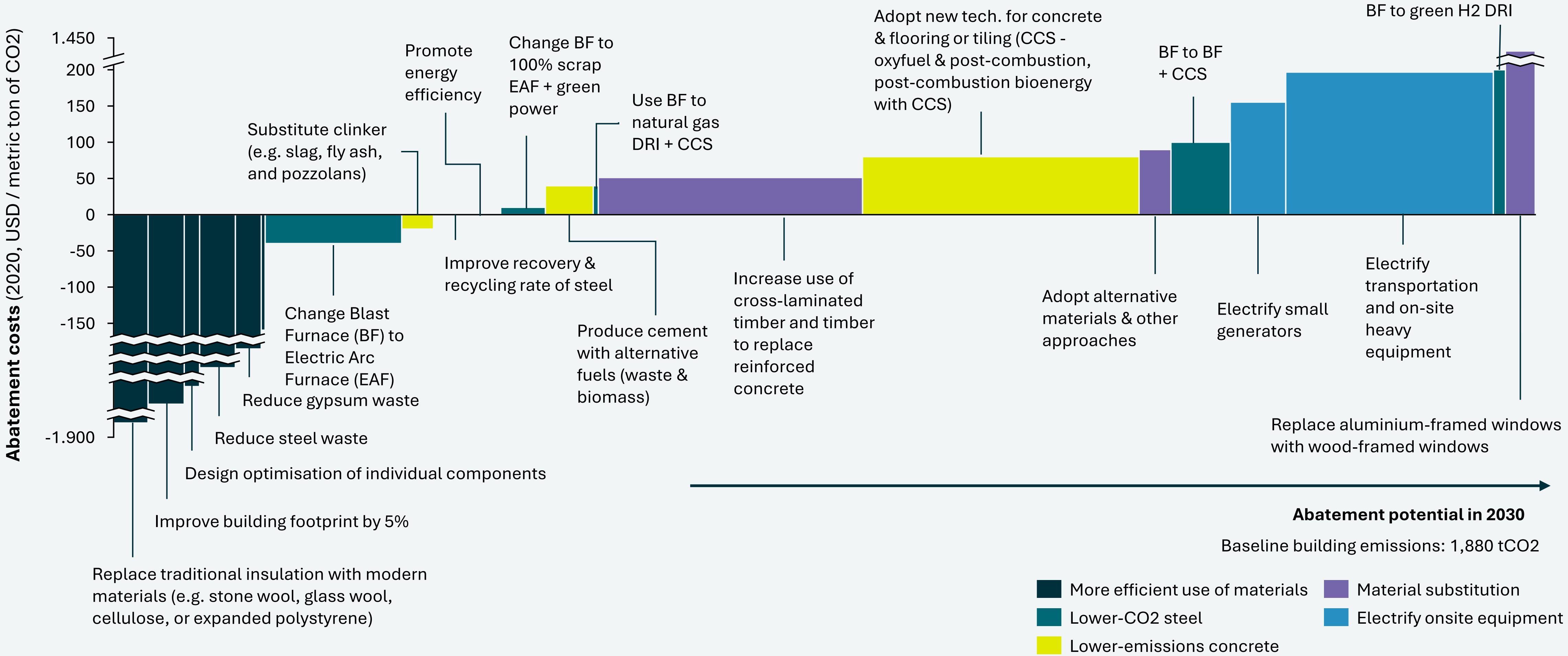
Mandatory mechanism

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 ton of CO2



Source: Figure adapted from McKinsey & Co and Energy Transitions Commission for MPP: Net-zero steel in construction: The way forward

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Mandatory mechanism

Examples of carbon intensity limits in construction

Examples of embodied carbon limits

Jurisdiction	Description of policy	Status
France	RE2020: Sets limits on embodied carbon for various building types, e.g. for A) Single-family homes: material production and construction-related emissions limit is 640 kg-CO2/m^2) in 2022 and 415kg CO2/m^2 by 2031. New apartment buildings: 740 kg-CO2/m^2 in 2022, and 490 kg-CO2/m^2 by 2031.	
Denmark	National Strategy for Sustainable Construction: New buildings over 1000m^2 subject to a limit on combined operational and embodied emissions of 12 kg CO2e/m^2/y. The limit will tighten depending on progress made as a sector. By 2025, the limit is projected to average 7.1 kg CO2e/ m^2 per year, depending on building type.	
Netherlands	Millieu Prestatie Berekening: Buildings must conduct whole-life LCA and convert environmental impact metrics to a shadow price (e,g, €0.05/kg CO2e), 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.	
USA	Regulations are currently at the state level, not national. 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 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.	

Sectors

- Steel
- Aluminum
- Concrete

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Examples of key enabling initiatives / detailed studies

- **World Green Building Council,** a non-profit organisation has a global network of green building councils in over 70 countries. They aim to catalyse the development of a sustainable built environment globally. Key initiatives include: #BuildingLife, Whole Life Carbon Policy Briefing, Whole Life Carbon Roadmaps
- Carbon Leadership Forum: Many other examples have been implemented at the sub-national level. For more details, see the Policy Tracker.

Sources: European Union, World Green Building Council, One Click LA, Institution of Structural Engineers, European Trade Commission

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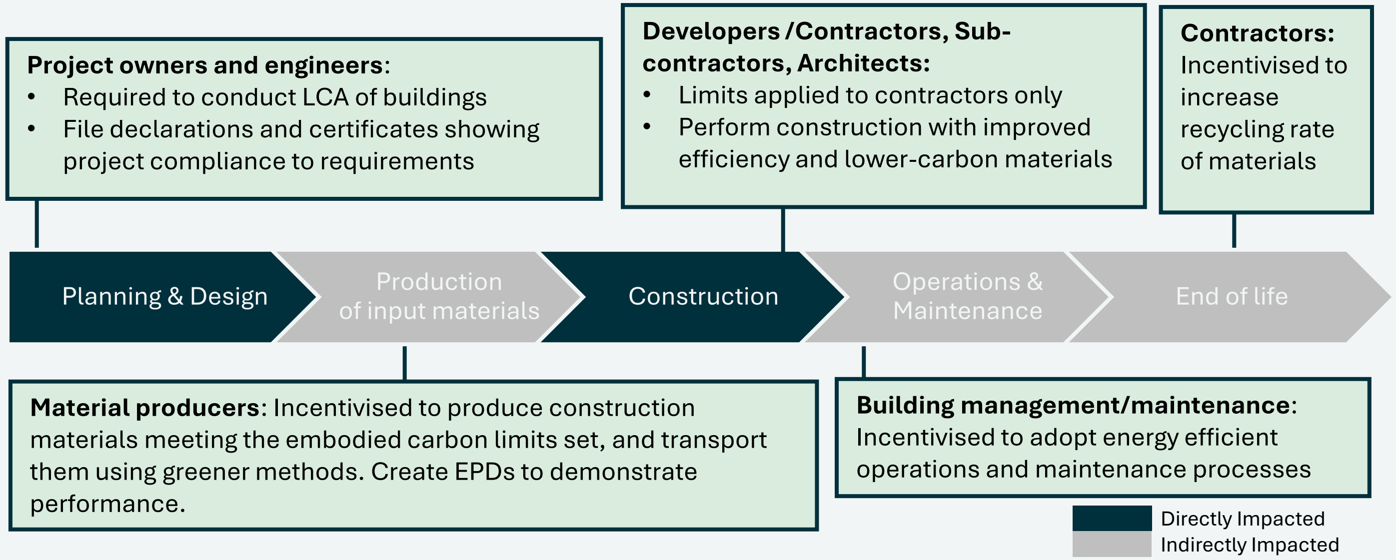
Mandatory mechanism

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

France Adopted: 2022 Applies to: Building Materials

- **RE2020** aims to (1) improve energy performance and decarbonisation of energy in operations, (2) reduce the lifecycle emissions of buildings and (3) 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 640 kg-CO2/m² in 2022 and 415kg CO2/m² by 2031. For new apartment buildings, it is 740 kg-CO2/m² in 2022, and 490 kg-CO2/m² by 2031, applied at the building level.

Construction value chain
Stakeholders impacted



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

Maximum threshold for building’s CO_2 content in construction phase

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

Source: BloombergNEF (2023) Scaling Technologies for Greening Heavy Industry , One Planet Network, Deepki How to address the challenges of embodied carbon

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Mandatory mechanism

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

Key challenges/ risks

Ambition level of thresholds	• RE2020 is one of few examples of national policies focusing on embodied carbon, thus lending certainty to the demand for lower-carbon construction materials and fostering market development for these greener products across a large jurisdiction. • Currently, the average production and construction emissions of an average residential building in France is estimated at 399 kg CO2/m^2. Critics have suggested that the limit of 740 kg CO2/m^2 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, but over time the limits are expected to tighten, increasing the impact.
The need for industry transformation	• Heavy industry needs to add new lower-carbon solutions to their catalogue to make sure they will still be able to exist in the construction market (otherwise, there is a risk of material substitution using lower carbon materials such as wood). • The construction industry needs to adapt the architecture of the buildings to integrate new low-carbon design and reduce the quantity of materials while preserving security. • The RE2020 hinges on EPDs registered in a publicly available database ("base INIES") managed since 2004 by actors 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 5000 declarations.
Lead time	• Bringing in the limits has required considerable efforts to build an effective foundation, involving over two years of public consultation, putting the new controls in place, and scaling up the creation of EPDs to underpin implementation.
Scope	• The regulation does not explicitly incentivise more longevity for buildings because the life cycle analysis is calculated on a fixed reference lifetime of 50 years. Nonetheless, the regulation values the reuse and recycling of materials. Buildings designers are thereby encouraged to use a more modular approach to facilitate the collect of materials during maintenance and demolition.

Sources: BloombergNEF (2023) Scaling Technologies for Greening Heavy Industry, base INIES

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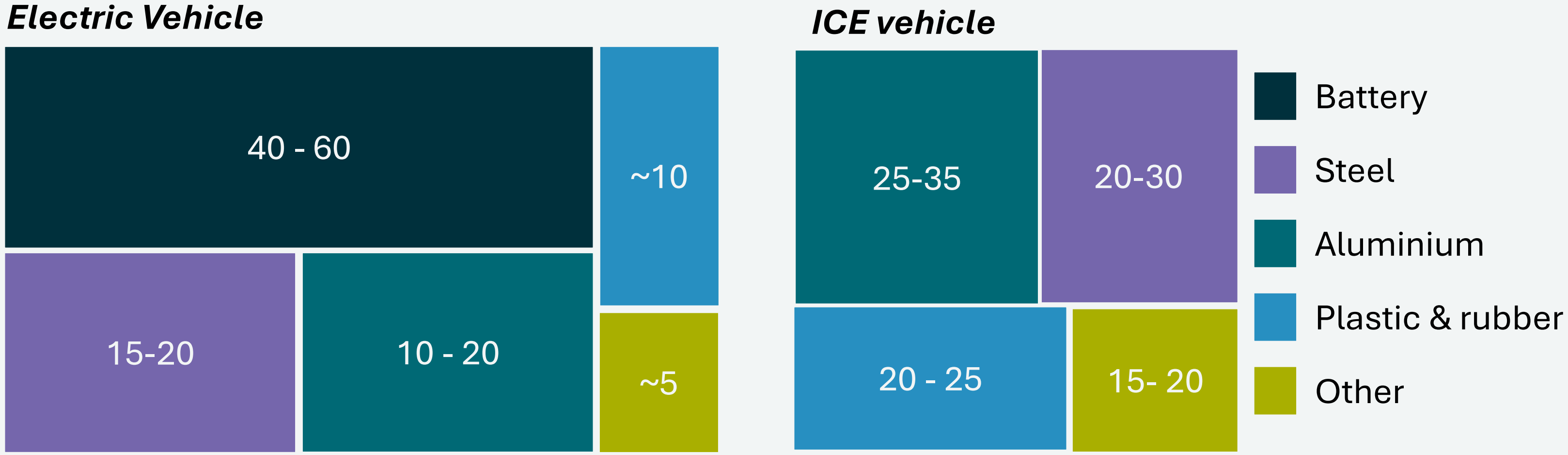
Mandatory mechanism

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.

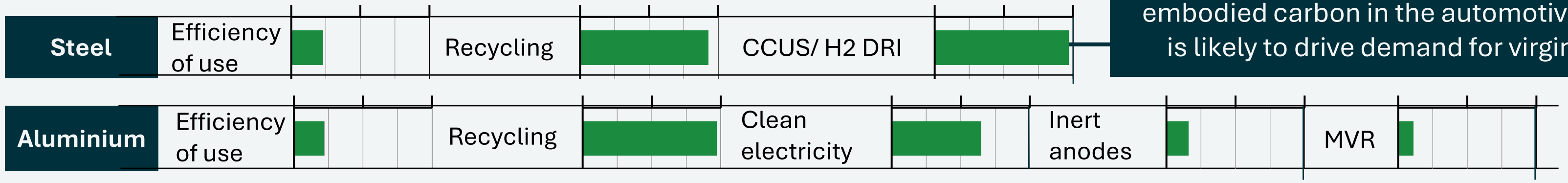
Typically, materials such as steel and aluminium comprise 35-40% of upstream emissions of EV's, and 45-65% for ICE vehicles. Therefore, setting embodied carbon limits on the materials used has significant potential to reduce GHG emissions for the sector, while stimulating demand in the materials sectors.

Indicative upstream emissions by vehicle type (%)*



Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see 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

Key
- Directly incentivised
- Indirectly incentivised
- Not incentivised

*Indiciative sizing based on EV embodied carbon being ~60% higher than an ICE vehicle. Note – doesn't account for recycling of materials
Sources: Low Carbon Vehicle Partnership, International Council on Clean Transportation, McKinsey & Co

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Mandatory mechanism

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.
- **Implementation over time**: The limits can be gradually tightened over time 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 set specifically 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**: These can ease the process of procuring lower-carbon materials for car manufacturers and help them navigate production pathways and associated emissions.
  - **Financial support**: While the cost impact to end consumers may be relatively low (e.g. €57 a vehicle), green steel may cost 20-50% more for car manufacturers. Subsidies could help ease the uptake of greener materials in the initial phases. Over time, subsidies can be phased out as production costs decrease.

Status of adoption of emissions standards

At the time of writing no prominent examples of embodied carbon limits for transport vehicles.

Examples of key enabling initiatives / detailed studies

- **International Council on Clean Transportation** - Technologies to reduce GHG from automotive steel in the US and EU.

Sources: Low Carbon Vehicle Partnership, International Council on Clean Transportation, McKinsey & Co

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Carbon Pricing

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Market based mechanism

Overview: Carbon pricing

Carbon pricing applies a cost to CO_2 emissions and of 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 ton of CO_2 they emit, which can be traded. This creates a market for emissions permits and hence incentivizes reductions.
- **Carbon taxes:** This directly sets a price per ton of CO_2 emitted. Emitters must pay this tax, which incentivizes them to reduce emissions to lower the resulting tax burden. While some carbon taxes are explicit (i.e. based directly on GHG emissions), others are implicit (e.g. applied to each unit of a given fossil fuel sold).

Priority for implementation by sector

We have developed an indicative prioritisation of each policy lever by sector, based on the share of demand this lever 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 carbon pricing as especially high priority for the aluminium, cement and steel sectors

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	Medium	Medium	Medium	High	High	High

Note - A multilateral measure for GHG pricing is currently under development at IMO which would likely supersede national systems

Included for deep dive in this report

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Market based mechanism

Key Attributes: Carbon pricing

Attribute	Scale	Description
Carbon leakage risk	Low / Medium / High	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.
Burden of cost	Government / Shared / Industry	The costs of carbon pricing would be borne by industry. Many Governments redistribute the revenues raised from the 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).
Technology Agnostic	Specific / Some flexibility / Agnostic	Carbon pricing systems are often applied across multiple sectors. In a cap-and-trade system, emissions can be traded between sectors, thereby incentivizing the cheapest and most near-term efficient ways to reduce emissions.
Long term stability	3-5 yrs / 5 – 15 yrs / 20 – 30 yrs	Carbon pricing systems, especially market-based systems, can fluctuate depending on economic conditions, policy changes and technological improvements. Measures such as price floors and ceilings can prevent extreme fluctuations. Long-term commitments, with progressively stringent prices / limits on emissions can create a stable trajectory.
Ability to ramp up over time	Low / Medium / High	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 competitiveness challenges without complementary measures.
Complexity	Low / Medium / High	Given their 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, implementation of carbon pricing is relatively complex to implement.

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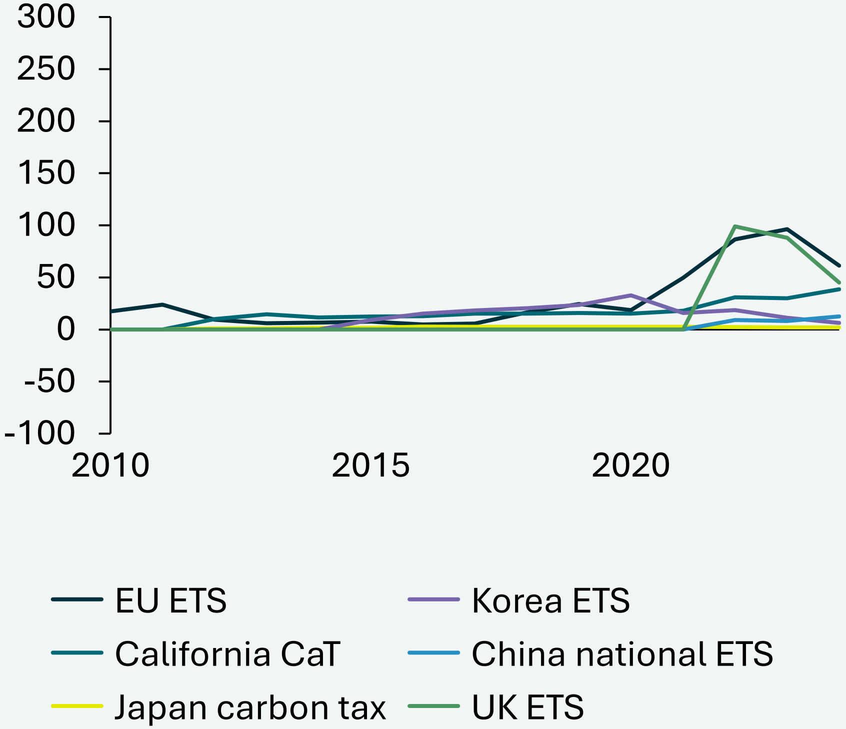
Market based mechanism

Deep Dive: carbon pricing in heavy industry sectors

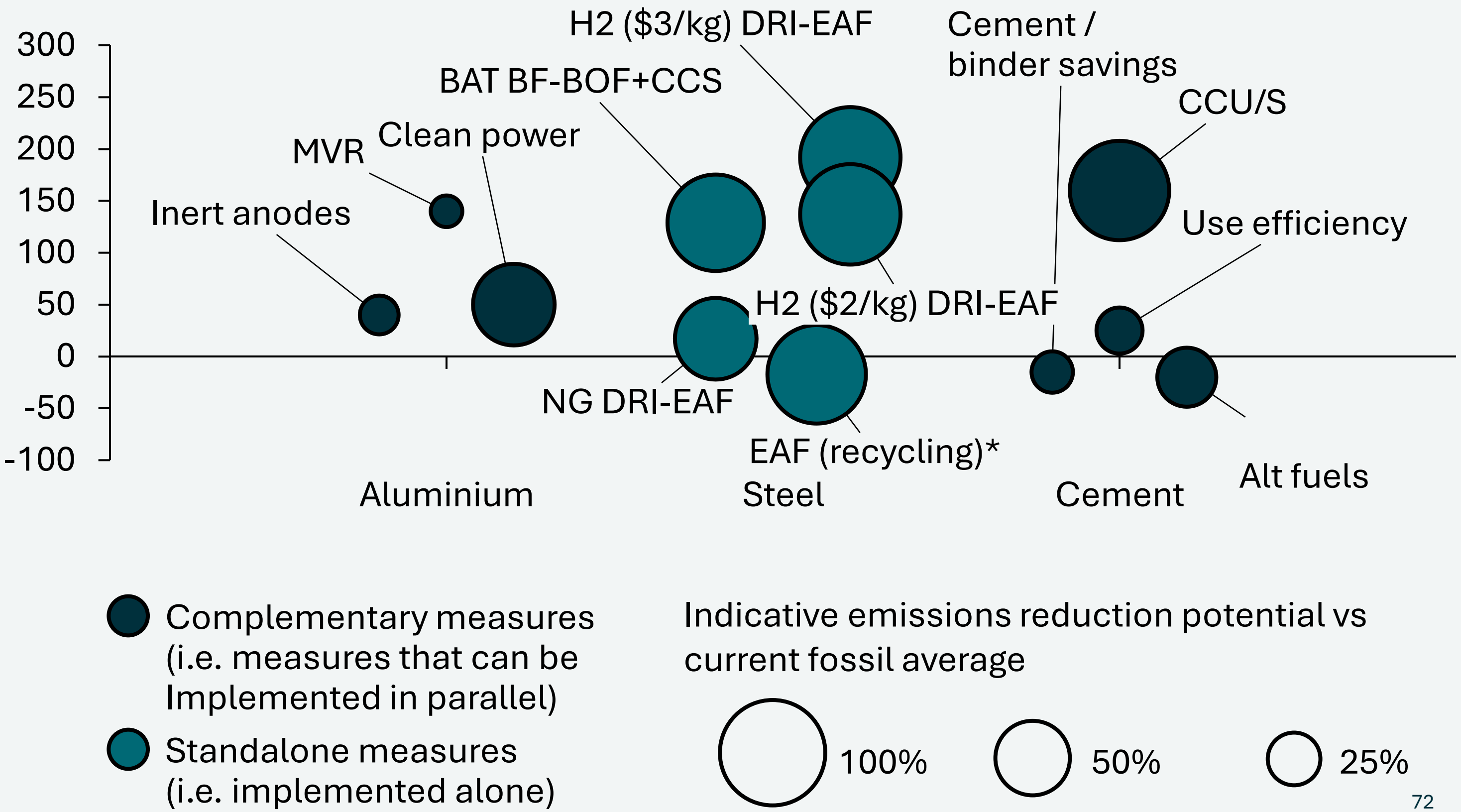
Historically carbon pricing has been instrumental in the decarbonisation of the electricity sector, but due to competitiveness concerns, it has been challenging to fully implement carbon pricing in sectors exposed to global competition. We estimate for aluminium, cement and steel sectors, a carbon price of up to ~$200/t$CO_2$e 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. ~$120 – 160/t$CO_2$e). Carbon prices in the most aggressive systems today are currently below ~$100/t$CO_2$e.

Carbon prices in select jurisdictions

$/tonne$CO_2$e



Indicative carbon prices to bridge GP for decarbonisation levers in 2030



Sources: World Bank Carbon Pricing Dashboard; Agora Industry (2024), MPP Making net zero steel/aluminium/cement possible

*Note that although steel recycling is a low cost decarbonisation option with very high emissions reduction potential, its scalability is limited by the supply of scrap & the potential need for virigin steel for certain use cases

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 production of 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 (WTO is initiating a taskforce on international cooperation 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 jurisdictions' 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 characterized 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 sufficiently stable to enable emissions reductions. Measures to stabalise carbon prices for heavy industry could include tightening overall caps on emissions over time, introducing price floors for emissions 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 monetize specific emissions 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 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 emissions 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) in the near term, and risks of carbon lock in (e.g. from fossil based plants with long lifetimes). Complementary measures (subsidies, regulations) can be used along-side to achieve this.
- **Revenue recycling:** the proceeds of carbon pricing systems can be recycled into subsidy schemes to support low carbon technologies.

Sources: Hydrogen insight, Reuters

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Market based mechanism

Case study: EU ETS and CBAM

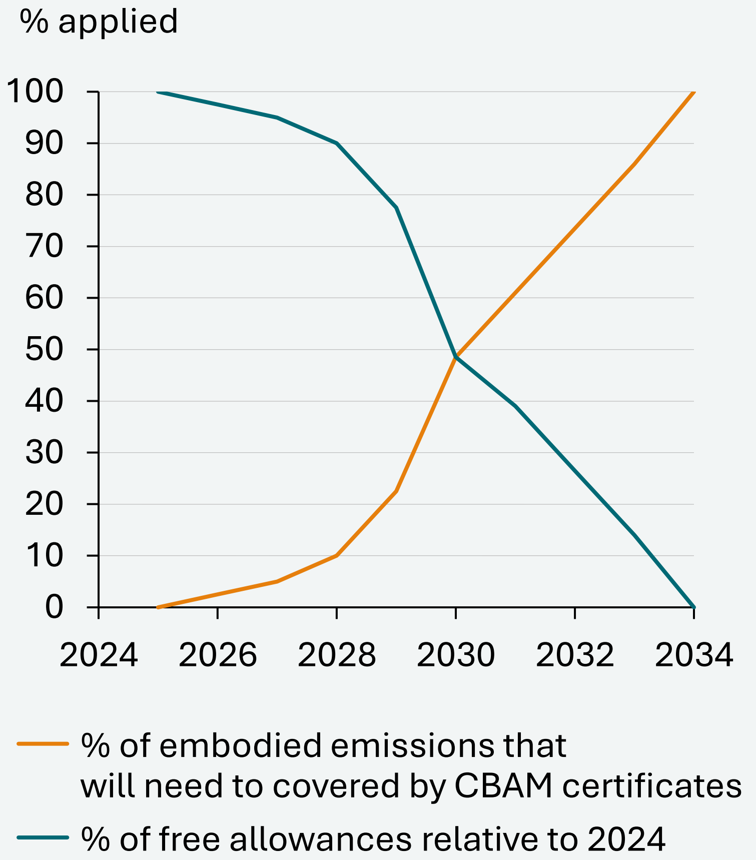
EU Adopted: 2005 Applies to: power, industry, aviation, maritime

The EU ETS is the world's largest carbon pricing system, it works by issuing a capped number of emissions allowances (EUAs) that represent 1 tonne of CO_2e 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 incentivize 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 being gradually reduced over time** to limit the emissions from the sectors in scope.
- Sectors exposed to risks of carbon leakage are currently provided with free allocation, however **free allocation will be phased out between 2026 and 2034**, 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 EU* of some goods (iron/steel, aluminium, cement, fertilisers, hydrogen and electricity) to buy and surrender CBAM certificates to match the emissions embodied in the goods, with the equivalent value to EUAs (phased in before 2034 – see plot on the right). If importers can demonstrate a carbon price has already been levied on the relevant goods, this amount can be deducted.
- Until 2025 a transitional period is in place where relevant importers need to report quantity of imports, their embedded/indirect emissions and carbon prices already paid on goods in their country of origin.

Phase out of free allocations & phase in of CBAM



Source: BloombergNEF (2023) Scaling Technologies for Greening Heavy Industry, European Commission, PtX Hub
*Excluding some countries that are part of the EU ETS / have a linked ETS **the number of certificates needed will be phased in from 2026 to 2034.

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Market based mechanism

Case study: EU ETS and CBAM

Impact

- The impact of an EU ETS with no free allocation on heavy industry is yet to be seen.
- Analyses[1] suggest that with sufficiently low hydrogen costs (e.g. of € 2-3/kg) stable carbon prices between ~$120 - 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, with the UK has also adopted a CBAM and measures are under consideration in Australia and Canada.

Key challenges/ risks

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.
Carbon leakage risk and additionality	• Some of the sectors in scope of the CBAM are currently subject to overcapacity (e.g. steel). The global fleet contains both lower carbon steel plants and carbon intensive plants. This creates a risk of "resource shuffling" whereby 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 jurisdiction and measures to tackle carbon leakage could mitigate this.
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.

Sources: BloombergNEF, European Commission 1: for example, Energy Transitions Commision (2023): Unlocking the First Wave of Breakthrough Steel Investments
*Excluding some countries that are part of the EU ETS / have a linked ETS

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Market based mechanism

Implementation examples of carbon pricing in industrial sectors

Examples of carbon pricing policies

Jurisdiction	Description of policy	Status
UK	Emissions Trading System (ETS) implemented together with a carbon border adjustment mechanism (CBAM). The UK CBAM will be bought in in 2027, with free allocations being maintained until 2026.	✓
EU	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 Safeguarding Mechanism, which sets emissions limits on industrial facilities. The Australian Carbon Credit Unit (ACCU) Scheme currently allows industry players to earn an ACCU per tonne of CO2e 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 aluminum, steel and cement in future.	●

Sectors

- Steel
- Aluminum
- Concrete

Covers >=10% demand | <10% of demand | Demand coverage uncertain | ✓ In place (and enforced) | ✓ In place, but to be implemented | ● Under consideration

Examples of key enabling initiatives / detailed studies

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

Sources: European Council, International Carbon Action Partnership, UK Department for Business, Energy & Industrial Strategy Department for Energy Security & Net Zero, Australia Department for Climate Change, Energy, the Environment and Water, India Bureau of Energy Efficiency, Oxford Institute of Energy Studies

3.8

Demand-side Subsidies & Tax Credits

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Overview: Direct Demand-side subsidies & tax credits (1/2)

Demand side subsidies are payments given to buyers/consumer that reduce the price they pay for materials/fuels. Tax credits are financial benefits that reduce the amount of tax owed for procuring a lower-carbon material/fuel. This lowers the post-tax cost to buyers/consumers, and thus stimulates demand, in some cases, these can be higher than the tax paid initially (this could either result in a net rebate or limit the tax credit provided).

A key limit on scalability/potential impact of subsidies is ensuring sufficient funding can be made available. Funds could be raised via general taxation, or the proceeds of carbon pricing systems. Furthermore, a significant amount of subsidies are currently provided for the production and use of fossil fuels/fossil-based products. There are opportunities to redistribute the subsidies towards lower carbon products. For example, in India, ~$30 billion[1] of subsidies were allocated to the fertiliser sector (FY 22-2023). Redistributing such subsidies could be one means incentivise green products without additional cost to Governments. Subsidies could also be leveraged to achieve other strategic aims e.g. building domestic capabilities in green markets, improving national balance of payments for fossil importers, and reducing exposure to the volatility of global energy prices.

Priority for implementation by sector

We have developed an indicative prioritisation of each policy lever by sector, based on the share of demand this lever 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. Demand side subsidies are most critical for sectors where the green premium is especially high (e.g. aviation and maritime fuels), or where certain consumers may not have the ability to afford to pay the green premium (for example, farmers and fertilisers).

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	High	High	High	Medium	Medium	High

Included for deep dive in this report

Sources: CEEW: Financing Green Hydrogen in India Global Maritime Forum, Bloomberg NEF and Climate Technology Coalition: Scaling up Hydrogen: the case for low carbon ammonia (2024) , US Department of the Treasury

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Market based mechanism

Overview: Direct Demand-side subsidies & tax credits (1/2)

There are many different models to provide subsidies to suppliers and users of deeply decarbonised commodities. A non-exhaustive set of archetypes (many of which can be applied either on the demand or supply side) is set out below:

Subsidy model	Description	Examples
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 R&D projects.	Grant funding via the EU innovation fund
Fixed premium subsidies / tax credits	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.	US Hydrogen production tax credit; Brazilian Hydrogen tax credits
Fixed premium subsidies (auction based)	Provide a fixed payment per-unit output over a set period of time. Auctions are 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, this could either be paid back to government or there could be no obligation to pay this back.	UK Hydrogen production Business Model, India SIGHT programme.
Carbon contracts for difference (CCFDs)	Can only be implemented in conjunction with an emissions trading system. Provides a contract for difference based on a pre-agreed carbon price reference (indexed to energy costs).	Dutch SDE++ , German Carbon Contracts for Difference
Indirect subsidies	Subsidies provided on an indirect basis (e.g. by providing free allocations in an emissions 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 de-risk offtake and 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.

Sources: List based on Global Maritime Forum, European Commission, US Department of the Treasury; Baker Mckenzie; UK Government; Ministry of New and Renewable Energy (India); Netherlands Enterprise Agency; Federal Ministry for Economic Affairs and Climate Action (Germany); ICCT

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Market based mechanism

Key Attributes: Subsidies & Tax Credits

Carbon leakage risk

Low | Medium | High

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

Burden of cost

Government | Shared | Industry

These would need to be funded by governments, and, depending on their extent could be very significant. 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.

Technology Agnostic

Specific | Some flexibility | Agnostic

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

Long term stability

3-5 yrs | 5 – 15 yrs | 20 – 30 yrs

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

Ability to ramp up over time

Low | Medium | High

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

Complexity

Low | Medium | High

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

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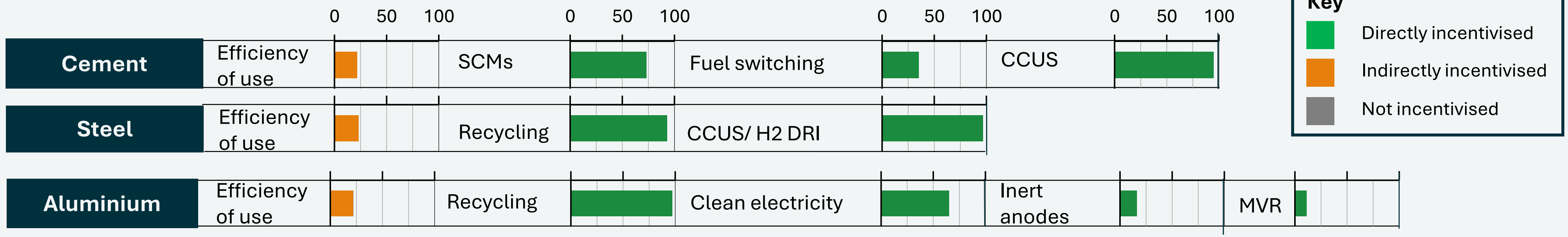
Market based mechanism

Deep dive: Subsidies in the materials sector

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



Key considerations

- **Stage of the value chain:** subsidies for the use of green materials could be applied at various stages of the value chain. In order to administer subsidies at scale, 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, or c) to localised hubs.
- **Technology pathways:** Subsidies can either A) target the procurement of material using specific production pathways, e.g. use of CCUS in production, or B) 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 risk artificially selecting technology "winners", and may not allocate funding to the most efficient technologies in the near term.
- **Implementation over time**: The qualifying criteria can be tightened over time, requiring lower carbon intensity of materials procured to be eligible for subsidies as production pathways mature, particularly for more novel decarbonisation levers.
- **Complementary policies**: Subsidies can be paired mandatory quotas to achieve a larger effect on emission reduction. They can be applied at different parts of the value chain (e.g. subsidies for demand side, mandates for producers), or at the same part. Mandates are typically more effective when applied to a concentrated market for easier enforcement. For subsidies, policymakers should assess the ability for various buyers to absorb the green premium across the value chain, and tailor the amount given. Because they reduce the overall costs associated with green products, they can also help to mitigate carbon leakage risks.

Sources: BloombergNEF

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Market based mechanism

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

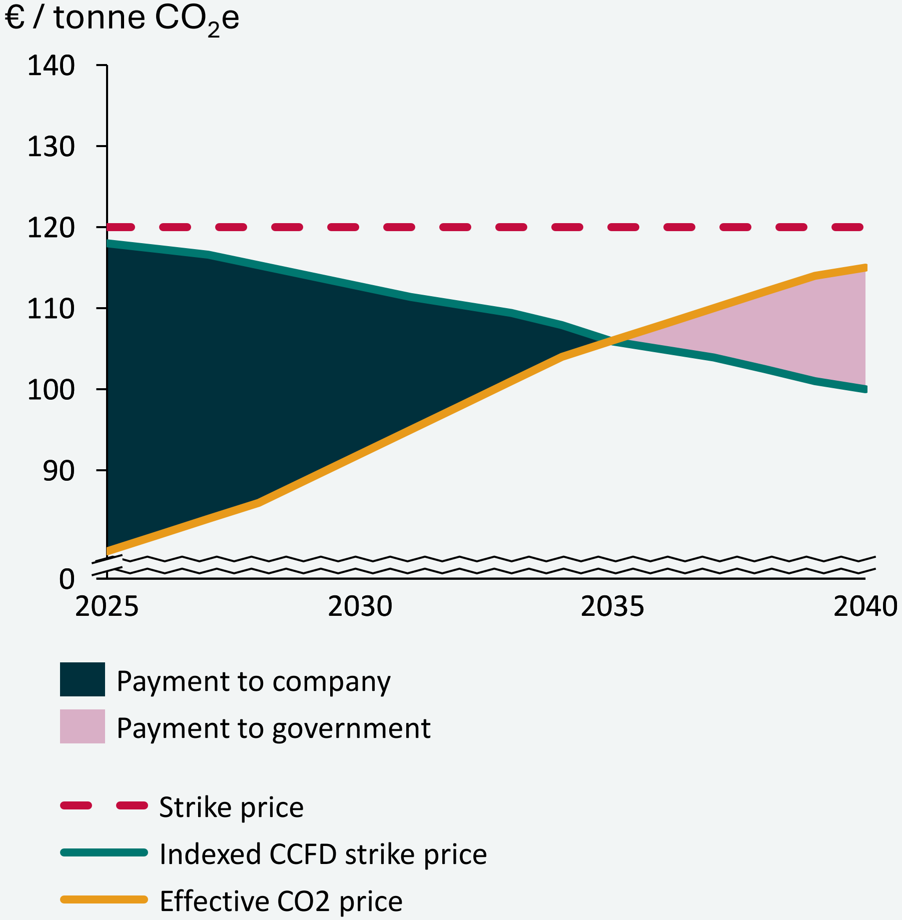
Germany

Applies to: heavy industry

- Germany has launched a €4bn auction for demand-side CCFDs, as the first step of a programme expected to ultimately be much larger. CCFDs work through three steps:
  1. **Bidding:** Companies assess the cost and CO2 emission delta between incumbent fossil and green plants. They use this to calculate a € per-tonne CO2 **strike price** that would bridge the green premium, within given parameters (EU-ETS carbon price, energy price, caps on bids)
  2. **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 for the **indexed CCFD price**.
  3. **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, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp/ paper, cardboard, acids and bulk organic chemicals. Projects would need to be 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 on a competitive basis based on achieving the lowest cost emissions reductions. The data from such bids may be able to be used to support price discovery in new markets (though this is not explicitly specified for the first auction)
- Other regions are now considering adopting CCFDs (for example Canada)

CCFD Payment Calculation – Illustrative Example



Source: BMWK (2023) – The German Carbon Contracts for Difference (CCfD) scheme, Climate Strategies (2022) – Carbon Contracts for Differences (CCfDs) in a European context

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Market based mechanism

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

Key challenges / risks

Need for large scale, prolonged funding	• Such an instrument requires steady funding in the multiple billions to be applied across a major economy (the programme is envisaged to provide €10s of billions in funds). Initially, the funds for the CCFD scheme were intended to be funded from leftover Covid-19 recovery funds that would be used to finance climate initiatives. A German court barred this funding 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.
Inter-sectoral competition	• Because the CCFDs are allocated across several industries, some industries are likely to have lower abatement costs than others, and hence be more competitive in auctions for CCFDs. To ensure breakthrough technologies are incentivised in a wide-range of sectors, separate buckets may needed for different sectors.
Uncertain pricing information	• Due to 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.
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.

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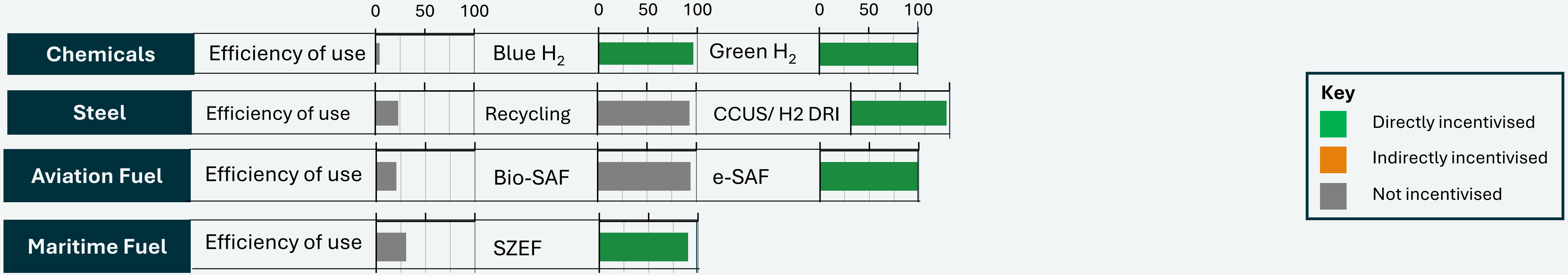
Market based mechanism

Deep Dive – Demand-side subsidies for green hydrogen

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



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. For example, demand-side subsidies may be more critical in the fertiliser sector to support farmers with tight profit margins to buy green fertiliser.
- **Coordination 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 coordinated between countries to build demand and enable infrastructure investments across international networks.
- **Achieving scale:** 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. For example, 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 willingness to pay, reducing the government funding needed for subsidies.

Sources: IEA

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Market based mechanism

Implementation examples of demand subsidies for green H2

Examples of demand-side hydrogen policies

Jurisdiction	Description of policy	Status
Australia	Regional Hydrogen Hubs Programme – under the programme AUD 490 million (USD 324 million) has been allocated to 7 hydrogen hubs, which are large clusters of demand for renewable hydrogen, targeting 2.8 Mtpa of H2 production.	
Germany	Through a first round of CCfD, EUR 4 billion was made available to support fuel switching of industrial assets (including switching to decarbonised hydrogen and CCUS). Results will be announced in Q3 2024. A second round, for EUR 19 billion is expected in 2024.	
New Zealand	Interim Hydrogen Roadmap includes the Regional Hydrogen Industry Transition which offers a rebate for hydrogen consumption by companies in the heavy transport and industry sectors, to be implemented in 2025	
Chile	Up to USD 1 million allocated for demand creation and the demonstration of new use cases, with up to 60% of costs covered.	
Japan	Clusters support scheme was announced, in conjunction with the supply chain subsidy, to develop 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.	
Italy	Under the Temporary Crisis and Transition Framework (2023), EUR 550 million (USD 596 million) and EUR 400 million (USD 434 million) was allocated to support investments for hydrogen consumption in industrial processes and should be granted by 2026.	

Sectors

- Chemicals
- Steel
- Maritime
- Aviation

Several other countries such as UK, US and Sweden, are providing grants to support industry transformation, including developing infrastructure and equipment to enable the use of renewable energy, including hydrogen.

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Examples of key enabling initiatives / detailed studies

- Hydrogen Council
- IEA Global Hydrogen Review 2024
- USA Hydrogen Demand Initiative

Sources: IEA, Norton Rose Fullbright, European Commission

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Policy Levers – Provide in-kind incentives for use of decarbonised products / services

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Non-financial incentives

Overview: Provide in-kind incentives for use of decarbonised products/services

In-kind incentives are non-financial benefits or advantages provided by public bodies to industry buyers for the uptake and use of low-carbon materials. These would be rewarded in return for meeting an emissions threshold (e.g. an end product standard). 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 area in return for reducing whole life carbon in construction projects, or giving users of low emissions shipping fuel 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).

Priority for implementation by sector

We have developed an indicative prioritisation of each policy lever by sector, based on the share of demand this lever 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. In kind incentives could be relevant across a range of sectors, but will likely be supplementary to other demand stimulating levers discussed in this document.

Sector	Aviation	Maritime	Chemicals	Aluminium	Cement	Steel
Prioritisation	Low	Low	Low	Low	Low	Low

Included for deep dive in this report

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Non-financial incentives

Key Attributes: In-kind incentives for use of decarbonised products/services

Carbon leakage risk

Low | Medium | High

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.

Burden of cost

Government | Shared | Industry

In order to gain the non-financial incentives, industrial players will need to make the necessary investments in low/ near zero carbon materials and fuels to qualify.

Technology Agnostic

Specific | Some flexibility | 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.

Long term stability

3-5 yrs | 5 – 15 yrs | 20 – 30 yrs

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 / near zero commodities scales up and more demand-side players become eligible.

Ability to ramp up over time

Low | Medium | High

The eligibility criteria can be tightened over time, to increase GHG emission reductions. The criteria can also be expanded across various categories of materials used.

Complexity

Low | Medium | High

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

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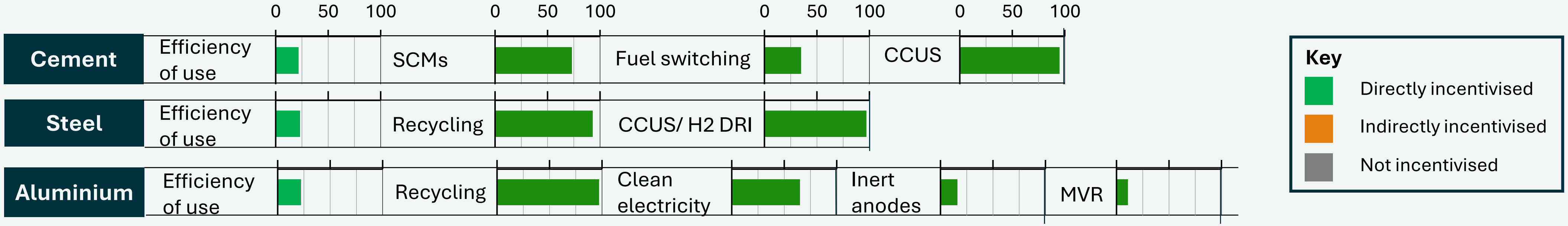
Non-financial incentives

Deep Dive – In-kind incentives in the construction sector

Potential Life cycle emissions reduction of decarbonisation levers incentivised by policy

Indicative potential % lifecycle emissions reduction vs fossil counterfactual by lever (see details in Annex 1)



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/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 cooperation between multiple authorities may be needed for in-kind incentives to have an significant impact on an industrial scale.
- **Scope and eligibility:** Policymakers should determine the type of building this applies (e.g. newbuilds vs retrofits, residential, commercial, and their various sub-categories) to 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, implementation of the incentives, and reporting and monitoring of the effectiveness of the programme.

Sources: US Department of Energy, Baker Mckenzie, GRESB

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Non-financial incentives

Implementation examples of In-kind incentives in Construction

Examples of in-kind incentives

Jurisdiction	Description of policy	Status
USA	**Seattle Priority Green**: Projects receive priority for permits approval processes, saving at least 3 months (roughly 50%) from intake to issuance, for meeting certain environmental criteria, including "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 250 ft^2 of carbon-negative material (for town homes).	In place (and enforced)
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.	In place (and enforced)
Peru	**Municipal Ordinance No. 610-MSB and Municipal Ordinance No. 496-MSB**: Municipal government schemes reward developers with additional 1-4 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.	In place (and enforced)

Sectors: Steel, Aluminum, Concrete

Covers >=10% demand | <10% of demand | Demand coverage uncertain | In place (and enforced) | In place, but to be implemented | Under consideration

Sources: US Department of Energy, Singapore Building & Construction Authority, GRESB

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Non-financial incentives

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 3 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, with criteria including goals for reduced embodied carbon.

Construction value chain

Stakeholders impacted

Project developers: Project plans must meet the eligibility criteria to reap the benefits from the programme. This includes obtaining green building certification. To do so, they would have to shift to clean energy, use EPDs, reduce material and energy use, etc.

Planning & Design → Production & Transport of materials → Construction → Operations & Maintenance → End of life

Directly Impacted: Planning & Design
Indirectly Impacted: Production & Transport of materials, Construction, Operations & Maintenance, End of life

Impact

- Despite the voluntary nature of the programme, 52% of homes in Seattle have obtained Built Green certification as of 2016, and in 2022, 41% of Seattle's office buildings are LEED-certified.
- **Case study**: The Seattle Storm Centre of Basketball Performance is a recent project that qualified for Priority Green. The 50,000 sq ft building uses lower-carbon concrete for its tilt-up concrete panels for the exterior. 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.

Credit: Sellen Construction

- The impact on GHG emissions reductions over the policy as a whole remain unclear. A study by Washington Policy Centre suggests that LEED-certified buildings only produced 5% fewer GHG emissions than uncertified buildings.
- The programme currently focuses on disclosure of embodied carbon through Product Declaration (EPDs), as opposed to setting strict limits, although developers must meet the embodied carbon requirements under certifications (e.g. Built Green). Thus, it currently may not create a significant impact in reducing embodied carbon of buildings, although it is expected to enforce limits in future.

Source: BloombergNEF, CBRE, US Green Building Council, Geekwire, Washington Policy Centre, Carbon Leadership Forum, Daily Journal of Commerce, Sellen Construction

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

Key challenges/risks

May not achieve significant environmental impact	• To achieve embodied emissions 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.
Increases strain on public agencies processing permits	• Increased manpower and resources are needed to approve projects for Priority Green (e.g. in 2018 there were 165 project applications), and to expedite the permit process for projects. A new department was created within the Seattle Department of Construction & Inspections, along with an online self-help portal.
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 decided not to explicitly include embodied carbon limits but to focus on disclosure through EPDs, and demonstration of meeting third party certification

Source: BloombergNEF, CBRE, US Green Building Council, Geekwire, Washington Policy Centre, Carbon Leadership Forum, Daily Journal of Commerce, Sellen Construction

Thank you

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Annex 1 - Sectoral decarbonisation levers

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Aviation decarbonisation levers

Decarbonisation lever	Efficiency	Drop-in SAF		
		HEFA	Alcohol to Jet & Gasification/FT	Power-to-Liquid
Description	Upgrading aircrafts, using the most fuel-efficient jets	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. hydrogen (derived from water) and carbon dioxide.
Technology maturity	Various	8-9	7-8	5-8
% lifecycle reduction potential vs fossil incumbent	15-20%	73-84%	85-94%	99%

Source: WEF Clean Skies for Tomorrow, European Union Aviation Safety Agency, Umwelt Bundes Amt

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Maritime decarbonisation levers

Decarbonisation lever	Efficiency	Novel propulsion aircraft	
		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 green 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 7-8
% lifecycle reduction potential vs fossil incumbent	-25-30%[1]	Up to -90%[2]	Up to 95%[3]

Sources: UMAS, Getting to Zero Coalition, Lloyd's Register, Methanol Institute, MPP Maritime Sector Transition Strategy

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 synthetise 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 synthetized.	Hydrogen is produced via biomass gasification or biomethane reforming (releasing non-fossil CO_2).
Technology maturity	Various	TRL 7-9	TRL 7-8	TL 6-7	TRL 3-7
% lifecycle reduction potential vs fossil incumbent	-4%	-96% (scope 1)	-100% (scope 1)	-100% (scope 1)	-100% (scope 1)

Source: MPP Making Net Zero Ammonia Possible

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Steel decarbonisation levers

Decarbonisation lever	Material efficiency	Steel recycling	Primary steel production		
			H_2-DRI	Steel w/ 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 4
% lifecycle reduction potential vs fossil incumbent	-23% (based on the steel demand it can reduce)	-93%	-97% to -98% (if based on low-carbon electricity)	-90% to -96%	-97% (if based on low-carbon electricity)

Source: MPP Making Net Zero Steel Possible, WEF Steel industry net-zero tracker

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Aluminium decarbonisation levers

Decarbonisation lever	Material and resource efficiency	Recycling of Al	Primary aluminium production		
			Low carbon elec.	Inert anodes	MVR for digestion
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 PPAs, CCS retrofit).	Replacement of conventional carbon anodes with innovative inert anode technology to cut process CO_2 emissions.	Mechanical Vapour Recompression (MVR) instead of fossil boilers to provide steam for alumina digestion
Technology maturity	Various	TRL 9	TRL 8-9	TRL7	TRL 7
% lifecycle reduction potential vs fossil incumbent	-22%	-97%	-65%	-16%	-11% (if low-carbon electricity)

Source: MPP Making Net Zero Aluminium Possible

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Cement decarbonisation levers

Decarbonisation lever	More efficient use of concrete	Reduction of clinker content	Fuel switching to waste and biomass	Kiln electrification	CCUS
Description	Reduction in concrete demand through optimization measures (e.g. improved design, precast concrete).	Substitution of clinker (i.e. the CO_2 bearing material) by 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) instead of fossil fuels.	Cement plant retrofitted with carbon capture, utilisation and storage.
Technology maturity	Various	TRL 9 (for most SCMs)	TRL 9	TRL 4	TRL 6-9
% lifecycle reduction potential vs fossil incumbent	-22% (indicative)	-2% to -73% (depending on SCM and compared to Portland cement)	Up to -35% (if fuel is 100% biogenic)	Up to -35% (if low-carbon electricity)	Up to -95% (depending on capture rate)

Source: MPP Making Net Zero Concrete and Cement Possible

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Annex 2 – policy lever selection

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Prioritization of policies by sector

This section prioritizes the various policy levers by sector according to 2 factors:

Factor	Definition	Rating	Assessment Criteria
Demand coverage	What is the maximum share of demand in the industry that this policy could apply to?	Low	Applicable to <<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 impact on a 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 / can come close to bridging the full green premium

Based on the ratings, we provide an overall assessment on whether the policy is identified as high priority in the playbook

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 ~25% of demand (with a much higher share in some countries e.g. India)	If emissions thresholds are sufficiently stringent, can create a market for decarbonised steel. Many projects may involve a large share of recycled steel.	High	Buy Clean

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Aviation fuel – policy prioritisation

Government policies	Demand coverage (Rating and rationale)	Impact on business case (Rating and rationale)	Priority[1]	Deep Dive included	Case Study
Green Public procurement	Public sector procurement accounts for only a small share of aviation fuel – public procurement is therefore likely supplementary to other measures to build a SAF market.	Sends a direct signal to producers for the procurement of SAF – but likely spread across multiple flights	Medium		
State backed intermediaries[2]	Supports private sector to procure SAF by absorbing cost and risk. Limited by government risk appetite and capitalisation.	Can bridge green premium and provide certainty of offtake to fuel producers over the lifetime of a contract	High	Deep Dive	H_2Global*
Mandatory quotas	Could be set on an economy wide basis and cover up to 100% of the fuel pool. Limited by SAF supply and cost to industry.	Sends a clear and stable signal to industry. When enforced with sufficient penalties or buy out fees can significantly impact a business case	High	Deep Dive	ReFUELEU
Transportation fuel standard programs	Could be set on an economy wide basis and cover up to 100% of the fuel pool.	If part of a wider fuel standard programme with other sectors, may have limited impact due to a range of decarbonisation levers	Medium		
Carbon pricing	Could be set on an economy wide basis and cover up to 100% of the fuel pool.	Carbon prices must be sufficiently high and stable to bridge the green premium for SAF. With abatement costs of up to \$900/t in 2030, this has to be paired with other measures, or multiplied to drive SAF uptake	Medium		
Demand-side subsidies & tax credits	Could be set on an economy wide basis and theoretically cover up to 100% of the fuel pool. Limited by government funding and SAF supply.	Reduces the green premium between SAF and conventional jet fuel, but depends on the extent of the subsidy, one key drawback is uncertainty over longevity of subsidy instruments	High		
In-kind incentives	Could potentially cover a significant number of departing flights from a certain jurisdiction	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: In theory could also be a blended finance measure

*Note – H2Global applies only to Power-to-Liquids

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Maritime fuel – policy prioritisation

Government policies	Demand coverage (Rating and rationale)	Impact on business case (Rating and rationale)	Priority[1]	Deep Dive included	Case Study
Green Public procurement	Public sector procurement accounts for only a small share of maritime routes – public procurement is therefore likely supplementary to other measures	Government of zero emission ships and fuel can provide a clear signal on specific routes for the uptake of Scalable Zero Emission Fuels (SZEF)	Medium		
State backed intermediaries[2]	Supports private sector to procure SZEF. Limited by government risk appetite and capitalisation	Can bridge green premium and provide certainty of offtake to fuel producers over the lifetime of a contract	High	Deep dive	H_2Global
Mandatory quotas	Likely to only be set at the country / regional level, limiting the level that it could be taken up relative to global standards	Sends a clear and stable signal for demand – for international may be complicated to implement in conjunction with global standards	High	Deep dive	RED III
Transportation fuel standard programs	National programmes could incentivize inland shipping and potentially be used to provide indirect subsidies to international shipping	If based on a carbon intensity, a fuel standard may incentivise not only SZEF, but also blending of biofuels. In many standards, SZEF would compete with other fuels.			
Carbon pricing	National carbon pricing systems could be extended to inland shipping, An international GHG pricing mechanism is being developed by IMO with very potential coverage.	Carbon prices must be sufficiently high and stable to bridge the green premium for SZEF. With projected abatement costs of >>$100/t in 2030, this needs to be coupled with other measures to drive SZEF uptake			
Demand-side subsidies & tax credits	Could be set on an economy wide basis and theoretically cover up to 100% of the fuel pool. Limited by government funding and SZEF supply.	Reduces the green premium between SZEF & conventional fuels, one key drawback is uncertainty over longevity of instrument	High	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		

Note – for international shipping, a global fuel standard will be superseded by IMO measures (which are multilateral measures, capable covering very high demand shares and not a focus of this work). Supporting these should be treated as a priority for demand stimulation.

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 be a blended finance measure

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Chemicals (methanol and ammonia) – policy prioritisation

Government policies	Demand coverage (Rating and rationale)	Impact on business case (Rating and rationale)	Priority[1]	Deep Dive included	Case Study
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]	Government can leverage state owned enterprises to procure (or produce and use) green H2 as a feedstock. E.g., SOE Sinopec built a 260MW electrolyser for the chemical industry.	Medium		
State backed intermediaries[3]	Supports private sector to procure decarbonised inputs (e.g. H2, NH3, CH3-OH). Limited by government risk appetite and capitalisation	Can bridge green premium and provide certainty of offtake to fuel producers over the lifetime of a contract	High	Deep dive	H_2Global
Mandatory quotas	Could be set on an economy wide basis	Sends a clear and stable signal to industry. When enforced with sufficient penalties or buy out fees, it can significantly impact a business case. Mandates could either be for companies to use H2 or otherwise.	High	Deep dive	RED III
Embodied carbon limits for basic materials	Could be set on an economy wide basis	Lifecycle emissions targets could support decarbonisation of bulk chemical uses	Medium		
Embodied carbon limits on end products	Could be set on an economy wide basis, but likely to be challenging for some sectors	Unlikely to bridge the green premium, as the cost is fully borne on the industry	Medium		
Carbon pricing	Could be set on an economy wide basis	Carbon prices likely to have some impact at moderate levels, but not bridge the cost gap for bulk chemicals such as methanol an ammonia until >>$100/t$CO_2$	Medium		
Demand-side subsidies & tax credits	Could be set on an economy wide basis and theoretically cover up to 100% of decarbonised supply. Limited by government funding.	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	RED III
In-kind incentives	Could be set on an economy wide basis	Could somewhat compensate for the green premium through in-kind incentives	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

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Aluminium – policy prioritisation

Government policies	Demand coverage (Rating and rationale)	Impact on business case (Rating and rationale)	Priority[1]	Deep Dive included	Case Study
Green Public procurement	Given the (relatively to concrete / steel) low share of aluminium usage in buildings, we rate the demand coverage medium for GPP for aluminium	May not successfully drive demand for aluminium as other materials (e.g. cement / concrete) make up much larger share of emissions	Medium		
State backed intermediaries[2]	Could effectively cover 100% of the aluminium market, or applied at the sector level (e.g. automotive)	Efficient method of reducing green premium through implementing competitive mechanisms	Medium		
Mandatory quotas	Could either be set at an economy wide basis, or could be set on individual sectors (e.g. automotive). Would likely start as a small share and increase over time.	May create a differentiated green Al market; Could be targeted at sub-sectors with highest WtP (e.g. automotive). May backfire by incentivising material substitution	High	Deep Dive	Theoretical example
Embodied carbon limits for basic materials	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 CI 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. May risk substitution w/ other materials rather than driving aluminium demand	High	Deep Dive	Theoretical example
Carbon pricing	Could be applied at an economy wide level, to create an effective pool of demand likely to need to be coupled w/ 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	Could be applied at an economy wide level, constrained by public finances made available	Reduces the green premium between green and conventional inputs, on key drawback is 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	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

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Cement and Concrete – policy prioritisation

Government policies	Demand coverage (Rating and rationale)	Impact on business case (Rating and rationale)	Priority[1]	Deep Dive included	Case Study
Green Public procurement	The public sector accounts for 40 – 60% of concrete sales.	If emissions thresholds are sufficiently stringent, can create a market for decarbonised concrete / cement.	High	Deep Dive	Buy Clean
State backed intermediaries	Depending on the share of demand from the private sector, this measure may cover a majority of the demand	Efficient method of disbursing subsidies through implementing competitive mechanisms to ensure the minimum amount is paid	Low		
Mandatory quotas	Could cover up to 100% of cement / concrete use in a given region (and would become more stringent over time). Would likely start as a small share and increase over time.	Can create a differentiated market for decarbonised cement (particularly given limited alternatives)	High	Deep Dive	Theoretical example
Embodied carbon limits for basic materials	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 CI reduction rates before 2030	Medium		
Embodied carbon limits on end products	Could be applied in housing and construction sector which accounts for almost all concrete consumption	Limits likely to be set at building level; since concrete and steel are key contributors to embodied carbon in buildings, these will likely support a low carbon cement market too	High	Deep Dive	RE2020
Carbon pricing	Could cover up to 100% of cement / concrete use in a given region and be applied to imports if cement/concrete were subject to a carbon border tariff	Carbon prices of ~$100-160/t CO_2 are expected to substantially support driving several cement decarbonisation levers	High	Deep Dive	EU ETS
Demand-side subsidies & tax credits	Could be applied at an economy wide level, constrained by public finances made available	Reduces the green premium between green and conventional inputs, on key drawback is uncertainty over longevity of subsidy instruments	Medium	Deep Dive	CCFD
In-kind incentives	Can be applied to all cement and concrete used in an economy	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

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Iron and Steel – policy prioritisation

Government policies	Demand coverage (Rating and rationale)	Impact on business case (Rating and rationale)	Priority[1]	Deep Dive included	Case Study
Green Public procurement	Public procurement of steel accounts for ~25% of demand (with a much higher share in some countries e.g. India)	If emissions thresholds are sufficiently stringent, can create a market for decarbonised steel. Many projects may involve a large share of recycled steel.	High	Deep Dive	Buy Clean
State backed intermediaries	Could theoretically scale to cover all private sector supply/demand, but limited by government funding/risk appetite (~75%)	Efficient method of reducing green premium through implementing competitive mechanisms	Medium		
Mandatory quotas	Could either be set at a sector wide basis or set at sub-sector level (e.g. automotive). Would likely start as a small share and increase over time.	Can create a differentiated market for steel; could be targeted at sub-sectors with highest WtP (e.g. automotive). May backfire by incentivising material substitution instead	High	Deep Dive	Theoretical example
Embodied carbon limits for basic materials	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	May be difficult to create for specific products, but may be possible in some sectors (e.g. automotive).	Given steel is a key contributor to embodied carbon in construction and automotive, they can support green steel market. Some sectors may prefer recycled steel.	High	Deep Dive	RE2020
Carbon pricing	Could be set on an economy wide basis, and could be applied to imports and exports alike if steel were subject to a carbon border tariff	Carbon prices of ~$100-200/t with sufficiently low H2/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	Could be applied at an economy wide level, constrained by public finances made available	Reduces the green premium between green and conventional inputs (up to 100%); Key drawback is uncertainty over longevity of subsidy instruments	Medium	Deep Dive	CCFD
In-kind incentives	Could be applied at a sector or sub-sector level, as incentives typically differ	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

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Glossary (1/4)

Key terms

Term	Definition
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 emission reduction policies in another country that lead to the relocation of production to regions with less stringent environmental regulations.
CCUS	Carbon capture, utilisation and storage is the capture of carbon dioxide from large point sources (e.g. power generation or industrial plants utilising fossil fuels), compression, transportation, utilisation, and/or storage, which typically occurs through injecting CO_2 into deep geological structures.
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. For example, in shipping, this would include reducing speed or increasing the vessel size.
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 used in the USA that details the life-cycle environmental impact of a product.
Emissions Trading System (ETS)	A "cap and trade" system where an emissions cap is placed on a specific group of organisations, who 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).

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Glossary (2/4)

Key terms

Term	Definition
Fuel Switching	Replacing the fuel feedstock or source, e.g. from natural gas to green hydrogen, to generate power for an industrial process
Global Cement and Concrete Association (GCCA)	GCCA is an international association seeking to build a resilient and sustainable future for the concrete and cement industry and the world. Its members account for 80% of the global cement industry output (excluding China's output, although its members include some Chinese manufacturers).
Green premium	The price differential 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
Government procurement mechanism	A demand stimulation policy mechanism that channels public funds towards the procurement of goods and services.
Grey materials/fuels	Materials or fuels that are produced with the use of fossil fuels
Hard-to-Abate (HTA)	This term refers to sectors (e.g. steel, cement, maritime) that are traditionally carbon intensive and high emitting, and have had slow progress in decarbonisation
Hydrogen-based direct reduced iron (H2-DRI)	H2-DRI is a low-carbon steel produced using iron obtained by removing oxygen from iron ore using low-carbon hydrogen and carbon monoxide.
Industrial Deep Decarbonisation Initiative (IDDI)	IDDI is a major collaborative effort launched by United Nations Industrial Industrial Development Organization (UNIDO) and the Clean Energy Ministerial 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.

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Glossary (3/4)

Key terms

Term	Definition
Lifecycle Assessment (LCA)	LCA is the measurement of the environmental impact of a product across its lifecycle from design and production to end of life.
Mandatory mechanism	A demand stimulation policy mechanism that places a regulation upon a targeted set of actors, by which they must comply to
Market-based mechanism	A demand stimulation policy mechanism that uses incentives to bridge the green premium and encourage the adoption of green materials/fuels.
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 countries under the Paris Agreement.
NH_3	The chemical structure for ammonia
Non-financial incentives	Non-financial benefits, such as access to advisory services, knowledge transfer, or streamlined processes that can increase the attractiveness of products or projects (e.g. expedited permit approval process, reducing overall construction time for a building)
Power-to-Liquid (e-SAF)	e-SAF 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.
Recycling (of materials)	The use of scrap materials in the production of new materials / products that are of the same quality and standard as those made from new raw materials

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Glossary (4/4)

Key terms

Term	Definition
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)	SZEF are fuels such as green hydrogen 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
Zero Emissions Vehicles (ZEV)	ZEV are vehicles that do not produce any GHG emissions when in use, e.g. battery electric vehicle, hydrogen fuel cell vehicles.