

**First Movers**  
Coalition



# First Movers Coalition: Status Report

WHITE PAPER

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# Foreword



**Rob van Riet**  
Programme Head,  
Climate Action and  
First Movers Coalition,  
World Economic Forum



**Annie Hills**  
Senior Advisor,  
United States Special  
Presidential Envoy for  
Climate, US Department  
of State

Prior to the landmark Paris Agreement emerging out of COP21 in 2015, high-emitting sectors across heavy industry (steel, cement, chemicals and aluminium) and heavy-duty transportation (aviation, shipping and trucking) were generally regarded as difficult, if not impossible to decarbonize. Due to complex and integrated industrial processes, combined with solutions that carry a significantly higher cost than current carbon-intensive technologies, these sectors were given the label “hard-to-abate” and put on the backburner in global climate mitigation efforts.

The clear objective of the Paris Agreement to limit warming to well below 2°C, ideally to 1.5°C, above pre-industrial levels made it clear that we need to reach net-zero CO<sub>2</sub> emissions around mid-century or shortly thereafter. This brought back into sharp focus the necessity of tackling these sectors, which are economically essential, but account for around a third of global emissions and represent a major proportion of companies’ scope 3 upstream emissions.

One of the challenges in decarbonizing these sectors is that around 50% of the reductions needed to achieve net-zero emissions by 2050 need to come from technologies not yet commercially available at scale. In response to this challenge, the US Government, under the auspices of the Office of the Special Presidential Envoy for Climate, and the World Economic Forum joined forces to launch the First Movers Coalition (FMC). Announced by US President Biden at COP26 in 2021, FMC is designed to build early demand for decarbonized solutions through purchasing commitments made by members, to help accelerate the adoption of breakthrough near-zero emissions technologies and reach commercial scale by 2030.

In the two-and-a-half years since its inception, the coalition has gone from strength to strength. Today, FMC sends an unparalleled demand signal for near-zero-emission products and services: around \$16 billion in aggregated demand by 2030 and an estimated 31 million tonnes of carbon dioxide equivalent in annual reductions.

This report strives to provide an overview of the activities FMC has undertaken across the sectors it has launched, to report on the evolution of the initiative, and to provide inspiring examples of FMC members moving from commitment to

implementation – such as through value chain collaboration, investments, joint ventures and offtakes. We hope this report provides a useful reference document for FMC members, prospective members, government partners and other stakeholders in the decarbonization ecosystem with whom FMC has collaborated over the years – and hopes to collaborate with going forward.

This last point is important. FMC’s progress since late 2021 is certainly impressive, but now is not the time to take our foot off the accelerator. We are approaching the halfway point in this “decade of action” and the window of opportunity to demonstrate and commercialize these innovative technologies is rapidly closing, given the urgency to scale-up them up sufficiently to enable net-zero emissions by 2050.

We are also aiming at a moving target, as global demand across these economically essential sectors is projected to climb steeply in the coming decades: an 80% increase for aluminium, 40% for cement and concrete, and 30% for steel, while demand for sea freight is predicted to triple and that for trucking to double by mid-century. Across FMC sectors, we are seeing challenges around uncertainty of supply in the coming years, delayed timelines and obstacles for projects in reaching final investment decisions (FIDs), along with concerns around prohibitively high green premiums.

In summary, FMC remains committed to building credible demand for these near-zero emission technologies and working with buyers, suppliers, financiers, policy-makers and non-governmental stakeholders to translate purchasing commitments into real-economy investments. On a positive note, the industry decarbonization ecosystem is considerably more crowded with actors and initiatives driving net-zero action than a decade ago, when the prevailing sentiment tended to regard these sectors as too-hard-to-abate. Today, the topic of eliminating emissions from heavy-duty industry and transportation is firmly on the agenda and pathways, partnerships and policies to get there are emerging. This report is therefore as much an update on what FMC has done to date as it is an invitation to readers and their organizations to deepen their collaboration with our coalition to continue driving greater impact in the future.

# Executive summary

The global goal to reach net-zero greenhouse gas (GHG) emissions by 2050 is critically dependent on the transformation of high-emitting sectors such as long-haul transportation (aviation, shipping, trucking) and industrial materials (aluminium, cement/concrete, steel) that account for roughly 25% of annual global GHG emissions; without interventions, this share could grow to 50% by 2050.

Half the emissions reductions needed to achieve net zero are expected to come from technologies not yet available at scale. Building early market demand for such technologies by 2030 is critical to help scale-up and catalyse their mainstream adoption for carbon-intensive sectors.

This status report captures the goals and achievements of the [First Movers Coalition \(FMC\)](#) since its launch in November 2021. In less than three years, members of the FMC – an initiative co-launched by the World Economic Forum and the US government (through the Office of the US Special Presidential Envoy for Climate) – have generated

the world's largest private sector demand signal for breakthrough low-carbon technologies, which typically deliver 80% or more of carbon abatement.

In total, 99 corporate members have made more than 125 commitments across FMC's seven sectors (in heavy transport and industry mentioned above, plus carbon dioxide removal). By 2030, these commitments will represent an annual demand of around \$16 billion for near-zero technologies – delivering an estimated 31 million tonnes (Mt) of carbon dioxide-equivalent (CO<sub>2</sub>e) in annual emissions reductions.

The FMC also counts 13 governments as partners. During 2023-24, FMC convened three in-country workshops in [Brazil](#), [India](#) and [South Africa](#), each of which attracted upwards of 100 attendees from across industry value chains, government and finance for three days of presentations, plenaries and breakout discussions on key levers across policy, regulations and finance to accelerate domestic supply relevant to meeting FMC commitments.



**Aviation** accounts for ~3% of global GHG emissions, but this share could quadruple by 2050 without deep decarbonization. The FMC has secured commitments from 28 companies to replace at least 5% of conventional jet fuel demand with sustainable aviation fuels (SAF) that reduce life-cycle emissions by at least 85%. While SAF offer the sector one of the quickest pathways to decarbonization, the volumes produced represent less than 1% of total jet fuel demand. Stand-out achievements by FMC and its members:

- [Sustainable Aviation Challenge](#) – attracted 129 submissions from innovators looking to decarbonize aviation, of which 16 were selected to join the new [First Suppliers Hub](#).

- Bank of America and Delta, plus EcoLab, have developed the world's first large-scale [SAF hub in Minnesota](#), where Delta aims to use SAF for more than 10% of its fuel by 2027, rising to 50% by 2035.
- June 2023: Publication of the [Sustainable Aviation Fuels: Offtake Manual](#); a SAF85 Technical Brief will follow in summer 2024.
- Regional insights on the sector from the [Brazil](#) and [India](#) in-country workshops.

**Shipping** accounts for over 2% of global GHG emissions, with maritime trade volumes set to triple by 2050. The FMC has secured commitments from 17 companies to power deep-sea shipping with zero-emission fuels (ZEF). Carriers must use at least 5% ZEF by 2030, while cargo owners must use ZEF-powered ships for 10% of goods by 2030, rising to 100% by 2040. Stand-out achievements by FMC and its members:

- Maersk has launched the world's first two dual-fuel methanol-enabled container vessels, including the 350-metre, [16,592 TEU "Ane Maersk"](#), with 25 such vessels delivered or on order.
- December 2023: Publication of [Fuelling the Future of Shipping: Key Barriers to Scaling Zero-Emission Fuel Supply](#), which identifies the top 10 barriers limiting ZEF projects from getting past final investment decision (FID) phase.
- Regional insights on the sector from the [South Africa](#) in-country workshop.

**Trucking** accounts for ~4% of global GHG emissions, with demand for road freight set to double by 2050. The FMC has secured commitments from 16 companies to ensure at least 30% of heavy-duty and 100% of medium-duty trucks they buy or use will be zero-emission by 2030. In-scope technologies include battery-electric vehicles (BEVs) and hydrogen fuel-cell electric vehicles (FCEVs). Stand-out achievements by FMC and its members:

- Holcim has finalized orders with [Volvo Group](#) and [Mercedes-Benz Trucks](#) for 2,000 battery-electric heavy-duty trucks to be deployed by 2030 – the world's largest such commercial order.
- January 2024: Launch of the [Procurement Playbook Toward Zero Emissions Logistics Services](#), which offers two procurement strategies, transactional and transformational, each tailored for different scenarios.
- Regional insights on the sector from the [South Africa](#) in-country workshop.

**Aluminium** accounts for ~2% of global GHG emissions, with demand forecast to increase 40% by 2030. The FMC has secured support from 19 companies for two commitments: first to ensure at least 10% of primary aluminium procured will be low-carbon (emitting <3 tCO<sub>2</sub>e per tonne of metal produced, compared to today's average of 15.1 tCO<sub>2</sub>e); the second commitment is optional, to ensure at least 50% of aluminium procured is "secondary" (manufactured from scrap, saving 9 tCO<sub>2</sub>e per tonne of metal produced). Stand-out achievements by FMC and its members:

- [Ball Corporation announced the launch of its first low-carbon aluminium cup](#), made of 90% recycled aluminium supplied by Novelis and 10% FMC-compliant low-carbon primary aluminium, supplied by Alcoa from the Elysis™ process.
- [Novelis](#) has invested \$2.5 billion in a new recycling and rolling plant in Alabama.
- Regional insights on the sector from the [Brazil](#) in-country workshop.

**Cement and Concrete** account for ~6% of global GHG emissions, with demand projected to increase 40% by 2050. Decarbonization options include clinker substitution using non-fossil-based [supplementary cementitious materials \(SCMs\)](#). This newest sector of FMC has secured commitments from seven companies to ensure at least 10% of cement/concrete purchased is near-zero emissions by 2030 (excluding fossil-based SCMs by 2035). Near-zero means <184 kg CO<sub>2</sub>e/tonne for cement and 70-144 kg CO<sub>2</sub>e /m<sup>3</sup> for concrete (depending on compressive strength) – compared to a US average of 922 kg CO<sub>2</sub>e/tonne of cement produced. Stand-out achievements by FMC and its members:

- [Holcim](#) aims to offer 8 Mt of net-zero cement per annum by 2030, enabled by carbon capture, utilization and storage (CCUS) projects.
- [Heidelberg Materials](#) is collaborating with Norway's government to create the first full-scale carbon capture and storage (CCS) facility in the cement industry, due to open end-2024 with an initial capacity of 400,000 tCO<sub>2</sub> per year.
- January 2024: Publication of the [First Movers Coalition Cement and Concrete Procurement Guide](#).
- Regional insights on the sector from the [India](#) in-country workshop.

**Steel** accounts for ~8% of global GHG emissions, with demand forecast to increase 30% by 2050. The FMC has secured commitments from 27 companies that at least 10% of steel purchased by 2030 will be near-zero emissions – meaning <0.4t (0% scrap inputs) to <0.05t (100% scrap inputs) of CO<sub>2</sub>e/t crude steel produced. This compares to around 2.0 tCO<sub>2</sub>e/t crude steel produced emitted by the prevalent blast furnace-basic oxygen furnace (BF-BOF) method. Stand-out achievements by FMC and its members:

- In January 2024, FMC's [Near-Zero Steel Challenge](#), which aimed to surface new demand and supply, attracted over 100 submissions from 21 buyers, 17 suppliers and 71 enabling technology innovators.

- Steel producer SSAB, mining company LKAB and power producer Vattenfall have collaborated to create [HYBRIT \(Hydrogen Breakthrough Ironmaking Technology\)](#), which uses zero-carbon electricity and hydrogen to eliminate emissions from steelmaking. In September 2022, HYBRIT announced a new hydrogen storage facility that could reduce the variable cost of hydrogen production by 25-40%.
- [Scania](#) announced it will manufacture its heavy-duty trucks almost entirely from hydrogen-based steel by 2030 – in June 2023, Scania placed its [first order with Sweden-based H<sub>2</sub> Green Steel](#).
- [ZF Group](#) and [Marcegaglia](#) have signed offtake agreements with H<sub>2</sub> Green Steel for future near-zero steel supply worth €1.5 billion and €1.79 billion respectively.

**Carbon dioxide removal (CDR):** To hit the Paris climate goals will require 10 billion tonnes of CO<sub>2</sub> removal every year by 2050. The majority will have to come from durable CDR – solutions that can demonstrably store captured carbon for 1,000+ years. However, advance purchases stand at just [1.1 Mt today](#). While durable/engineered CDR scores highly on integrity, its scalability is hampered by high costs, lack of mature measurement, reporting and verification (MRV), and low support from policy-makers. Eleven companies have joined FMC's CDR commitment to contract for 50,000+ tonnes or \$25 million of durable and scalable CO<sub>2</sub> removal by 2030. Stand-out achievements by FMC and its members:

- Microsoft has signed an agreement with Ørsted to purchase [2.7 Mt of durable CDR credits](#) over 11 years, one of the largest ever carbon removal offtake deals. The agreement was part of the Ørsted Kalundborg CO<sub>2</sub> Hub, where ~430,000 tonnes of biogenic CO<sub>2</sub> per year will be captured and stored from 2026.
- In May 2024, Microsoft purchased an [additional 1.0 million tonnes of carbon removal](#) over 10 years from the same hub. The company, whose target is 5.5 Mt of CDR per year by 2030, accounts for ~64% of all engineered CDR purchases made to date.
- January 2024: Publication of [Carbon Dioxide Removal: Best-Practice Guidelines](#), which shares lessons from eight FMC members and seeks to lower entry barriers to the nascent removals market.

**FMC Finance** works to unlock cross-sector investment in zero-emission technologies through accelerating public-private collaboration in the “capital stack”. This requires overcoming the tension between venture-like risk and infrastructure-sized cheques. Concessional capital, blended finance and de-risking mechanisms are essential to open the way for private capital to scale-up this market. FMC Finance focuses on the pilot project and early

deployment phase, the “valley of death” when public and philanthropic capital is running out but concessionary capital and more adventurous equity is yet to kick in. Stand-out achievements by FMC:

- May 2024: Publication of [Scaling Clean Technology Offtakes: A Corporate Playbook for Net Zero](#), which explores ways to stimulate demand for SAF and green hydrogen, based on interviews with more than 20 suppliers, offtakers, financiers and public sector actors.
- **First Suppliers Hub:** launched in January 2024, it features suppliers’ projects that meet or are working to meet FMC commitment thresholds, which can be used by finance organizations to identify potential investment opportunities.
- Ripple effect of in-country workshops: e.g. FMC’s workshops in [India](#), which paved the way for a financing roadshow in mid-2024 focusing on green hydrogen; and in [South Africa](#), which surfaced opportunities for public-private engagement to drive development of green industrial value chains.

**FMC Government engagement** works with host governments on supportive policies, incentives, standards and mandates, which can accelerate the market for climate-critical technologies. The pillar’s goal is to build a deeper understanding between public and private sectors of the policy levers that might prove effective to accelerate industry decarbonization in specific country contexts. The pillar also aims to demonstrate to companies that there is significant public support for FMC’s work. Stand-out achievements by FMC and its partners:

- Since its launch, FMC’s [government partners](#) have increased from one (US) to 13 countries, collectively accounting for around half of global GDP.
- FMC convened three in-country workshops in [Brazil](#), [India](#) and [South Africa](#) to surface supply and discuss sector-specific policy measures.
- FMC convened meetings on the sidelines of other milestone events, e.g. Clean Energy Ministerial meetings, Singapore’s Ecosperity Week 2023, COP27 and COP28.
- December 2023: the UK government’s engagement with Brazil culminated in the launch of the [Brazil Industrial Decarbonization Hub](#).
- COP28: Sweden and India launched the [India-Sweden Industry Transition Platform](#) to strengthen collaboration on industry decarbonization.
- Forthcoming Briefing Paper: *Sector Conversations on Government Enablers and Barriers*.

**Way ahead:** Since late 2021, the FMC has nearly tripled its membership from 35 to 99 corporate members, who have made around 100 offtake agreements and investments across FMC's seven sectors. FMC will continue to seek credible companies capable of committing to large-scale purchases of near-zero fuels and materials. Advance offtake is critical because, without it, suppliers cannot get the financing they need to invest in near-zero technologies. As it enters its third full year, FMC aspires to be not only the place where members make their public commitments, but also the place where they can find the tools and partners they need to make good on those commitments.

The coalition will continue to organize in-country workshops (US and Japan are scheduled for 2024), as well as convene meetings on the sidelines of milestone events (e.g. COP) to facilitate collaboration and showcase examples of FMC members moving from commitment to action. Quarterly sector working groups will continue to give a space for FMC members to discuss opportunities and challenges, feature initiatives from FMC implementation partners, and offer a platform for FMC government partners to share relevant initiatives.

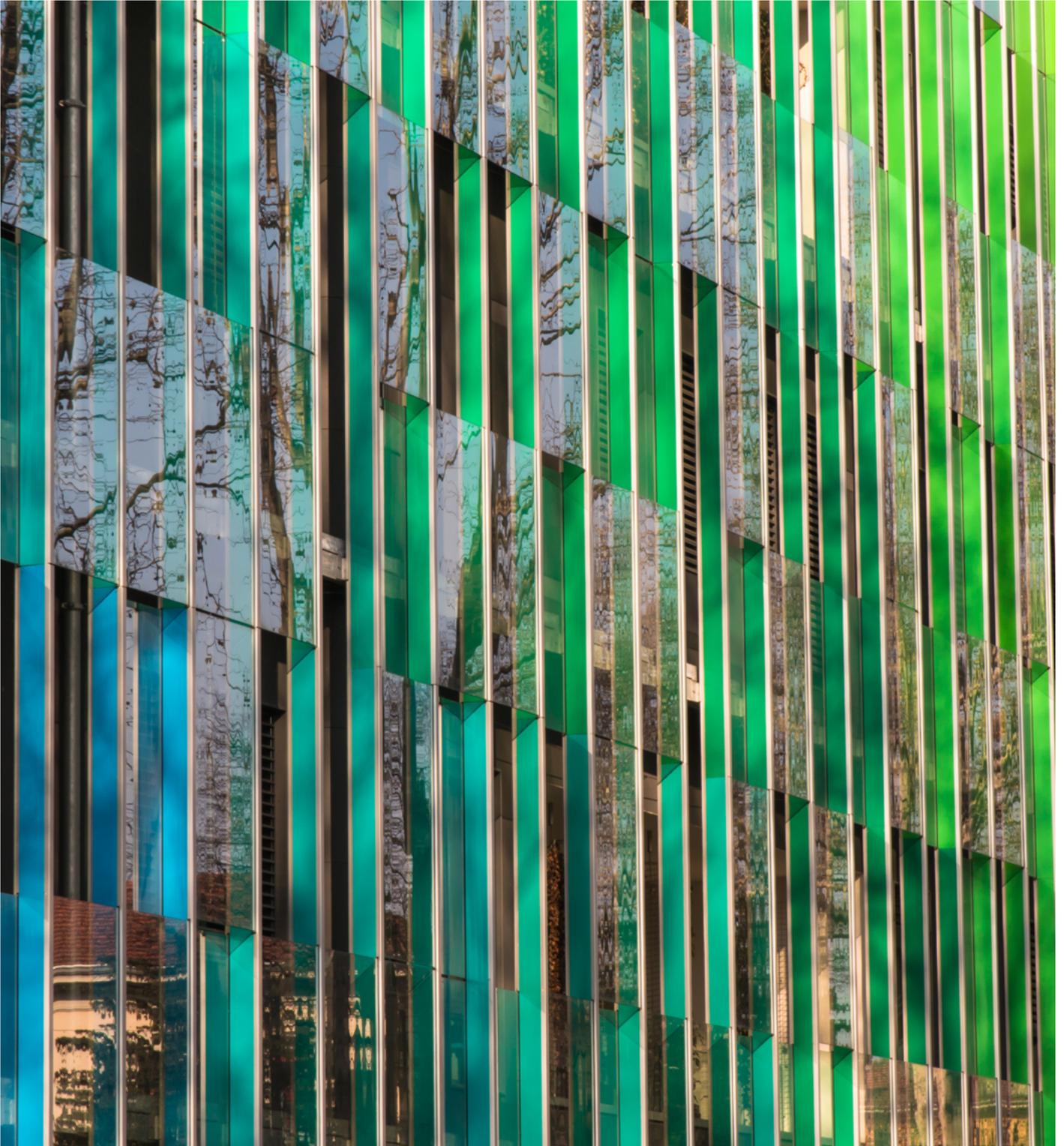
In addition, FMC has launched three related initiatives:

- **First Suppliers Hub** – a global, online repository of suppliers working on innovative and emerging zero-carbon technologies. Launched in January 2024, the hub already features 150+ projects from 100+ registered suppliers, while 400+ users have registered on the portal.
- **Procurement guides** – aimed at encouraging traditionally risk-averse Chief Procurement Officers (CPOs) to embrace new technologies. So far, four have been published on [aviation](#), [CDR](#), [cement/concrete](#) and [trucking](#).
- **Procurement innovation dialogues** – aimed at sharing innovative procurement practices and fostering strong partnerships among member companies. Started last year, the September 2024 edition will require CPOs to bring a CPO from one of their supply chain partners.



# Overview

In just two years, members of the First Movers Coalition have generated the world's largest private sector demand signal for breakthrough low-carbon industrial technologies.

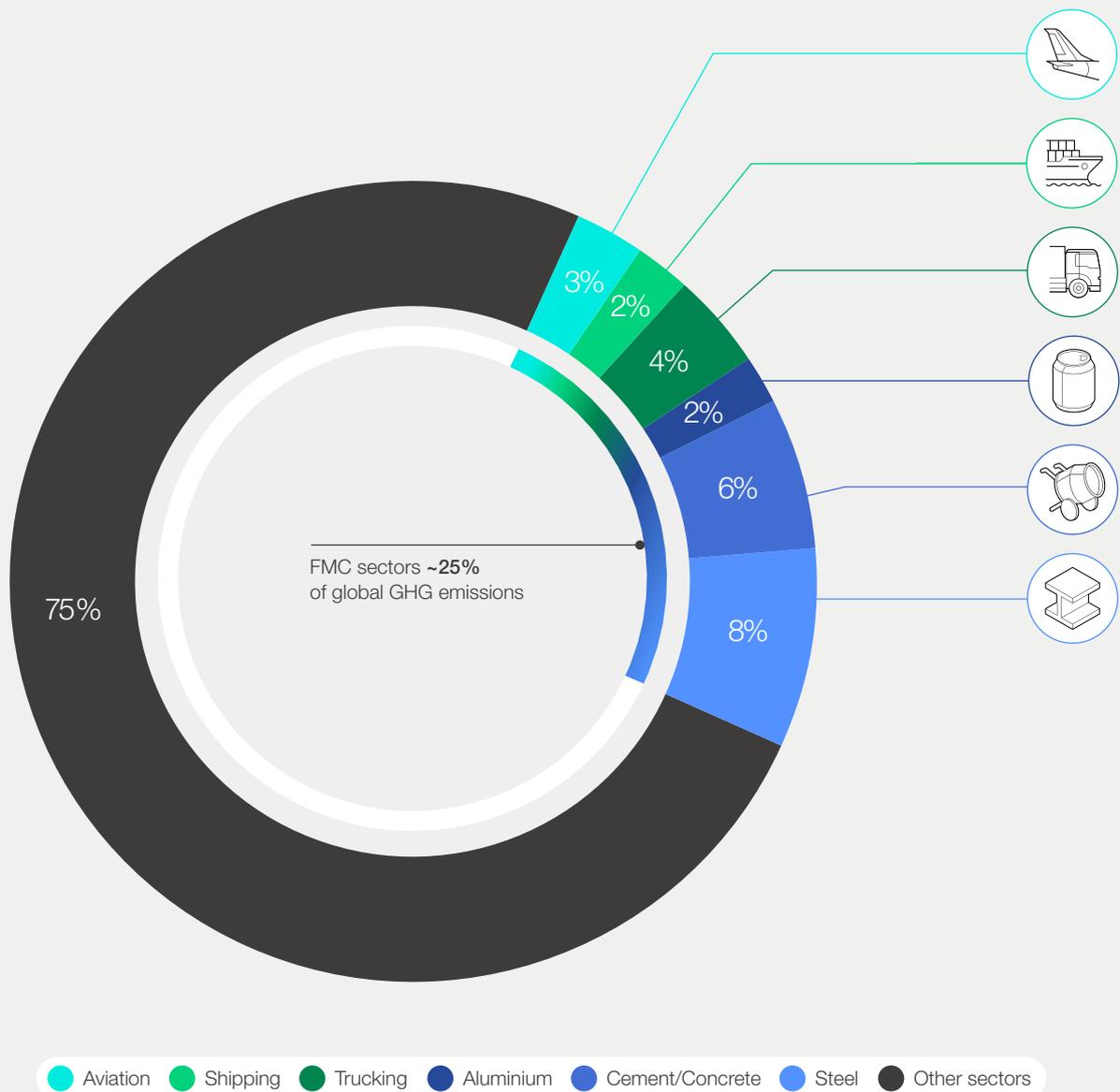


## Context: the challenge to decarbonize hard-to-abate sectors

Amid the intensifying climate crisis, the urgency to pivot towards a sustainable global economy is mounting. The collective ambition of global economies to achieve net-zero greenhouse gas (GHG) emissions by 2050 is critically dependent on the transformation of heavy industries, historically entrenched in high carbon footprints. The transition towards low-carbon technologies is emerging as the most significant economic realignment in recent history, affecting billions of lives and livelihoods. As such, this energy shift presents a unique opportunity, rendering breakthrough zero-carbon industrial products as the most valuable assets of the future.

High-emitting sectors such as long-haul transportation (aviation, shipping, trucking) and industrial materials (aluminium, cement/concrete, steel) account for roughly 25% of annual global GHG emissions (see Figure 1). When the chemicals industry is included (currently not within the ambit of FMC), these hard-to-abate sectors account for close to 30% of global emissions. Without interventions, this share is projected to grow to half of global emissions by 2050.

FIGURE 1 Global greenhouse gas (GHG) emissions, by FMC sector



# Mission and objectives of FMC

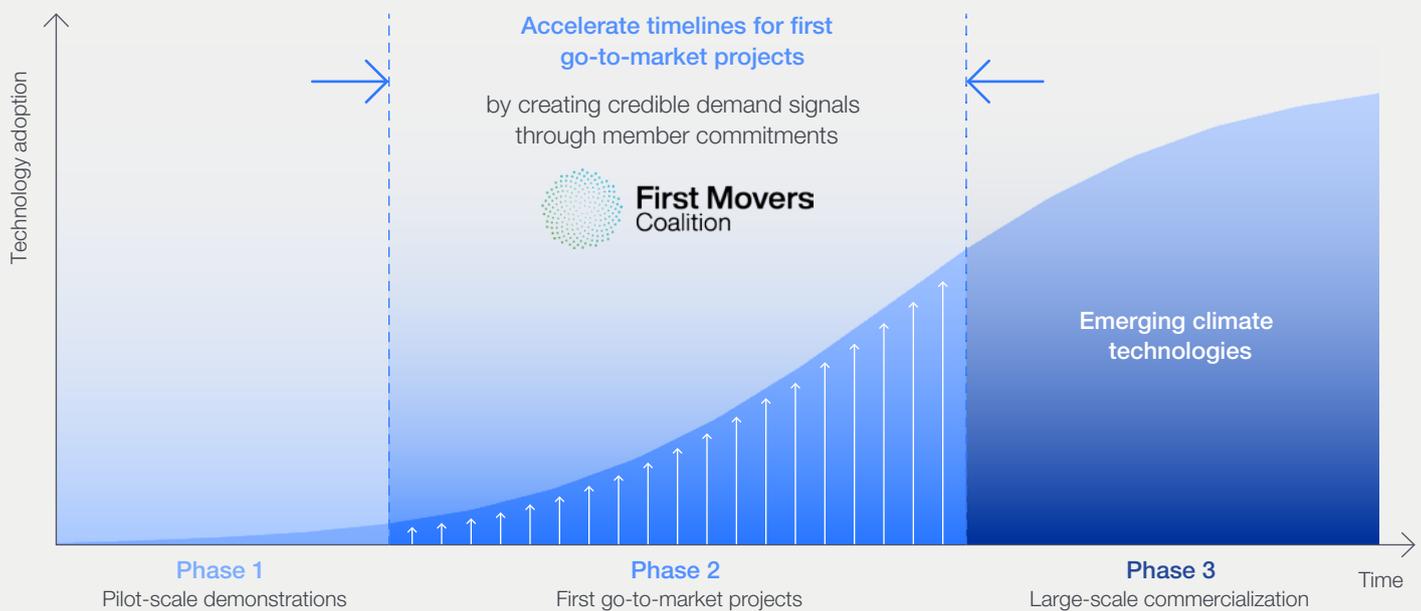
By 2050, 50% of emission reductions needed to achieve net zero are expected to come from technologies not yet available at scale. Building early market demand for such technologies by 2030 will be critical to help scale-up and catalyse their mainstream adoption for carbon-intensive sectors.

At the leading edge of this transformation challenge is the First Movers Coalition (FMC), an initiative by the World Economic Forum and the US Government,

under the auspices of the Office of the Special Presidential Envoy for Climate, that advances the most critical emerging climate technologies required to decarbonize heavy-emitting industrial sectors. By translating member purchasing commitments into the world's largest, credible demand signal and surfacing qualified suppliers that can meet the demand, FMC can accelerate first-in-market projects that deliver offtake agreements and enable members to achieve green procurement commitments.

FIGURE 2 FMC's goal is early uplift of emerging climate technologies

**FMC is the largest coalition of companies looking to scale emerging tech across hard-to-abate sectors through early demand signals**



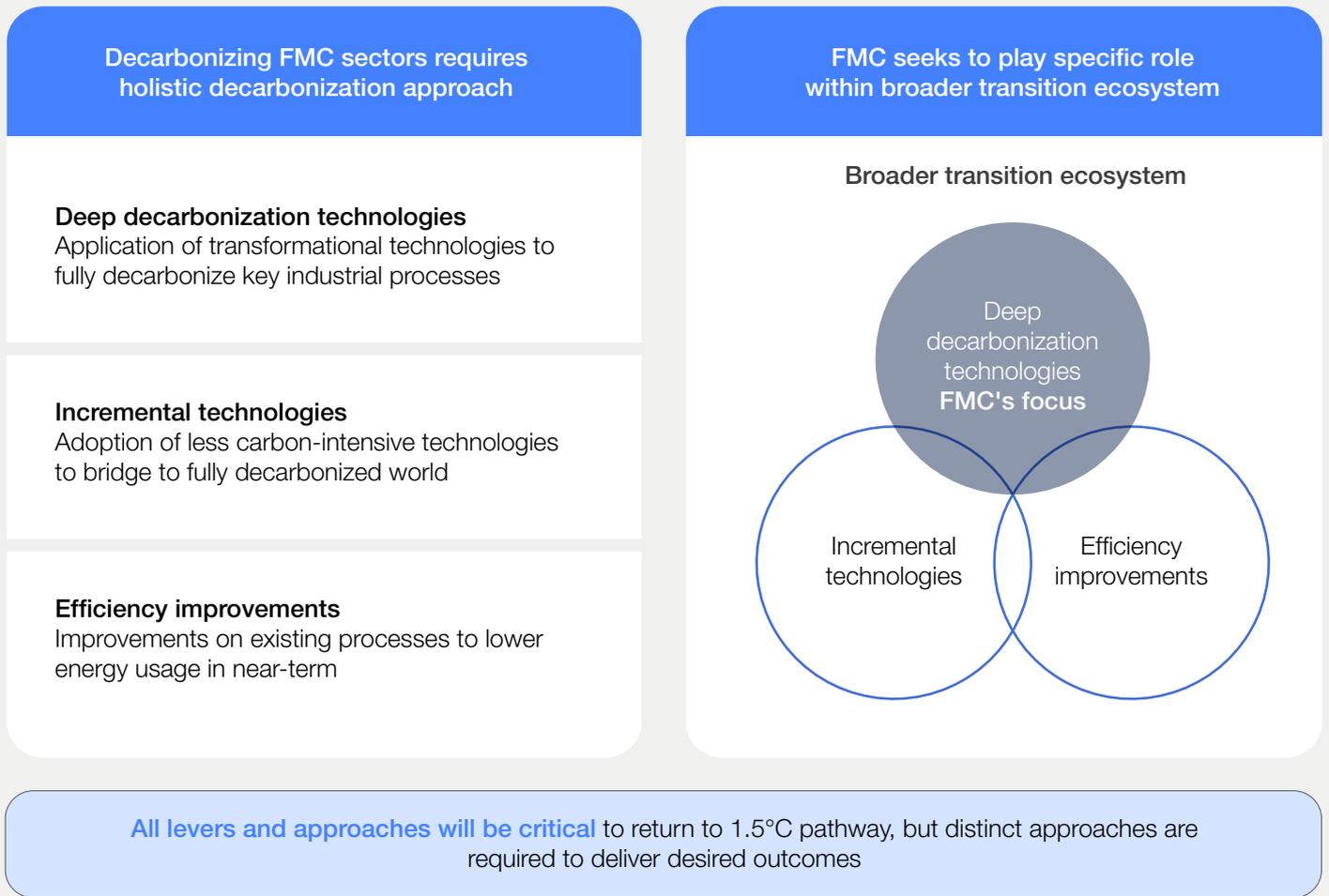
## How FMC works

FMC is laser-focused on only the most transformational near-zero emission technologies, typically those that deliver 80% or more of carbon abatement compared to business-as-usual fuels and materials. Every two years, FMC reviews these commitments to ensure that the coalition is focused on the right technologies and that the commitment language and structure are serving the function of drawing those technologies forward.

While efficiency improvements and incremental technologies play an important part in the transition, FMC consistently sets the highest bar for its seven sectors, comprising three in heavy-duty transportation (aviation, shipping, trucking), three in

heavy industry (aluminium, cement/concrete, steel), and carbon dioxide removal (CDR).

By joining FMC, members commit to purchasing emerging climate technologies, signalling strong support for green suppliers and enabling green purchases and investments. Their collective purchasing power sends a powerful demand signal to stimulate the market for essential climate technologies, driving investment and accelerating supply to meet corporate demand. This accelerates the development and cost reduction of these technologies, mirroring the advancements seen in now cost-competitive solar technology.



The coalition has achieved scale across the world's leading companies and support from committed governments around the world to tackle the hardest challenge of the climate crisis: reducing the emissions from the sectors where we don't yet have the toolkit to replace unabated fossil fuels and swiftly reach net-zero emissions.

John Kerry, US Special Presidential Envoy for Climate 2021-2024

## From commitment to action and impact

For the latest updates on impact data, corporate members, government partners, FMC reports, publications, sector-specific blogs and videos, visit the [FMC's Impact page](#).

In the two-plus years since its inception at COP26 in November 2021, FMC has become the world's largest private sector clean demand signal. Today, members are moving from commitment to action: signing offtake agreements to purchase new, clean technologies, driving demand within global decarbonization initiatives and fostering collaboration with global partners.

When FMC was launched, it had 35 members. As of today, FMC counts 99 corporate members that have made more than 125 commitments across

FMC's seven sectors. By 2030, these commitments will represent an annual demand of around \$16 billion for near-zero technologies – an estimated 31 million tonnes (Mt) of carbon dioxide-equivalent (CO<sub>2</sub>e) in annual emissions reductions. As FMC continues to grow, this premium demand signal will also grow, giving increasing confidence to the nascent market for these technologies and products. An encouraging data point is that over the past two years members have engaged in around 100 offtake agreements and investments across the seven sectors.

FIGURE 4 | Supporting members' move from commitment to action

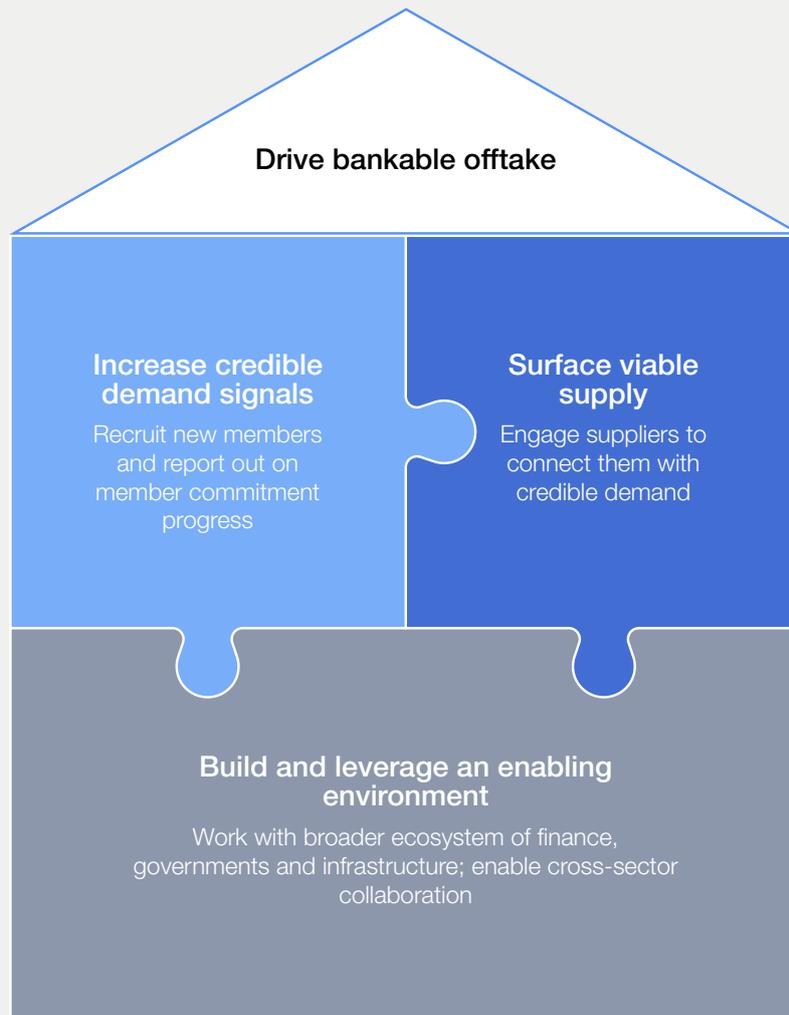


FIGURE 5 | FMC in numbers – impact to date



Some FMC members have participated in collaborative efforts across multiple sectors, pooling demand to further accelerate progress, including in the shipping, aviation, CDR and steel sectors: the [Zero Emission Maritime Buyers Alliance \(ZEMBA\)](#), [Sustainable Aviation Buyers Alliance \(SABA\)](#), the [NextGen carbon dioxide removals](#) facility, and the

[Near-Zero 2030 Steel Challenge](#) with the Rocky Mountain Institute (RMI). FMC has also worked with a large network of implementation partners, governments, standards authorities and more to further accelerate innovation in the most carbon-intensive sectors.



**The discussion and collaboration consistently encouraged by FMC have proven fundamental not only to share and test our vision and commitment for a decarbonized aluminium sector, but also to advance and scale efforts to meet the decarbonization targets we have adopted.**

Ramon Arratia, Chief Sustainability Officer, Ball Corporation

## Catalysing demand

For emerging technologies, the early demand demonstrated by FMC's members can prove catalytic. For example, FMC commitments represent 500,000-1,000,000 tonnes per year (0.5-1.0 Mtpa) in clean hydrogen demand by 2030. For green hydrogen, this translates to an estimated

150-300 new electrolyzers of 20 megawatt (MW) capacity each (assuming 100% utilization) and 9-30 gigawatts (GW) of new renewable electricity capacity. Alternatively, for blue hydrogen, this demand symbolizes 3-7 new facilities of 150,000 tonnes per annum (150 Ktpa) each.

FIGURE 6 **FMC commitments represent a significant hydrogen demand signal by 2030** (million tonnes per year, Mtpa)



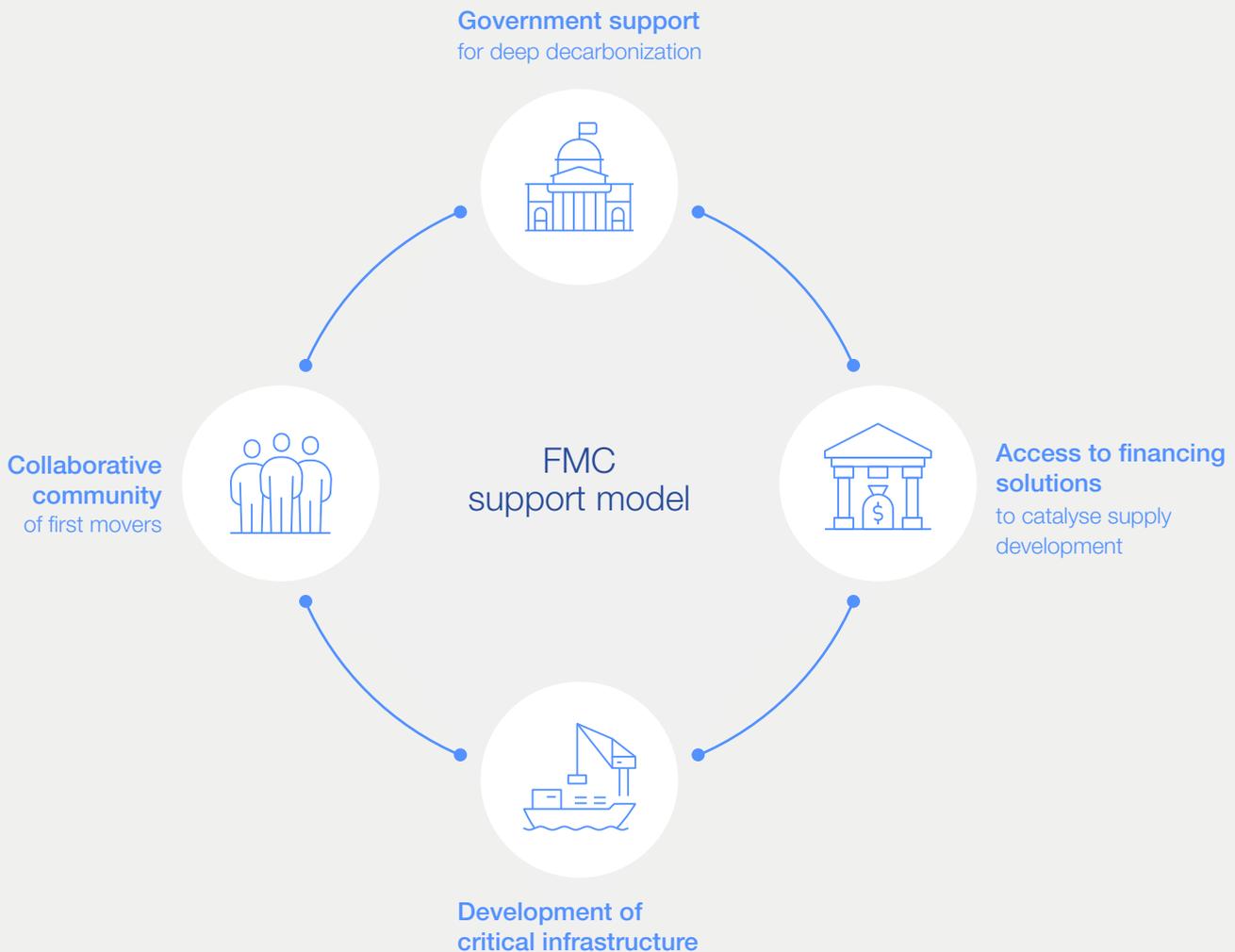
**Note:** PtL = power-to-liquid; SAF = sustainable aviation fuel; DRI=direct reduced iron; CCUS = carbon capture, use & storage; BEV = battery-electric vehicle; ATR = autothermal reforming; RES = renewable energy sources.

# Strengthening the ecosystem needed to decarbonize heavy industries

FMC's work reaches far beyond the corporate sector. Its vision is rooted in the realization that the transition to near-zero emissions industrial technologies requires all partners in the value chain to play their part. These include FMC's 13 government partners, international financial institutions, development banks and private finance players as well as the companies on the demand- and supply-side of the breakthrough technologies each sector needs.

These stakeholders convene regularly within the context of FMC working groups across sectors, as well as in-country workshops, where key players across the value chain can meet to discuss the state of decarbonization in FMC sectors. In addition to dedicated sector pillars, FMC has a Finance pillar (see Chapter 8) and a Government engagement pillar (see Chapter 9) to help strengthen the enabling environment of supportive regulation, incentives and blended finance needed to make the transition a reality.

FIGURE 7 FMC strengthens the decarbonization ecosystem



## In-country workshops

During 2023-24, FMC convened the following in-country workshops:

- **New Delhi, India (July 2023):** the workshop focused on three sectors: aviation, cement/concrete, and steel. [Read the report here.](#)
- **São Paulo, Brazil (October 2023):** the workshop focused on three sectors: steel, aluminium and aviation. [Read the report here.](#)
- **Cape Town, South Africa (March 2024):** the workshop focused on two sectors: shipping and trucking. [Read the report here.](#)

Each workshop attracted upwards of 100 attendees from across industry value chains, government and finance for three days of presentations, plenaries and breakout discussions. The workshops' aims were threefold:

- To identify the existing potential within the country to scale-up the supply of these technologies.

- To analyse the challenges and barriers to increasing both demand and supply of these near-zero emission solutions.
- To fashion the outcomes of the workshop into recommendations for a way forward.

In addition, in June 2023 FMC held a [workshop session on sustainable aviation fuel \(SAF\) in Singapore](#) during Ecosperity Week, an annual gathering of global business leaders, policy-makers, investors and civil society to address technology, policy and finance levers to drive the low-carbon transition.

Sector-specific insights, challenges and solutions from each of the three FMC in-country workshops, as well as the Singapore session, can be found at the end of each chapter.



**We truly value FMC's work during the organizing of the workshop session in Brazil, which resulted in a thorough report. We recognized all the work involved and we surely intend to keep those discussion alive in Brazil and reference FMC's report in many of the ongoing public-policy-related discussions.**

Janaina Donas, President, Brazilian Aluminium Association (ABAL)



## Status report

This status report captures the goals, objectives, actions and achievements of the First Movers Coalition over the first two-and-a-half years of its life since its launch in November 2021.

The report addresses each of the seven FMC sectors chapter by chapter, with additional chapters on FMC pillars for Finance and Government engagement. The Way ahead chapter includes a brief account of next steps and future projects.

1

# Aviation

Sustainable aviation fuels offer the sector one of the quickest pathways to decarbonization. FMC members are looking to procure fuel with over 85% carbon abatement potential.



## 1.1 Sector overview and status

International aviation currently accounts for nearly 3% of annual global GHG emissions,<sup>2</sup> but if the industry fails to deeply decarbonize, these emissions could double or even quadruple by 2050. Meanwhile, the global policy environment is tightening around aviation. In 2022 the International Civil Aviation Organization (ICAO) declared its long-term aspirational goal (LTAG) for international aviation to achieve net-zero carbon emissions by 2050, and in 2023 a 5% carbon emissions reduction target was agreed for 2030, to be achieved through increased use of sustainable aviation fuels (SAF).

SAF is the sector's most promising near- to mid-term route towards decarbonization, given that larger electric or hydrogen aircraft are unlikely to be commercially

available at scale before 2040. Made using feedstocks like waste oil, fats or biomass, SAF can achieve carbon emission savings throughout its life-cycle. From an infrastructure angle, SAF is also relatively easy to adopt, given that – when blended with fossil jet fuel – it does not require retrofits to either aircraft or airports.

However, while [SAF could contribute around 65% of emissions reductions needed](#) by the sector to reach net zero by 2050, the volumes produced currently [represent less than 1% of total jet fuel demand](#). Forward purchase agreements from airlines have accelerated in recent years and now total over 37 million tonnes worth \$45 billion – but supply has struggled to keep up, due in part to the technology barriers that prevent production from scaling-up.

### BOX 1 Aviation sector overview

- ~3% of annual global GHG emissions.
- Global production of SAF forecast to [increase 30-fold by 2030](#).
- 28 corporate members – the most of any sector in FMC.

## 1.2 Progress and impact of FMC

### Corporate members and commitment

Aviation in FMC has attracted the largest number of members of any sector in the coalition. A total of 28 companies have now joined the aviation commitment to ensure that at least 5% of their jet fuel procurement by 2030 comprises sustainable aviation fuels that reduce life-cycle emissions by at least 85% (SAF85).

By no means all SAF delivers this level of carbon abatement, so FMC's commitment positions members at the most ambitious, high-quality end of the SAF spectrum. Next-gen propulsion such as battery-electric and hydrogen technologies are also within the scope of the FMC commitment (see Box 2).

### BOX 2 FMC Aviation commitment

**Airlines and air transport companies:** “By 2030, we will replace at least 5% of our conventional jet fuel demand with sustainable aviation fuels (SAF) that reduce life-cycle GHG emissions by 85% or more when compared with conventional jet fuel and/or zero-carbon emitting propulsion technologies.”

**Airfare and air freight purchasers:** “By 2030, we will partner with air transport operators to replace at least 5% of conventional jet fuel demand for our air transport with sustainable aviation fuels (SAF) that reduce life-cycle GHG emissions by 85% or more when compared with conventional jet fuel and/or zero-carbon emitting propulsion technologies.”

#### \*In-scope technologies include:

- Sustainable aviation fuels (SAF) with life-cycle assessment (LCA) emissions abatement of 85% or more.
- Next generation near-zero emissions propulsion technologies, including battery-electric, hydrogen turbine and fuel cells.
- Other technologies with LCA GHG reduction of 85% or more.
- These commitments do not include SAF with LCA of less than 85%, fossil jet fuels and carbon offsets.

Learn more about the FMC Aviation commitment [here](#).

## FMC member progress and impact

Since 2022, FMC members have engaged in a number of offtake agreements and investments, including the following achievements:

**Airbus:** Airbus has announced a strategic partnership with DG Fuels to advance SAF production, using cellulosic waste and renewable energy. The initial production target is 120 million gallons of SAF annually by 2026, potentially reducing CO<sub>2</sub> emissions by 1.5 million tonnes each year. This initiative is part of the [US Government's SAF Grand Challenge](#), which seeks to significantly boost domestic SAF production and reduce GHG emissions.

**Avelia:** In 2022, FMC member American Express Global Business Travel (Amex GBT) partnered with Shell Aviation to launch Avelia, making 1 million gallons of SAF available for corporate customers – enough to power almost 15,000 business trips from London to New York. Its aim is to create a transparent, trackable and verifiable way to reduce emissions from business travel. Avelia is one of the first live blockchain-powered “book and claim” platforms for SAF.<sup>3</sup> Avelia continues to grow and recently added FMC member Bank of America as its first financial institution.

**Bank of America** recently announced that through platforms like Avelia, it has been able to purchase SAF and work towards fulfilling its goal of carrying 20% of corporate travel on flights powered by SAF. Furthermore, the bank has committed to investing \$2 billion to support production of 1.2 million gallons of SAF per year starting in 2025.

**DHL** purchases SAF from eight airports around the globe. In 2022, the company signed the largest deal at the time with Neste/AirBP for 800 million litres of SAF up to 2026. In late 2023, DHL and World Energy signed a 7-year contract until 2030 for 668 million litres-worth of SAF certificates (SAFc)

on a book and claim basis. This will enable DHL to reduce ~1.7 million tonnes of CO<sub>2</sub>e on a life-cycle basis, equivalent to operating DHL's Americas aviation network carbon neutrally for one year. By the end of 2023, DHL had committed to buy 14.5% of globally available SAF supply.

**Minnesota SAF Hub:** FMC members Bank of America and Delta, alongside EcoLab, have partnered in developing the world's first large-scale SAF hub in Minnesota. As a result of this initiative, Delta aims to use SAF for more than 10% of its fuel at Minneapolis-Saint Paul International Airport (MSP) by 2027 and 50% by 2035 (see Box 3).

**Sustainable Aviation Buyers Alliance (SABA):** In April 2024, SABA – which comprises 20 major organizations, including a number of FMC members – committed to channel close to \$200 million into purchasing SAF certificates over the next five years. This amounts to about 50 million gallons of high-integrity SAF or 500,000 tonnes of abated CO<sub>2</sub>e – roughly equivalent to the emissions of 3,000 fully loaded passenger flights from New York City to London.

**United Airlines Sustainable Flight Fund for SAF Investment:** FMC members Amex GBT, Bank of America, Boeing and Boston Consulting Group (BCG) have joined United Airlines' Sustainable Flight Fund, helping grow it to nearly \$200 million within five months of inception. The fund invests in start-ups working on SAF research, production and technology, supporting the future production of more than 5 billion gallons of SAF. By doing so, the fund's members gain first access to SAF offtakes that advance their own decarbonization goals, while investing in companies that are increasing global SAF supply. This collaborative approach sends a strong demand signal to future suppliers, encouraging add-on investments and advancing the aviation industry along its pathway to net zero.



**FMC has played an important role in putting SAF on the big stage, improving awareness and visibility for corporate boards as well as serving as a convener for discussion.**

Roger Libby, Vice President and Head of Corporate Public Affairs in the Americas, DHL



In August 2023, the [Greater MSP Partnership](#) launched the first large-scale SAF hub in the US Midwest. The coalition’s anchor partners include the State of Minnesota, Xcel Energy and FMC members Bank of America, Delta and Ecolab.

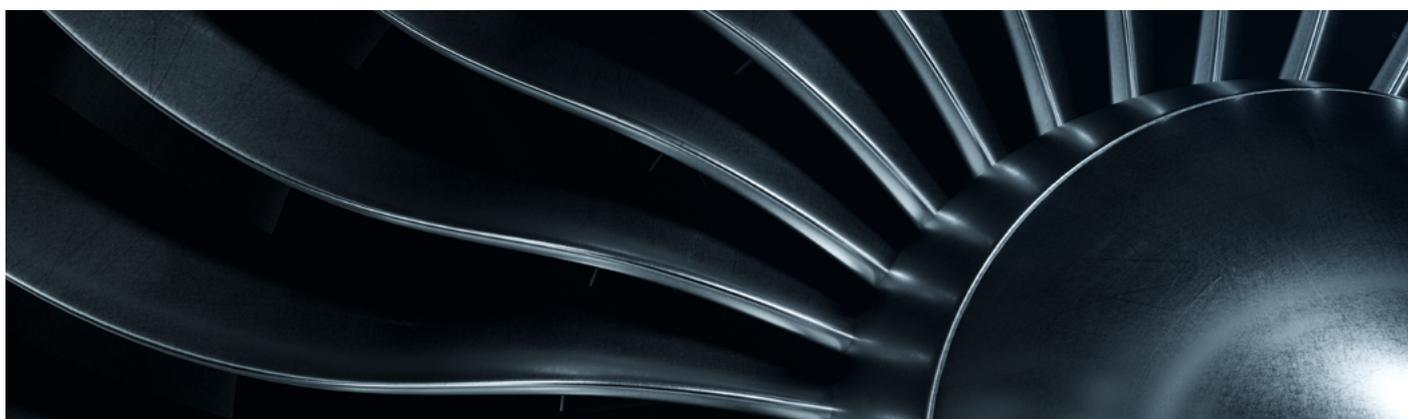
The Minnesota SAF Hub is initially focused on bringing commercial-scale volumes of affordable SAF to the Minneapolis-St Paul (MSP) International Airport by 2025. It is accomplishing this by taking a full value-chain approach to decarbonizing aviation – liaising with agricultural players at the very start of the SAF supply chain and ending with airlines demanding less-emitting fuels. In addition, over the next decade, the hub will focus on establishing multiple SAF production facilities in Minnesota.

Significantly for FMC, the coalition intends to support university and private-sector research and collaboration to address scientific and technical hurdles associated with the commercially viable production of ultra-low carbon SAF from regenerative agricultural inputs.

The hub benefits from a mix of success factors: strong policy support in the form of a new state-level SAF tax credit, a rich agricultural landscape, affordable renewable energy, R&D capabilities and existing aviation fuel infrastructure. Most importantly, there is strong demand for jet fuel at MSP, where Delta alone consumes around 250 million gallons annually. Through this coalition and corporate partners, Delta aims to use SAF for more than 10% of its fuel at MSP by 2027, rising to 50% by 2035.

“ **The Minnesota SAF Hub is the game changer aviation needs to start producing SAF at the volumes required to meet our aggressive goals. This coalition of heavy hitters from across the SAF ecosystem are collaborating to rapidly scale production, demonstrating the power of partnerships to meet our shared goal faster than any of us could do on our own.**

Ed Bastian, Delta CEO



### FMC Sustainable Aviation Challenge

In August 2023, with an eye to the technology barriers preventing aviation from becoming more sustainable, FMC collaborated with UpLink, the World Economic Forum’s innovation platform, to launch the [Sustainable Aviation Challenge](#). This called for innovative solutions to decarbonize aviation and accelerate novel technology pathways, such as sustainable fuels, propulsion technologies and value chain innovations including feedstock, engineering, infrastructure and market development.

During the two-month challenge window 129 submissions were made. Following a review by independent experts, 16 Top Innovators were announced at the World Economic Forum’s Annual

Meeting in Davos-Klosters in January 2024. Technologies proposed by the Top Innovators include e-fuels made with renewable energy and waste CO<sub>2</sub>, hydrogen fuel-cells, cryo-compressed hydrogen, hybrid-electric engines, electrothermal propulsion and third-generation feedstocks for SAF such as bioengineered algae.

The 16 winners are now part of the FMC’s newly created [First Suppliers Hub](#), which provides a database of suppliers that currently meet or are working to meet the thresholds established in the FMC commitments for its various industry sectors. For more information on the First Suppliers Hub, see Chapter 10.2.

## FMC's Sustainable Aviation Fuels: Offtake Manual and SAF85 Technical Brief

SAF offtake can be a complex venture. Although there is plenty of information available on SAF procurement and contracting, the knowledge landscape is fragmented and the process itself involves multiple players. So in June 2023, FMC published its [Sustainable Aviation Fuels: Offtake Manual](#).

For suppliers, the report lends a better understanding of the fuel purchaser's needs and allows them to consider the interests of corporate customers. For airlines, the report explains technical, feedstock, economic and policy-related aspects of SAF to raise awareness and enable successful offtake agreements. For corporate buyers, the report shares best practices for procuring scope 3 credits by detailing key

stakeholders, watch-outs and accounting methods to make SAF offtakes more accessible, especially for companies outside the aviation space (which applies to a number of members of the FMC Aviation sector). FMC Aviation community members also provide practical experiences to call attention to gaps and address key questions.

FMC has also created the SAF85 Technical Brief in collaboration with Boston Consulting Group (to be published summer 2024) that guides members in assessing whether a project meets FMC's ambitious SAF threshold. This brief includes a rule-of-thumb framework for assessing projects, deep dives on key SAF pathways including power-to-liquids and gasification Fischer-Tropsch, and a review of key standards.

## Collaboration with Airports of Tomorrow

FMC is working closely with the Forum's flagship aviation decarbonization initiative, [Airports of Tomorrow](#), which seeks to address the energy, infrastructure and financing needs of the aviation industry's transition to net-zero carbon emissions by 2050. This initiative, which has partnered with Airports Council International (ACI) World, focuses on the role of airports as not only passenger hubs but also energy hubs. Airports of Tomorrow takes a holistic view of the requirements for aviation's energy transition, including hydrogen and battery-

electric propulsion, the electrification of airport services, and the scale-up of biofuel and synthetic SAF. All of these developments will require technical expertise and roadmaps on new infrastructure, analysis on feedstock sustainability and viability for SAF, and conversations on mobilizing finance.

The full set of Forum reports on sustainable aviation, published under the Airports of Tomorrow initiative as well as its predecessors Target True Zero and Clean Skies for Tomorrow, can be found [here](#).

## Lessons from the FMC process

The 28 member companies of the aviation commitment represent the largest demand signal within FMC. They demonstrate the growing interest in SAF across a wide market, with members representing the aviation, energy, finance, logistics, mining, professional services and technology sectors.

Building on this promising start, FMC has considerable scope to expand demand from airlines in as yet untapped markets such as South America and Southeast Asia. Equally, there is an opportunity to build greater demand from a wide range of corporate buyers outside the aviation sector that are looking to decarbonize their scope 3 emissions.

The focus of FMC's aviation sector is to strengthen this demand signal and use it to accelerate supply, which is lagging behind. Unlike other sectors, such as trucking and shipping, where a key part of the

supply challenge is charging/fuelling infrastructure, the challenge facing SAF supply is more around innovative yet affordable technology to produce the highest performing fuels capable of 85% or more carbon emissions abatement. FMC's call out to industry and innovators through its Sustainable Aviation Challenge demonstrates how the coalition is increasing the visibility of actors working to overcome this hurdle on the pathway to delivering net-zero aviation.

Progress can only come through partnerships. The [Minnesota SAF Hub](#) represents a stand-out example of the kind of full value-chain collaboration needed, with multiple FMC members from different sectors – banking, aviation and water – collaborating across the value chain with the state government and airport to find solutions that work for business, society and the planet.

## 1.3 Insights from in-country workshops



### Findings from Brazil workshop

Brazil's rich history in biofuel production — especially ethanol from sugarcane — and expansive aviation sector — with over 100 airports and a fleet of over 2,000 aircrafts — provide a solid foundation for pioneering SAF. Brazil can leverage its experience and potential in both biofuels and aviation to become a pioneer in the production and use of SAF.

Jet fuel is the biggest expense for domestic airlines<sup>4</sup> and demand is expected to outstrip supply by 1.2 Mt per year by 2030.<sup>5</sup> But with Brazilian SAF production yet to start, supply risks lagging behind demand. Brazil generates 2 billion tonnes of waste and residue a year, which could be converted into 9 billion litres of SAF — enough to cut emissions 15% by 2030. Brazil's abundant clean power and second generation feedstocks are sufficient to meet all its SAF demand, with 25% more for export.



**Airlines are ready to buy every single drop of SAF that becomes available.**

Brazil in-country workshop participant

#### Challenges

- High cost of making SAF — around 1.4 to 4 times the average cost of jet fuel in Brazil today.
- Access to affordable finance, given Brazil's benchmark lending rate of 12.75% (September 2023).
- Lack of policy incentives to support SAF and an imbalance between the SAF mandate and the 12% biodiesel blend mandate for road transport, causing producers to focus on the latter.

#### Solutions

- Given long lead times, the next 24 months are critical for taking decisions and mobilizing finance needed to build the SAF infrastructure Brazil needs.

- More government incentives (e.g. tax credits, low-interest loans, grants) are needed to develop SAF feedstock collection, production plants and distribution networks.
- Blended finance is needed to de-risk investments, while banks need to provide financing with at least 7-year terms.
- Producing SAF from forestry and agriculture residues and biogenic CO<sub>2</sub> would open up export markets that require second generation feedstocks.
- SAF production takes large amounts of green hydrogen — the government should consider allocating a proportion to the sector.
- Partnerships between industry and R&D institutions are very important to adapt SAF technology to local realities.

Read the Brazil in-country workshop report [here](#).



### Findings from India workshop

While aviation in India currently emits around 25 Mt of CO<sub>2</sub>e a year, this figure could soar as the country's air traffic is set to triple by 2040. Both Boeing and Airbus predict that India will be the world's fastest-growing aviation market, with 7% annual growth until 2040.

Domestic actors — including Indian Oil, IndiGo and Vistara airlines, and the Indian Air Force — are piloting the use of SAF, but none is yet approaching

the carbon abatement performance required by FMC, to reduce life-cycle GHG emissions by 85% or more. The economics of shifting to more expensive SAF are also very tight, given that jet fuel already accounts for 30-40% of operating costs for domestic airlines.

## Challenges

- High cost of SAF 85 production (two or three times the cost of jet fuel in India today).
- Fragmented supply chains for the feedstocks that SAF needs (e.g. agricultural residues, municipal solid waste).
- Uncertain access to green hydrogen.
- Limited domestic expertise in SAF85 production technologies.
- Lack of demand.

## Solutions

- Domestic SAF mandate (starting at 1% blending) to accelerate the establishment of a SAF industry in India.
- Policies to ensure India's abundant sustainable feedstocks remain in-country to scale-up domestic production of SAF, rather than being exported to other countries with feedstock incentives.
- Tax breaks for SAF, given that value-added tax constitutes 45% of airlines' operating costs.
- Emphasize co-benefits of a domestic SAF industry: reduces emissions, generates economic growth, reduces waste, creates green jobs, reduces dependence on imported jet fuel which is expensive and unpredictable.

Read the India in-country workshop report [here](#).



## Findings from Singapore workshop on SAF

FMC's workshop session on SAF, held during Singapore's Ecosperity Week in June 2023, found that while progress is strong in the US and Europe, Southeast Asia will be the demand epicentre for air travel over the coming decades. Consequently, the region needs champion countries to lead SAF commercialization efforts. As an established sustainable aviation hub, refinery hub and financial hub, Singapore is ideally placed to lead regional decarbonization efforts.

The opportunities and challenges facing Singapore and the region include the following:

**Supportive policies and regulation:** Regional governments can enact supportive policies and regulations to encourage SAF adoption, e.g. targets for SAF use, carbon pricing and long-term incentives for airlines to invest in SAF. The Civil Aviation Authority of Singapore (CAAS) has established a SAF Taskforce and introduced supportive incentives to encourage airlines to use SAF. In February 2024, [CAAS announced its aim for a 1% SAF blending target by 2026, rising to 3-5% by 2030](#), partly funded by a passenger levy.

**Feedstock availability:** Singapore relies heavily on imported feedstocks. Southeast Asia possesses abundant biomass resources, but needs to develop local collection, processing and production of SAF feedstocks to ensure a reliable, sustainable supply.

**Technological innovation:** Collaborative investment in R&D between governments, academia and industry is crucial to overcome technological barriers and make SAF production economically viable. Governments, industry players, research institutions and international organizations should collaborate to promote information-sharing, best practices and capacity-building.

**Financing:** Governments and financial institutions can provide incentives, grants and loan guarantees to attract capital investment. Public-private partnerships between governments, airlines, fuel suppliers and investors can expedite the deployment of SAF. Public-private partnerships and blended finance models can unlock funding.

**Infrastructure development:** Regional governments should prioritize the development of infrastructure for SAF production, storage and distribution to ensure a reliable supply chain.

Read the *Singapore Situational Analysis on Sustainable Aviation Fuels* [here](#) and more about *How Singapore can lead the way on scaling-up sustainable aviation fuels* [here](#).

2

# Shipping

The shipping industry emits over 1 billion tonnes of greenhouse gases annually. With maritime trade volumes set to triple by 2050, FMC has a critical role to drive demand for zero-emission fuels.



## 2.1 Sector overview

Shipping serves a critical role in [shifting over 80% of world trade](#) and demand for sea freight looks set to [triple by mid-century](#). However, while shipping may be a less polluting way to move goods around the planet than the alternatives, the industry still emitted over one billion tonnes of greenhouse gases into the atmosphere in 2018,<sup>6</sup> accounting for over 2% of annual global GHG emissions.<sup>7</sup>

The industry needs to abandon the fossil-based [bunker fuel that powers 99% of commercial shipping](#) and chart a course towards full decarbonization. [Two low-carbon fuels that can power big vessels](#) stand out: e-methanol offers a viable pathway, with dual-fuel engines being deployed and vessels on the water, although fuel supply remains limited. Meanwhile, e-ammonia looks set to make an impact, especially later in the decade, as ammonia-powered engine testing continues and more companies announce vessel

orders. Feedstocks for these breakthrough fuels include renewable energy, green hydrogen and organic waste. Hydrogen could also directly power vessels in the longer term.

In July 2023, the [International Maritime Organization \(IMO\)](#) adopted a historic ambition of net-zero GHG emissions for international shipping by [“close to 2050”](#). This was a game-changing moment for the industry’s decarbonization journey, especially given that international shipping was not included in either the Kyoto Protocol or the Paris climate agreement. In March 2024, the [IMO moved closer towards creating the world’s first global carbon price](#), by proposing a draft net-zero framework that would allow for a [“new global pricing mechanism for maritime GHG emissions”](#). Meanwhile, FMC government partner Norway has set an ambitious target to cut emissions from domestic shipping by 50% by 2030.



**I’m very confident that there is going to be an economic pricing mechanism by this time next year.**

Arsenio Dominguez, Secretary General, International Maritime Organization

### BOX 4 Shipping sector overview

- [1.076 Gt of GHG emissions](#) – all shipping (international, domestic and fishing), comprising 2.89% share of annual global GHG emissions (2018).
- [0.76 Gt of GHG emissions](#) – international shipping (2018), comprising ~2% of annual global GHG emissions.
- Potentially [10% of global emissions by 2050](#).
- Global demand for sea freight is forecast to [triple maritime trade volumes by 2050](#).
- 17 corporate members of FMC.
- Over [200 dual-fuel methanol-powered vessels on order](#) – requiring ~21 Mtpa of e-methanol to achieve 100% zero-emission operability.

## 2.2 Progress and impact of FMC

### Corporate members and commitment

Shipping is one of FMC’s founding sectors and 17 companies have [made the commitment](#) to power at least 5% of their deep-sea shipping by zero-emission fuels (ZEF) by 2030 or to ensure that at least 10% of the volume of their shipped goods will be on such vessels by 2030, increasing to 100% by 2040 (see Box 5).

In late 2023, FMC conducted the first of its periodic two-yearly reviews of sector commitments. The shipping sector revised its definition of ZEF to encompass those that reduce well-to-wake GHG emissions by 80% or more compared to fossil heavy fuel oil. While the IMO is in the process of formulating a fuel standard to give more context

around what constitutes “green” or “clean” fuels, currently no such international standard exists. FMC’s criteria are not intended to be seen as a global standard, but are an attempt to steer companies towards what good looks like within the parameters of existing guidance in the market. For example, the EU’s Emission Trading System

has set a threshold of 65% abatement, while the Zero Emission Maritime Buyers Alliance (ZEMBA) – a buyers group with a mission to accelerate commercial deployment of zero-emission (ZE) shipping – recently issued a request for proposal to ship its products in vessels that can abate 90% of emissions.

## BOX 5

### FMC’s Shipping commitment

**Carriers:** “At least 5% (on an energy basis) of our deep-sea shipping will be powered by zero-emission fuels\* by 2030.”

**Cargo owners:**<sup>8</sup> “At least 10% of the volume of our goods shipped via deep-sea shipping will be on ships using zero-emission fuels by 2030, reaching 100% by 2040.”

Learn more about the FMC Shipping commitment [here](#).

#### \*FMC definition:

- Zero-emission fuels are those that reduce well-to-wake GHG emissions by 80% or more compared to fossil heavy fuel oil.<sup>9</sup>
- Current list of fuels includes: ammonia, methanol, hydrogen, battery.
- These commitments do not include biofuels, liquid natural gas (LNG), carbon offsets or efficiency improvements.

### FMC member progress and impact

Since its launch in late 2021, FMC shipping sector members have engaged in a number of offtake agreements and investments, with the following stand-out achievements:

**Amazon**, a founding member of FMC, has been instrumental in getting the Zero Emission Maritime Buyers Alliance (ZEMBA) off the ground. Through ZEMBA, cargo owners can demonstrate demand through forward-procurement of zero-emission maritime freight services. Amazon is supporting joint efforts under ZEMBA to ship 600,000 TEUs (twenty-foot equivalent units) on zero-emission vessels over a time-span of three years – which will result in close to 1 million tonnes of carbon emissions reduction. In April 2024, ZEMBA announced the successful conclusion of its first tender for ocean shipping that achieves at least a 90% reduction of GHG emissions on a life-cycle basis relative to fossil fuel-powered services.

**BHP Group** is planning to receive its first ammonia-fuelled bulk carrier in 2026, as part of the company’s plans to reduce shipping emissions.

Eight companies have been shortlisted to construct, operate and supply fuel for at least one such vessel, but the final number of vessels is not yet determined.

#### **Höegh Autoliners and Yara Clean Ammonia**

have announced a ground-breaking partnership to supply clean ammonia for use in Höegh Autoliners’ 12 new Aurora-Class vessels. These ships, which are approved by global classification advisers DNV as “ammonia ready”, will be some of the most environmentally friendly car carriers ever built. Deliveries of the first new vessels start in 2024. Initially equipped with engines primed to run on liquefied natural gas (LNG) and low-sulphur oil, they can be [converted to run on green ammonia using MAN’s ground-breaking ammonia 2-stroke engines](#).

**Maersk** signed an offtake agreement with Chinese wind energy producer Goldwind to supply 500,000 tonnes of green methanol each year, starting in 2026. The long-term deal, inked in November 2023, will support Maersk’s goal to reach net-zero GHG emissions by 2040.



**We are encouraged by the agreement [with Goldwind] because its scale and price confirm our view that green methanol currently is the most viable low-emission solution for ocean shipping that can make a significant impact in this decade.**

Rabab Raafat Boulos, Chief Infrastructure Officer, A.P. Moller – Maersk

[Mitsui O.S.K. Lines \(MOL\)](#) has signed agreements to time-charter two new dual-methanol carriers designed to operate on e-methanol produced with recovered CO<sub>2</sub> and green hydrogen or bio-methanol derived from biogas. The new vessels are expected to enter service in 2025 and 2027 respectively. MOL operates one of the world's largest fleets of methanol carriers, including five methanol dual-fuel methanol carriers. The agreements are part of MOL's wider ambition to have 130 net-zero emission fuelled vessels by 2035.

**Rio Tinto**, one of the largest bulk carriers in the world, has partnered with fellow FMC member **BHP**, the Global Maritime Forum and two other bulk carrier companies to form the [Western Australia-](#)

[East Asia Iron Ore Green Corridor Consortium](#), which recently completed a research study to show that ships powered by zero-emission ammonia could be deployed on the iron ore trade routes between West Australia and East Asia by 2028 and reach 5% adoption by 2030. An estimated 360 vessels could sail this corridor by 2050.

[Unifeeder](#), part of FMC member DP World, has completed a long-term agreement to charter two methanol-capable container feeder vessels, scheduled for delivery in 2026. These 1,250-TEU (twenty-foot equivalent units) vessels add to the company's initial two methanol-capable vessels announced in October 2023.

## BOX 6

### SUCCESS STORY – Maersk operates world's first green methanol container vessels

Maersk, the Danish shipping and logistics multinational, has led the decarbonization of sea freight by example. In 2021, the firm ordered the world's first dual-fuel methanol container vessel, a 2,100 TEU (twenty-foot equivalent units) capacity feeder container ship, launched in April 2023 and named "Laura Mærsk".

Maersk now has a total of [25 dual-fuel methanol-powered container vessels delivered or on order](#): in addition to the Laura Mærsk, 18 of these vessels have a 16,000-17,000 TEU capacity, while six have a 9,000 TEU capacity. Maersk expects to take delivery of six of the larger vessels during 2024.

In January 2024, the first of these larger vessels – the 350-metre, 16,592 TEU "Ane Mærsk" – became the [world's first large methanol-enabled container vessel](#) when it was christened at a

ceremony in the shipyard of HD Hyundai Heavy Industries in Ulsan, South Korea, from where it embarked on its 21,500 km maiden voyage to Denmark. The vessel is fuelled by green bio-methanol from biomass waste, a technology that can [reduce emissions from vessels by up to 95%](#) compared to traditional bunker fuels.

Maersk recently announced an agreement to [purchase 500,000 tonnes of green methanol](#) a year to power its dual-fuel vessels, with production expected to start in 2026. The company aims to transport a minimum of 25% of ocean cargo using green fuels by 2030 (compared to a 2020 baseline). This interim target will contribute to Maersk's goal to reach net-zero GHG emissions by 2040, which would see the company cutting its emissions by an estimated [450,000 tonnes of life-cycle CO<sub>2</sub>-equivalent per year](#).

## Lessons from the FMC process

### Supply-side barriers

FMC's work has brought to light challenges around why the supply side of low-carbon shipping is not scaling-up fast enough. The risk is that as demand-side signals increase, potential supply shortages will emerge. To analyse this issue further, FMC published a detailed insight report in December 2023, in collaboration with Boston Consulting Group, entitled [Fuelling the Future of Shipping: Key Barriers to Scaling Zero-Emission Fuel Supply](#). The report identifies the top 10 barriers limiting zero-emission fuel projects from getting past the final investment decision (FID) phase, meaning that the decision to invest capital and start construction has not been made (see Figure 8). The report is based on interviews with 12 leading companies and a roundtable of 20+ stakeholders, offering different vantage points along the maritime shipping value chain.

At the time of writing, over 200 methanol dual-fuel vessels are on order which, if operating on 100% consumption, would require roughly 21 million tonnes of e-methanol a year. However, the sobering reality is that over 95% of projects to produce these fuels are in the pre-FID phase, while just 0.3 Mtpa of capacity is operational or under construction. To achieve operability by 2030, these FIDs need to happen as soon as possible.

The report offers an initial perspective on how to start addressing these barriers and get more projects off the ground, for example, through unconventional partnerships and business models with transparent cost and risk sharing.

FIGURE 8 | Ten barriers limiting zero-emission fuel projects from getting final investment decision



Customer and consumer demand

1. **Lack of clear demand signals with sufficient willingness to pay:** Methanol uptake volumes in dual-fuel ships remain uncertain. Companies struggle to absorb green premiums alone.
2. **Expectations gap between fuel producers and carriers on terms of offtake agreements:** Friction on length (long term vs. spot), volume (how much) and price (what premiums are acceptable).



Economics and finance

3. **Lack of credible third-party cost estimates:** Makes it difficult for financiers and offtakers to assess investments and contract options for different zero-emission fuel pathways.
4. **Lack of fit-for-purpose financing instruments:** Time horizons and risk appetite of existing options not suitable, e.g. PE fund life too short, infrastructure funds come in late, gaps in pre-FID funding.



Regulatory

5. **Lack of strong near- to mid-term mandates or a global price on carbon:** Policies emerging (e.g. EU, IMO) but need geographically reciprocal regulations to set a demand-side price and volume floor.
6. **Lack of standard definitions, methods and certifications:** Hinders contracting terms, e.g. what defines "green", how to measure, track and report emissions, how to assure quality.



Supply chain and infrastructure enablers

7. **Methanol- and ammonia-specific risks:** Access to biogenic CO<sub>2</sub> for methanol is getting tougher. Safety, especially for use as a marine fuel and handling at ports is the biggest barrier for ammonia.
8. **The competition and (lack of) alignment with other sectors:** Shipping is competing against chemicals for methanol, fertilizers for ammonia, and more broadly across sectors for H<sub>2</sub> and CO<sub>2</sub>.
9. **The zero-emission fuels infrastructure gap:** Uncertainties on responsibility for last-mile logistics. Physical gap between promising e-fuel locations and major ports.



Organizational

10. **Decision-making and risk appetite limited by gaps in expertise:** Decarbonization decision and P&L don't always sit with the same team, creating friction and requiring new ways of working together.

Source: BCG

**Building collaborations across the value chain**

One of the biggest challenges facing the scaling-up of methanol supply is the green premium and how to split it in the most equitable way – because zero-emission fuels currently cost 3-4 times the price of bunker fuel. According to Brian Davis, Chief Executive Officer of C2X, a global green methanol developer backed by Maersk, the industry needs

government support to close this cost gap: "First, by providing incentives that lower the cost of green fuel production, this will promote the rapid scaling-up of these new technologies. And second, by creating a strong and visible demand-pull through mandates and clear carbon-pricing signals. Together this can kick-start the industry to drive faster scale-up and better climate outcomes."



**We need the proactive support of governments around the world to close the cost gap through supply-side and demand-side actions.**

Brian Davis, Chief Executive Officer, C2X

It is clear that the shipping sector cannot solve these challenges on its own. FMC members are therefore ramping up their collaborations with governments and seeking unconventional partnerships between value chain actors and other industry sectors, to bridge the gaps between supply, demand and ecosystem enablers (e.g. finance, ports, governments). These cross-value-chain partnerships are already producing innovative business models, sharing risks and costs, and catalysing zero-emission shipping fuel projects.

One of FMC's strengths is that members represent different shipping segments, including container, dry bulk and car carriers (RoRo), as well as cargo owners, vessel builders, ship owners and fuel suppliers, which enables the kinds of collaborations at a value chain level that are vital to unlocking this challenge.

In terms of practical measures, FMC is supporting members to move from MoUs and commitments

into offtake agreements, as well as increasing transparency on suppliers through identifying and surfacing producers of FMC-compliant technologies through the First Suppliers Hub.

### First Suppliers Hub

An important recent initiative of FMC has been to focus on surfacing supply of zero-emission fuels and materials through the establishment of a supplier database. Launched during the World Economic Forum Annual Meeting in January 2024, the [First Suppliers Hub](#) features suppliers' projects that meet or are working to meet FMC commitment thresholds, with the aim of supporting procurement efforts for members and other decarbonization-focused companies active across all seven sectors. At the time of writing, the database included 13 green methanol and green ammonia projects aiming to service the shipping industry this decade. For more detail on the First Suppliers Hub, see Chapter 10.2.



## 2.3 Insights from in-country workshops



### Findings from South Africa workshop

South Africa sees the highest volume of maritime traffic in Sub-Saharan Africa. Its strategic location, abundant natural resources and export economy have made the country a long-standing hub of international trade.<sup>10</sup> Maritime imports and exports accounted for ~90% of all South African trade volume in 2023.<sup>11</sup>

The country's plan to develop a hydrogen economy positions it at the centre of global efforts to decarbonize maritime shipping. The two leading ZEFs, e-methanol and e-ammonia are both derived

from green hydrogen, so South Africa has the potential to become a shipping fuel producer and exporter. Its location astride two major shipping lanes – from Asia to South America and from Asia around the Cape of Good Hope to Europe and North America, avoiding the politically unstable Red Sea – makes it an ideal bunkering stop-off. Furthermore, given zero-emission fuels are half the energy density of fossil fuels, vessels will need to stop off more often to refuel and South Africa would offer an ideal location.

South Africa's great opportunity is to combine the global shipping industry's demand for ZEFs with the specific geography of the supply landscape of domestic ZEF production, ports and bunkering. The challenge is that South Africa is not much used as a bunkering hub by the global shipping industry, as its port facilities are considered to be unreliable and run down. Considerable investment in port infrastructure will be needed to realize the opportunity for the country to become a hub for ZEF production and supply.

### Challenges

- **Lack of renewable power supply for green hydrogen production:** South Africa's unstable grid operates at little over 50% capacity. A lack of renewable power will undermine the country's capacity to produce green hydrogen feedstock.
- **Low domestic demand for ZEF due to high green premium:** There is little evidence of domestic demand for ZEF, partly due to high green premiums. This increases the dependence of future domestic ZEF production on global demand.



**The green premium and who is going to pay is a challenge. Everyone in the supply chain thinks it shouldn't be themselves.**

South Africa in-country workshop participant

### Solutions

- **Global demand as a catalyst for domestic supply and bunkering of ZEF:** A clear demand signal for bunkering ZEF in South African ports is needed to realize the country's opportunity to become a global hotspot for zero-emission shipping. Certainty from global demand will play a key role.
- **Investment in port facilities to create stable, reliable, modern ZEF bunkering:** Considerable investment is needed to boost the efficiency of port infrastructure, before the country's ports are ready as hubs for ZEF bunkering and supply to global shipping.
- **Export of ZEF production to global hubs:** South Africa could address the limitations around its ports by exporting its ZEF production to high bunker-demand ports (e.g. Singapore, Rotterdam), which will rely on importing green fuels from competitive renewable energy countries like South Africa.

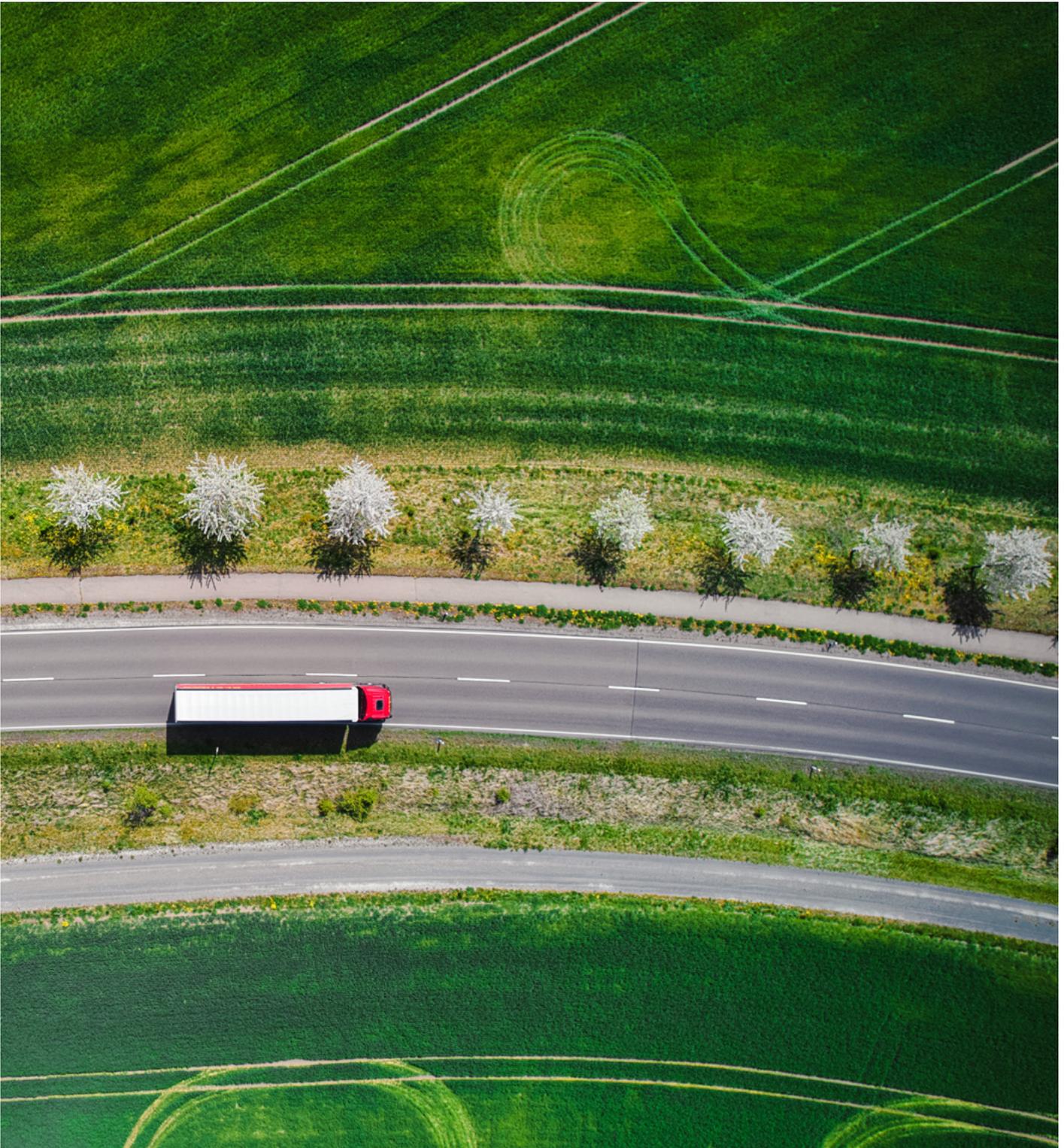
Read the South Africa in-country workshop report [here](#).

- **Port infrastructure needs investment in world-class bunkering:** South Africa is not a preferred bunkering hub for the global shipping industry. Operators lack confidence in the country's ports, facilities and infrastructure to deliver as consistent or reliable a service as other ports.
- **Shipping-related policy challenges:** Support and regulation will be needed from the government to develop the country's ZEF economy. With leading trade partners moving towards carbon border taxes, up to 35% of South Africa's export value could be at risk if decarbonization is not pursued.<sup>12</sup>
- **Shipping-related finance challenges:** An insufficient and unprepared project pipeline, combined with technology risk, deters investment in the country's nascent ZEF sector. Financial risks are amplified by the high cost of financing in South Africa and other emerging markets.

- **Relationships with export partners:** Bilateral agreements with key trade partners could be used to support the transition and lower the green premium. South Africa can leverage relationships with top export markets leading the way in green technology (e.g. EU, United Kingdom, Japan).
- **Standards and certifications:** As ZEF becomes a standardized product or commodity, its definition will need to keep pace with new policies and regulations. The development of a fuel standard by the IMO is an important enabler.
- **Policy measures,** including: regulation to support the transport and bunkering of ZEF in ports, a national port strategy, international regulation (e.g. on "guarantee of origin" and "green requirements"), incentives to keep sustainable sources of CO<sub>2</sub> for e-methanol within the country, and a global pricing mechanism for carbon.

## 3 Trucking

Trucking emits 1.8 billion tonnes of CO<sub>2</sub> a year. With demand for road freight set to double by 2050, decarbonizing the sector depends on battery-electric and fuel-cell technologies.



## 3.1 Sector overview

Trucking was responsible for about [1.8 billion tonnes of CO<sub>2</sub> emissions](#) in 2020, accounting for roughly 4% of annual global GHG emissions.<sup>13</sup> With demand for road freight expected to [more than double from 12 trillion to 26 trillion tonne-kilometres \(tkm\) by 2050](#),<sup>14</sup> emissions are currently on a steep upward curve. Reducing these emissions means finding alternatives to diesel in the medium- and heavy-duty truck segments, where regional and long-haul missions account for three-quarters of all fuel consumption.

There are currently [over 300 models of battery-electric and fuel-cell electric trucks available](#), with many more expected to enter the market in the coming years. However, despite this positive

technological progress in developing zero-emission trucks (ZETs), the pace of deployment is far too slow. In the European Union, for example, where road freight generates [15% of all the continent's CO<sub>2</sub> emissions](#), just [0.6% of new trucks sold today are electric vehicles](#), while nearly 97% are diesel powered.

Market scepticism around zero-emission trucks is linked to the high initial capital costs, limited charging infrastructure and overall energy security issues. Consequently, commitments – such as those made by FMC's trucking community – to purchase zero-emission technologies and services play a crucial role in decarbonizing the sector.

### BOX 7 Trucking sector overview

- 1.8 billion tonnes of CO<sub>2</sub> emissions in 2020.
- ~4% of annual global GHG emissions.
- Global demand for road freight is forecast to increase from 12 trillion to 26 trillion tonne-kilometres by 2050.
- 16 corporate members of FMC.

## 3.2 Progress and impact of FMC

### Corporate members and commitment

In the two years since FMC was launched at COP26, 16 leading global companies have joined the trucking sector commitment, whereby truck owners and operators must ensure that at least 30% of their heavy-duty and 100% of medium-duty

new truck purchases are ZETs by 2030. Equally, retailers and manufacturers making the commitment must require the same of their trucking service providers (see Box 8).

### BOX 8 FMC's Trucking commitment

**Trucking owners and operators:** "At least 30% of our heavy-duty and 100% of our medium-duty new truck purchases are zero-emission trucks\* by 2030."

**Retailers and manufacturers:** "We require our trucking service providers to meet the commitment that at least 30% of heavy-duty and 100% of medium-duty new truck purchases will be zero-emission trucks\* by 2030."

#### \*In-scope technologies include:

- Battery-electric vehicles (BEVs).
- Fuel-cell electric vehicles (hydrogen – FCEVs).
- Any zero tail-pipe emission technologies.
- Commitments do not include liquid natural gas, drop-in fuels and carbon offsets.

Learn more about the FMC Trucking commitment [here](#).

## FMC member progress and impact

Since 2022, FMC members have engaged in a number of offtake agreements and investments. This demand signal encourages manufacturers to invest in production, innovation and logistics services to operate zero-emission trucks, thereby instilling confidence in other players within the industry. Below are some of the stand-out achievements from members of the sector:

[Agility](#), a logistics company and FMC founding member, has signed an agreement with Hyliion to pre-order 1,000 Class 8 heavy-duty trucks featuring a fully electric drivetrain and a natural gas-powered onboard generator. The trucks offer over 1,000 miles of range, significant cost savings and a lower carbon footprint. The powertrain produces electricity locally at roughly 30% less than the average grid cost, which yields a seven-year cost-of-ownership unmatched by any diesel, battery-electric (BEV) or hydrogen fuel-cell (FCEV) Class 8 truck under development.

[Fortescue](#) is pioneering innovation in emerging technologies and has announced the expansion of its UK manufacturing capability to supply advanced batteries and electric powertrains for off-road vehicles globally, including trucks and trains. Fortescue is also [testing a 240-tonne battery-electric haul truck prototype](#) at its mining operations in Western Australia, aiming to achieve zero emissions by 2030, and [has entered into a deal](#) with Liebherr Mining for the delivery of 120 zero-emission trucks, initially diesel-powered, to be converted to Fortescue's in-house battery solution before the end of the decade.

[Heidelberg Materials and Volvo](#) have embarked on a ground-breaking collaboration to reduce CO<sub>2</sub> emissions in the construction industry by deploying Volvo's electric vehicles and innovative loaders across Heidelberg's north European operations. The partnership began with a six-month feasibility study last year and has the potential to reduce emissions by 200,000 tonnes a year. Meanwhile, in February 2023, Volvo Trucks supplied FMC member [Cemex](#) with the world's first fully electric and zero-emission heavy concrete mixer truck.

[Holcim](#), the Swiss building products manufacturer, has recently finalized two offtake agreements with Volvo Group and Mercedes-Benz Trucks for a total of 2,000 battery-electric trucks (BETs) to be deployed by 2030, representing the world's largest ever commercial order of heavy-duty battery-electric trucks (see Box 9).

[PepsiCo Beverages](#) has invested in a fleet of 21 electric Tesla Semi trucks at its facility in Sacramento, California, to help deliver the company's goal of net-zero emissions by 2040. The trucks run a mixture of short deliveries as well as long-haul routes of up to 520 miles per trip. PepsiCo has installed four 750kW Tesla chargers at the facility to support 24/7 operations.

[Rio Tinto](#) recently purchased its first Scania battery-electric truck. The vehicle is destined for the company's Pilbara mining operation in Australia, where Rio Tinto operates one of the world's largest microgrids and is looking to [generate 1GW of solar and wind power](#) to support the electrification of its fleet.

[Vattenfall](#) has partnered with Coca-Cola to install three heavy-duty electric truck charging stations at Coca-Cola Europacific Partners' plant at Jordbro outside Stockholm.

[Volvo Trucks](#) and [Scania](#) are in the process of developing hydrogen-powered fuel cell trucks, anticipated to hit the market in the second half of this decade. Both companies have pledged [that 50% of their truck sales will be electric or zero-emission by 2030](#). The two truck manufacturers exemplify the potential synergies across FMC sectors, including with FMC Steel. For example, Scania has signed agreements with Swedish steelmakers H<sub>2</sub> Green Steel and SSAB to deliver near-zero steel for its heavy-duty trucks by 2030, as part of its goal to phase out the main sources of CO<sub>2</sub> from its supply chain by 2030.

While these orders for battery-electric trucks demonstrate tangible progress towards decarbonizing the sector, it is also essential to ensure the right infrastructure is in place, especially for EV charging and hydrogen fuelling. The global mining industry, which runs [around 28,000 large mine hauling trucks](#), is a case in point (see Fortescue and Rio Tinto examples above). Mining operations, with their high demand for heavy-duty trucks and their off-grid locations, are an ideal location for captive renewable energy projects.

Holcim, a global building products manufacturer based in Switzerland, has recently finalized two offtake agreements for a total of 2,000 battery-electric trucks (BETs) to be deployed by 2030, supplied by [Mercedes-Benz Trucks](#) and FMC member [Volvo Group](#).

These deals represent the world’s largest ever commercial orders of heavy-duty battery-electric trucks and have the potential to reduce CO<sub>2</sub> emissions by 100,000 tonnes a year, when using green electricity on a typical route.

The new battery-electric vehicles (BEVs) will replace diesel trucks of a similar specification, with the initial delivery of 130 vehicles scheduled for 2024. The new trucks will have a range of 500km without intermediate charging, making it possible to travel more than 1,000km per day.

The orders will help Holcim deliver on its upgraded climate targets, validated by the Science Based Targets initiative in line with the sector’s new 1.5°C framework. The company’s targets include a 2030 goal to reduce its scope 3 downstream transportation emissions by 24% per tonne of material transported, versus a 2020 baseline.

“ **The net-zero transition requires deep collaboration across value chains. We are excited to be partnering with Volvo to decarbonize our European operations’ logistics with electric fleets, advancing our goal to reach 30% of zero-emission heavy-duty trucks by 2030.**

Jan Jenisch, chairman and chief executive, Holcim



### Connecting players in the ecosystem

For the decarbonization of trucking to gather pace, sector leaders must continue to send strong demand signals for zero-emission trucks to suppliers. Equally, FMC is identifying suppliers of green trucking technology through dedicated workshops and the [First Suppliers Hub](#) – a database of suppliers whose projects currently meet or are working to meet the thresholds established in the FMC commitments (see Chapter 10.2).

FMC also provides support for the wider ecosystem through collaborating with initiatives such as the Forum’s [Road Freight Zero](#) and [Smart Freight Centre’s Fleet Electrification Coalition \(FEC\)](#). The FEC’s main objective is to enable 30% zero-emission truck sales by 2030 and 100% by 2040 globally, and its focus is to address challenges around vehicle availability and affordability, charging infrastructure and financing solutions.

## Lessons from the FMC process

Despite an abundance of innovation on a technology level, as well as willingness to decarbonize among both public and private sector actors, the current deployment trajectory for ZETs is not considered sufficient to limit global warming to 1.5°C above pre-industrial levels. FMC has worked hard both to boost demand as well as surface supply. However, as demand for zero-emission trucks strengthens, the main question mark will be around infrastructure, especially in emerging economies.

Supporting infrastructure for zero-emission trucks, including BETs and FCEVs, is a complex challenge. It requires extensive charging and refuelling networks, substantial electrical grid upgrades and standardized technologies for both

charging and hydrogen refuelling. This complexity is compounded by the need for coordinated policies and collaboration among governments, utilities, manufacturers and logistics providers, each with different priorities and challenges.

The value of collaboration has been evident in the past two years of FMC's activities. For example, before committing to purchasing ZETs, truck operators need visibility on when and where grid connections, charging points and hydrogen fuelling stations are likely to be deployed. This requires a greater degree of collaboration between the trucking industry and national governments, something which FMC has been actively promoting through its in-country workshops.

## Flagship report: *Procurement Playbook Toward Zero Emissions Logistics Services*

At the Forum's Annual Meeting in January 2024, FMC launched an important new piece of work, the [Procurement Playbook Toward Zero Emissions Logistics Services](#) – developed by the Smart Freight Centre and Implement Consulting Group in collaboration with the members of the Sustainable Freight Buyers Alliance.

The playbook presents a practical guide for professionals aiming to transform their logistics procurement operations. It proposes revisions

to existing procurement processes by defining a systematic approach to sustainability that relies on established standards and methodologies. Building on insights from workshops with freight buyers and logistics service providers, the playbook offers two procurement strategies: transactional and transformational, with each tailored for different scenarios. The playbook also provides examples of a logistics maturity matrix, standardized RFI/RFP templates and a standardized bidding template in the various appendices.

## 3.3 Insights from in-country workshops



### Findings from South Africa workshop

South Africa serves as a compelling case study for trucking decarbonization due to several key factors. Trucks are the backbone of South African commerce, with 86% of all cargo travelling by road. As a crucial logistics entry point for the region, South Africa has the opportunity to attract capital allocated for scope 3 emission decarbonization efforts.

The country has a thriving domestic automotive manufacturing sector that provides 5.7% of the country's GDP and employs over 500,000 people.<sup>15</sup> The government has set a goal to shift up to 190,000 commercial vehicles from internal combustion engine (ICE) to zero-emissions.<sup>16</sup> Medium- and heavy-duty trucks play an outsize role, accounting for 63% of the country's transport emissions and 7% of total emissions.<sup>17</sup>

Moreover, the country possesses abundant mineral resources necessary for the local or global production of batteries, as well as being the world's largest producer of platinum – an important catalyst in fuel cell technology. With significant solar and wind energy potential, South Africa is well-suited for the uptake of electric trucks or the production of green hydrogen.

Finally, South Africa hosts many of the key actors – from the mining, logistics and transport sectors – necessary to transform the entire supply chain for the production and operation of ZETs. There are also global players in-country whose international decarbonization commitments need to be realized in this region.



## Decarbonizing trucking is not just about swapping diesel for batteries but re-imagining sustainable logistics.

South Africa in-country workshop participant

Investing in the adoption of ZETs in South Africa presents an opportunity to drive a just transition while stimulating economic growth through the localization of component production and energy sources. Encouragingly, there have been inspiring initiatives from local and global actors driving both demand and supply in the ZET sector. However, these pilot projects remain experimental and do not yet represent a significant demand signal.

### Challenges

- **Demand and confidence:** the lack of demand for ZETs is a major challenge, due to cost of technologies, inadequate infrastructure and power instability.
- **Total cost of ownership (TCO):** although operating costs can be lower than for ICE trucks, the upfront costs for BEVs are typically two to three times higher.<sup>18</sup> These costs are exacerbated by import duties, which range from 12-20% on clean technology in South Africa.
- **Energy infrastructure:** Nascent demand for ZETs is impeded by a lack of infrastructure to deliver the power needed. To instil confidence in the market, the government needs to roll out 30,000-45,000 new public charging units per annum. Moreover, load-shedding has been a major ongoing problem for South Africa's energy sector in recent years.

### Solutions

- **National infrastructure rollout plan:** This would support the installation of new public charging units and hydrogen refuelling stations along key long-distance freight routes. Given the electricity grid is operating at little more than half capacity, several participants described plans to generate their own power for EVs. Green hydrogen hubs have been identified to fill the energy gap.
- **Fostering partnerships:** Scaling-up pilot solutions to create bankable projects requires collaboration between the government, OEMs, utilities and financiers. Public-private partnerships play a critical role in facilitating blended finance – a mix of public and private funding, grants, subsidies and innovative financing models – essential to overcome financial barriers and incentivize investment in ZETs.
- **Policy measures:** As part of its EV white paper published in December 2023, the South African government acknowledged the need for higher levels of funding to catalyse investment in automotive assembly and component manufacturing for EVs. The government could reconsider its 20% import duty on finished or CBU (completely built-up unit) trucks, including BEVs. To offset the impact of battery weight and dimensions on payload capacity and profitability, the government could adopt allowances similar to those in the EU, which would enhance the total cost of ownership (TCO) for these vehicles.



## Getting import duty lifted is imperative, as the impact of bringing one electric truck onto the road is the same as 100 electric cars.

South Africa in-country workshop participant

Read the South Africa in-country workshop report [here](#).

4

# Aluminium

With emissions of 15.1 tonnes of CO<sub>2</sub>e per tonne of primary metal, the sector urgently needs a strong demand signal for low-carbon aluminium to accelerate decarbonization.



## 4.1 Sector overview and status

Aluminium is the second-most widely used metal after steel, owing to its high strength-to-weight ratio, durability, recyclability and non-corrosive attributes. Global demand is forecast to [increase by almost 40% to 119.5 million tonnes by 2030](#) and in some jurisdictions aluminium is even included in lists of critical raw materials. The sectors driving three-quarters of this demand are transportation, electrical, construction and packaging.

Aluminium production accounts for roughly 2% of annual global GHG emissions.<sup>19</sup> According to the International Aluminium Institute (IAI), the processes of refining raw bauxite ore into alumina and then smelting alumina into pure metal emitted on average [15.1 tonnes of CO<sub>2</sub>e for every tonne of primary aluminium](#) produced in 2022.<sup>20</sup>

Reducing the sector's climate footprint depends on accelerating new technologies to decarbonize primary aluminium, which still represents 70% of global production. The most critical factors here are stable and continuous access to zero-carbon electricity supply, as well as investment in breakthrough technology for the refining and smelting processes.

Scaling-up use of secondary (recycled) aluminium is another important decarbonization pathway. [Secondary aluminium requires just 5% of the](#)

[energy needed to make virgin aluminium](#). Recycling one tonne of aluminium [saves 9 tonnes of CO<sub>2</sub> emissions and 6 tonnes of bauxite](#), which adds up to 100 million tonnes of CO<sub>2</sub> emissions saved annually by the global aluminium recycling industry. The silver – or should we say aluminium – lining in the story is that this so-called “miracle metal” is infinitely recyclable, with estimates that as much as 75% of all aluminium ever produced, equalling 1.5 billion tonnes, remains in circulation. As a result, recycling has become the leading short- to medium-term decarbonization strategy for many primary producers.

[According to the latest available data](#), industry-wide GHG emissions show a decline despite an increase in production. Global aluminium production in 2022 grew by 3.9% to 108.2 million tonnes, while at the same time GHG emissions declined slightly from 1.13 billion tonnes to 1.11 billion tonnes of CO<sub>2</sub>e. This decline comes from a 4.4% drop in average emissions per tonne of primary aluminium from 15.8 tonnes to 15.1 tonnes CO<sub>2</sub>e. The change is incremental but symbolically important as 2022 was the first year that emissions intensity reductions offset production growth, offering evidence that the industry is heading in the right direction.



### BOX 10 Aluminium sector overview

- 1.1 billion tonnes of GHG emissions.
- ~2% of annual global GHG emissions (2022).
- Global demand forecast to increase nearly 40% by 2030 and 80% by 2050.
- 2022 – the first year that emissions intensity reductions offset production growth.
- 19 corporate members and over 100 ecosystem professionals and partners.
- 25 FMC-compliant commitments (on primary and secondary aluminium).



## 4.2 Progress and impact of FMC

### Corporate members and commitment

A total of 19 corporate members have joined FMC's aluminium commitment to ensure that at least 10% (by volume) of primary aluminium procured by 2030 embodies less than 3.0 tonnes of CO<sub>2</sub>e per tonne of metal produced (see Box 11). This ambitious target represents a very substantial reduction in

the carbon emissions of aluminium production compared to the current global average of around 15 tonnes of CO<sub>2</sub>e per tonne of metal produced. An optional additional commitment is to ensure that at least half their aluminium procured comes from recycled sources.

BOX 11

#### FMC Aluminium commitment

"At least 10% (by volume) of all our primary aluminium procured per year will be low-carbon (as per FMC definition\*) by 2030."

**\*FMC definition of low-carbon:**

Emitting <3 tonnes of CO<sub>2</sub>e per tonne of aluminium produced, including all emissions from cradle to gate.

**Optional commitment on secondary [recycled] aluminium:**

"In addition to our primary aluminium commitment, we commit to ensuring that at least 50% of all aluminium we procure per year is sourced from secondary aluminium by 2030."

Leading analysis identifies that FMC's goals for primary aluminium production are most likely to be accomplished by using nascent and advanced green technologies, including but not limited to:

- Mechanical vapour recompression.
- Green hydrogen.
- Inert anodes.
- CCUS (carbon capture, utilization and storage).

Learn more about the FMC Aluminium commitment [here](#).

## FMC member progress and impact

The impact of FMC's members over the past two years has been in the production of both primary and secondary aluminium. For example, FMC members have signed a number of offtake agreements and investments, including:

[Apple](#), FMC aluminium sector champion, has from the start supported the innovative carbon-free smelting technology Elysis™ both financially and technically as a non-equity investor. Apple has used low-carbon primary aluminium in the production of some of its flagship products.

[Ball and Novelis](#) have collaborated to produce the first low-carbon aluminium cup, comprising 90% recycled aluminium and 10% low-carbon primary aluminium. The two FMC members have also partnered to accelerate aluminium recycling, with [Novelis investing \\$2.5 billion](#) in a new recycling and rolling plant in Alabama (see Box 12).

[Constellium](#) launched a partnership with Renault Group to create a closed-loop recycling process for Renault's new Megane E-TECH electric vehicle. The companies plan to bring manufacturing scrap directly back to Constellium, avoiding any loss of properties and no downcycling. Additionally, Constellium is expanding its recycling capacity with a €130 million new recycling centre in France.

[Hydro and Volvo Group](#) announced a partnership at COP28 to create a roadmap to enable the global transport manufacturer to reach its 2040 target of delivering net-zero vehicles, through supplying primary aluminium in 2030 with an 80% reduced carbon footprint compared to today's global average.



**Partnership is the new leadership. I am delighted to see two of our First Movers Coalition partners joining forces, utilizing the power of procurement to spearhead the shift towards green aluminium and accelerate the demand for net zero technologies.**

US Special Presidential Envoy for the Climate John Kerry, speaking at the launch of Hydro and Volvo Group's new partnership at COP28

### BOX 12

#### SUCCESS STORY – Ball Corporation and Novelis

In January 2024, FMC member Ball Corporation announced the launch of its first ever low-carbon aluminium cup, in a collaboration with fellow FMC member Novelis. The “Ball Cup” is made of 90% recycled aluminium supplied by Novelis and 10% FMC-compliant low-carbon primary aluminium, supplied by Alcoa from the Elysis™ process, an R&D technology that eliminates direct GHG emissions from the aluminium smelting process.

The two FMC founding members also partnered in 2023 to accelerate their aluminium recycling, with a \$2.5 billion investment by Novelis in a new recycling and rolling plant in Alabama, as well as a long-term advance offtake agreement between the two companies. The project is expected to generate 600,000 tonnes of finished goods and create up to 1,000 new jobs.



**Producing the net-zero cup was a team effort, echoing FMC's goal of increasing supply chain collaboration to decarbonize the aluminium sector.**

Dan Fisher, President and Chief Executive Officer, Ball Corporation

## Lessons from the FMC process

The power of FMC to convene players right across the value chain has been appreciated by some of the industry's leading companies. For example, according to Ramon Arratia, Chief Sustainability Officer, Ball Corporation: “FMC has provided a meaningful platform to identify, align and act on key

scope 3 decarbonization levers with our suppliers, their suppliers and our customers; and Ball is certainly privileged that key stakeholders in both our upstream and downstream supply chains are FMC members, too.”

Equally, FMC's role both in boosting demand and surfacing supply has proved valuable. According to Trond Olaf Christopherson, Chief Financial Officer and Executive Vice President, Corporate Development, Norsk Hydro: "The First Movers Coalition has become an instrumental partner in Hydro's strategy to pioneer the green aluminium transition. Activation of the purchasing power in the market is vital to stimulate a systemic change in hard-to-abate sectors. Through the First Movers Coalition, Hydro has committed to be a first mover by purchasing low-carbon aluminium in the market, while being one of the two first qualified companies in the First Suppliers Hub for aluminium."

The experience of FMC members in this sector illustrates that there is no single, simple solution to the complex set of problems that each individual aluminium producer faces. Instead, each producer needs to frame its own multi-layered decarbonization strategies. Luciano Alves, CEO of FMC member Companhia Brasileira de Alumínio (CBA), speaks to this challenge: "To lower our emissions, we are pushing for 100% use of renewable power, investments to substitute natural gas for biomass in our alumina boilers, smelter technology upgrade and new skills."



**The First Movers Coalition has become an instrumental partner in Hydro's strategy to pioneer the green aluminium transition. Activation of the purchasing power in the market is vital to stimulate a systemic change in hard-to-abate sectors.**

Trond Olaf Christopherson, Chief Financial Officer (acting) and Executive Vice President, Corporate Development, Norsk Hydro



## 4.3 Insights from in-country workshops



### Findings from Brazil workshop

The workshop highlighted Brazil's role as a global leader in the aluminium industry, with 60 years of experience and half a million people currently employed in the sector. The country has significant bauxite reserves and is the world's third-largest alumina producer, refining around 11 million tonnes per annum (Mtpa) or 8% of global production in 2022. By using hydropower in smelters, Brazil has been able to reduce the carbon intensity of its aluminium smelting to an average of 4.5-6.5t CO<sub>2</sub>e per tonne of smelted aluminium – around 2.5 times less than the global average. Likewise, the carbon intensity of Brazil's alumina refining (0.6t CO<sub>2</sub>e per tonne of alumina) is 4.6 times lower than the global average. As a major mine-to-metal producer with a low-carbon power grid, Brazil is well-positioned to capture the growing demand for green aluminium driven by the global energy transition.

Brazil is also a world leader in the secondary market – where scrap inputs can cut emissions by 95% and costs by 25-30%. The country recycles 0.7-0.9 million tonnes per year – nearly as much as primary production. The aluminium scrap industry is growing, fuelled by continuous investments in recycling capacities since the 1990s and by the efforts of 800,000 people collecting aluminium scrap metal. As a result, Brazil achieved an aluminium beverage can recycling rate of 100% in 2022 and has the potential to expand into other aluminium recycling segments.

Workshop participants identified a number of key challenges and solutions to accelerate the growth of the low-carbon aluminium market, outlined below.



**We believe that FMC's initiative converges in many aspects with the agenda and issues that ABAL is also committed to leverage and promote. We truly value FMC's work in organizing the workshop session in Brazil, which resulted in a thorough report. We recognized all the work involved and we surely intend to keep those discussion alive in Brazil and reference FMC's report in many of the ongoing public-policy-related discussions.**

Janaina Donas, President, Brazilian Aluminium Association (ABAL)

#### Challenges

- Policy barriers, such as complex domestic tax rules and a lack of clear definitions of green products.
- Access to affordable finance, given Brazil's benchmark lending rate of 12.75% (September 2023).
- Unwillingness of fragmented downstream buyers to pay a green premium ranging from 10-50%, especially in sectors such as automotive, construction and packaging.
- Low public awareness about sustainable value chain practices and environmental, social and governance (ESG) stewardship.

#### Solutions

- Improve access to blended finance and government incentives, including seed financing for R&D and pilots.

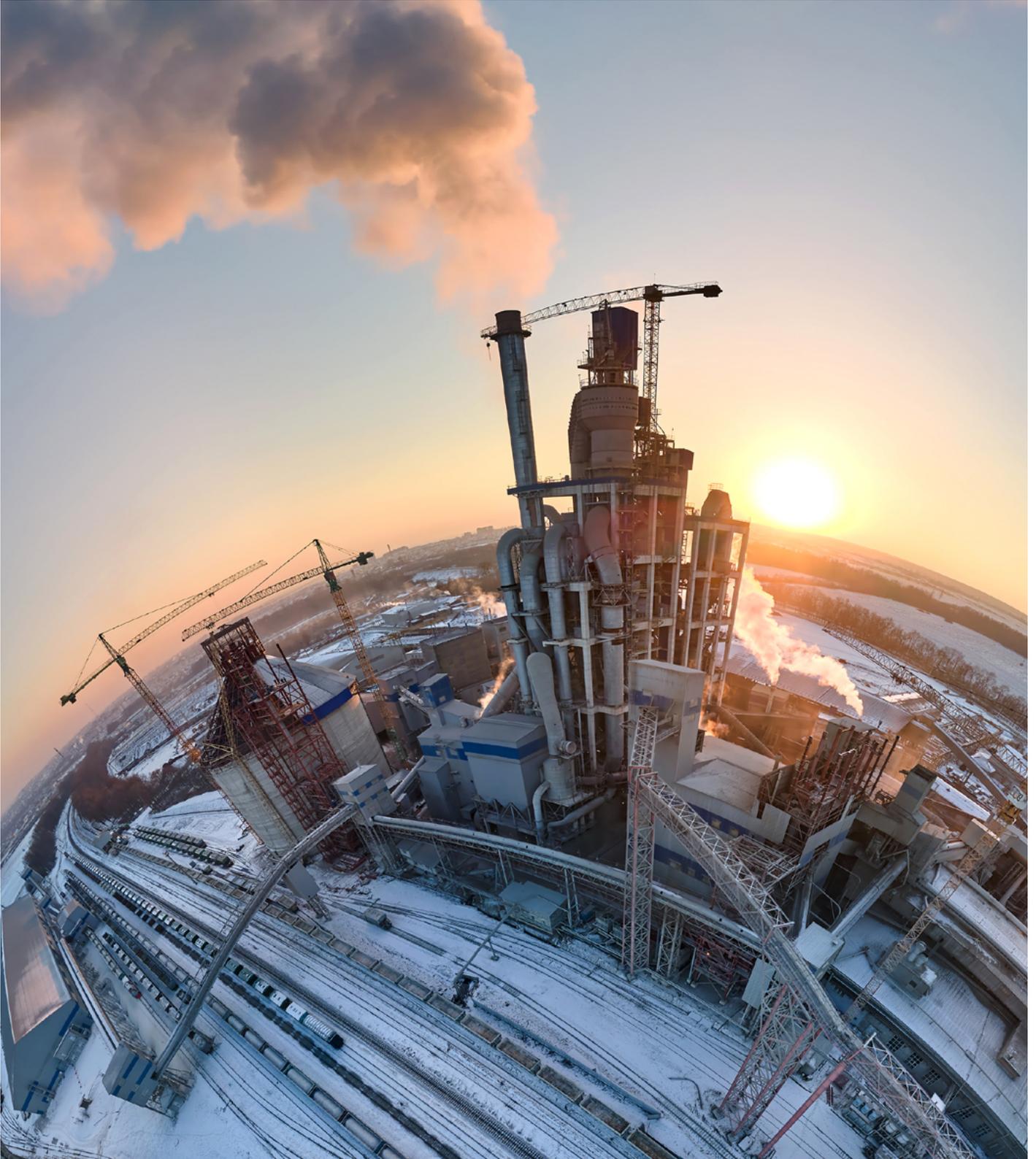
- Explore opportunities for diversification of energy mix and investment in captive renewable power for the sector.
- Differentiated tax incentives to boost the commercial viability of decarbonization initiatives.
- Streamlined permitting for projects such as biomass-powered e-boilers.
- Public-private partnerships to stimulate R&D and bring pilots to market.
- Advanced sorting and purification of scrap aluminium.
- Design for recycling and invest in closed-loop systems to collect and reuse products, building on the success story of can recycling in Brazil.

Read the Brazil in-country workshop report [here](#).

5

# Cement and Concrete

Demand for cement and concrete is projected to grow 40% by 2050, driving emissions up to 3.8 billion tonnes without more efforts to decarbonize.



## 5.1 Sector overview

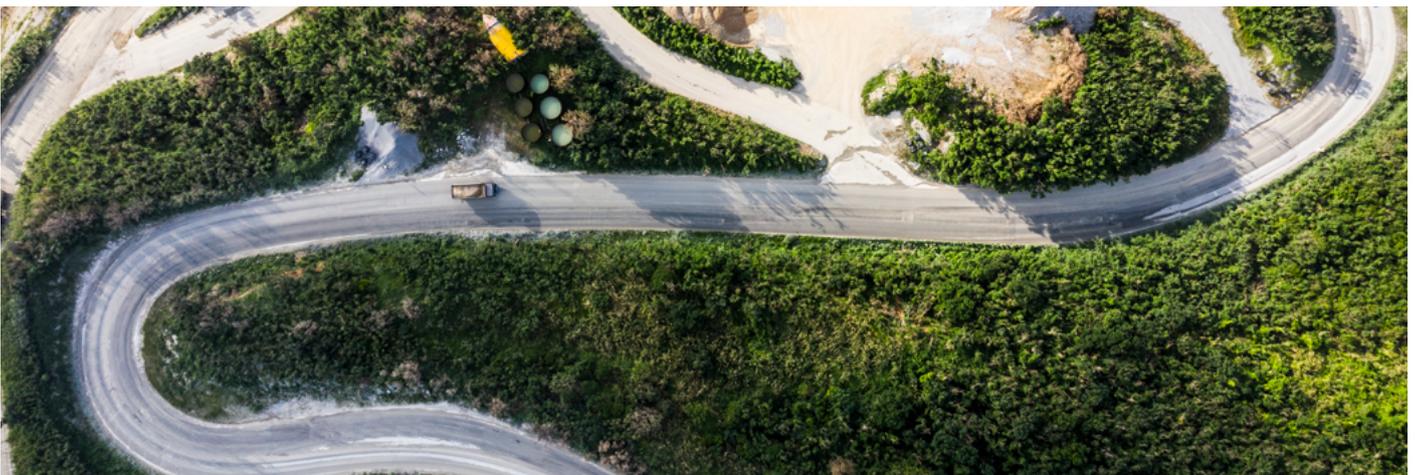
Concrete is the most widely used material on the planet after water. With cement and concrete production accounting for around 6% of annual global GHG emissions,<sup>21</sup> significant changes are required to make the industry sustainable. Meanwhile, the Global Cement and Concrete Association has forecast that annual demand for concrete could grow by more than 40% [from 14 billion m3 \(cubic metres\) today to 20 billion m3 by mid-century](#), as human societies urbanize and demand for infrastructure grows. This trajectory would see CO<sub>2</sub> emissions from the sector soar to 3.8 billion tonnes per year, based on current practice. Given that 2050 is just one investment

cycle away, due to the long life of capital assets in the industry, the time for taking decisions critical to decarbonizing this sector is now.

Currently, around [90% of cement manufacturing emissions come from producing clinker](#), used as a binder in most cement products. Cutting the sector's emissions will require deep decarbonization technologies, such as [carbon capture, utilization and storage \(CCUS\)](#) to capture process-related emissions at source, clinker substitution using non-fossil-based [supplementary cementitious materials \(SCMs\)](#) and alternative cement chemistries based on binders from alternative production pathways.

### BOX 13 Cement and Concrete sector overview

- ~6% of annual global GHG emissions.
- Global demand forecast to increase 40% by 2050, driving up emissions to 3.8 billion tonnes without efforts to decarbonize the sector.
- 7 corporate members – the newest sector in FMC.
- The sector has 18 suppliers and 39 projects included in the First Suppliers Hub.



## 5.2 Progress and impact of FMC

### Corporate members and commitment

Launched at COP27 in December 2022, cement and concrete is FMC's newest sector. It is one of the demand-side initiatives with the most ambitious near-zero thresholds to decarbonize the industry. FMC's near-zero threshold of 184 kg of CO<sub>2</sub> per tonne of cement produced represents a challenging target in relation to the US industry's baseline of 922 kg of CO<sub>2</sub> emitted per tonne of cement produced in 2021. The FMC's threshold was agreed to be an ambitious but feasible target with key partners

and suppliers during the commitment formulation process, given carbon capture technology's potential of capturing over 90% of a plant's emissions.

The threshold for concrete depends on the compressive strength of the concrete (see Box 14). Seven companies have so far joined the commitment to purchase or specify procurement of at least 10% of all their cement/concrete per year as near-zero emission cement/concrete.

**Construction and engineering:** “We commit to purchasing at least 10% (by volume) of our cement/concrete per year as near-zero cement/concrete\* inclusive of any SCMs by 2030 and excluding fossil-based SCMs by 2035.”

**Real estate, developers and advisory:** “We commit to ensuring/specifying that at least 10% (by volume) of the cement/concrete procured for our projects per year is near-zero carbon cement/concrete\* inclusive of any SCMs by 2030 and excluding fossil-based SCMs by 2035.”

**\*Cement and Concrete detailed commitment:**

**Subject of demand signal**

First movers will make a commitment<sup>1</sup> for either cement or concrete:

1. **Cement** with embodied carbon below 184 kg CO<sub>2</sub>e/tonne.<sup>2,3</sup>
2. **Concrete** that meets the embodied carbon limits below.<sup>4,5</sup>

Specified compressive strength (f'c in psi) <sup>6</sup>	Embodied carbon (kg CO <sub>2</sub> e/m <sup>3</sup> )
0 - 2500 psi	70
2501 - 3000 psi	78
3001 - 4000 psi	96
4001 - 5000 psi	117
5001 - 6000 psi	124
6001 - 8000 psi	144

**Technological pathways**

**Solutions may include (but are not limited to):**

- **Carbon capture, use & storage (CCUS).**
- **Non-fossil-based SCMs.<sup>7</sup>**
- **Fuel switching.**
- Renewable electricity.
- Energy efficiency improvements.
- Decarbonated raw materials.
- Alternative cement chemistries.
- CO<sub>2</sub> mineralization during curing.

**Out-of-scope:**

- **[By 2035] Fossil-based SCMs (i.e. GGBS and fly ash).**
- **Carbon offsets.**

**Bolded** abatement technologies seen as most critical to meeting FMC targets according to FMC research.

**Note:** 1. Depending on locality-specific regulatory / technical requirements; 2. Using 2021 baselines for US-based manufacturers with >80% clinker ratio chosen to avoid penalizing suppliers in countries with inherently low clinker ratios; 3. Modules A1, A2, A3 in life-cycle analysis (cradle-to-gate) as per EPD standards for Portland cement; Scope 1 and 2 emissions 4. Modules A1, A2, A3 in life-cycle analysis (cradle-to-gate) as per EPD standards for ready mix concrete; Scope 1 and 2 emissions; 5. Standard applies to both FMC and precast concrete given that both are specified by compressive strength and do not present significantly different emissions profiles; 6. Specified compressive strength of concrete using standard cylinders of six inches diameter and twelve inches height after 28 days of curing; 7. Any supplementary cementitious materials (SCMs) from non-fossil-based processes, i.e. not ground granulated blast-furnace slag (GGBS) and fly ash.

**Source:** 2021 US-based NRMCA Member Industry-average EPD for Ready Mixed Concrete with 0-19% SCM, 2021 US-based Portland Cement Association Industry-average EPD for Portland cement (91.4% clinker by weight), 2018 IEA Cement Low-Carbon Transition Technology Roadmap.

Learn more about the FMC Cement and Concrete commitment [here](#).

## FMC member progress and impact

Since its launch in late 2022, members of FMC’s cement and concrete sector have made some notable progress:

**Cemvision and FMC member Vattenfall**, a Swedish multinational power company, have entered an agreement (LOI) for the development and future supply of near-zero emission cement, which has the potential to reduce CO<sub>2</sub> emissions by up to 95% by 2030. Cemvision is developing cement made from residual materials recycled from mining and steel industries, using kilns fuelled by fossil-free energy.

**Consolidated Contractors Company (CCC)**, the Middle East’s largest construction company, is targeting the integration of 10% green concrete in its civil and mechanical projects across the Middle East and North Africa region by 2030. This commitment involves replacing traditional cement with eco-friendlier SCMs such as GGBS and fly ash (in-scope for FMC until 2035). CCC has found that

the quality and strength of green concrete is not compromised by substituting up to 60% of Portland cement with GGBS.

**Vattenfall** has developed a hydropower concrete with less cement content that reduces CO<sub>2</sub> emissions by around one-quarter. The concrete is being used to build a new spillway dam at one of the company’s hydropower stations. Vattenfall has found that reducing cement use in large concrete structures results in a lower temperature during the curing process, which in turn reduces the risk of cracks. The company has conducted extensive tests to ensure its greener concrete meets 100-year safety and durability requirements.

**ZGF Architects**, based in the US, has worked on two major projects in which they challenged local concrete suppliers to create low carbon Environmental Product Declarations (EPDs), which in turn led to higher use of SCMs.

EPDs are independently verified reports on the environmental impact of a product throughout its life cycle. As a result, these two projects have achieved a 20-34% reduction in global warming potential, compared to average regional practices, and stimulated the production of more, lower-carbon cement. In September 2023, ZGF published an interactive guide, *Concrete: A Pragmatic Approach to Lowering Embodied Carbon*.<sup>22</sup>

However, the impact of FMC members on decarbonizing cement and concrete is not limited to the companies signed up to the commitment. Four of the world's largest cement producers – Holcim, Heidelberg Materials, Cemex and Dalmia Cement – have signed up to FMC's trucking sector commitment. These companies are also making major steps in terms of both carbon capture and manufacturing low-carbon cement and concrete (see Box 15).

## BOX 15 SUCCESS STORIES – Holcim and Heidelberg

Two of the world's largest cement and concrete producers – both FMC members – are leading the charge in decarbonizing one of the planet's toughest-to-abate sectors. Neither of these companies is yet meeting the very high bar of FMC-compliant near-zero cement/concrete, but both are demonstrating that the pathway to meet that commitment is possible.

**Holcim**, a major international building materials company with a cement production capacity of 260 million tonnes per year. In 2023, Holcim announced its goal to offer 8 million tonnes of net-zero cement per annum by 2030. This will be enabled by Holcim's CCUS projects, six of which have been selected for grants from the European Union Innovation Fund to capture 5 million tonnes

of CO<sub>2</sub> per annum by 2030. The company's brands of [low-carbon ready-mix concrete](#) and [low-carbon cement](#) deliver at least 30% lower CO<sub>2</sub> emissions and reached 19% of net cement and concrete sales in 2023.

**Heidelberg Materials** is a German multinational building materials company which produces 176 million tonnes of cement annually. The company is collaborating with the Norwegian government to create a carbon capture and storage (CCS) facility in Brevik, Norway, scheduled to start operations at the end of 2024. This will be the world's first full-scale CCS facility in the cement industry, with an initial capacity of 400,000 tonnes of CO<sub>2</sub> captured and stored annually.

## Lessons from the FMC process

The story about FMC's impact in cement and concrete is less about building demand through offtake agreements and more about decarbonizing the sector as a whole, through working with a range of value chain actors. There are several reasons for this, including geography, logistics, market complexity and bureaucracy.

**Geography:** First the geographical challenge. Since cement and concrete are so heavy and expensive to move, these products are typically sold within 250km of where they are produced. As a result, the sector – unlike say aluminium – is very localized. To clean up cement, the problem must be tackled where it is found – at the local level, in the thousands of locations across the world where clinker is produced and used.

**Logistics:** Cement can spoil and ready-mix concrete needs to be used as soon as it's made. So on the demand side, buyers are reluctant to purchase more than they know they can consume. This means that long-term offtake commitments are currently less common in the sector than short-term purchases.

**Market complexity:** According to the US Department of Energy,<sup>23</sup> about 96% of all cement shipped goes through intermediaries (e.g. ready-mix concrete companies, concrete product manufacturers, contractors and materials dealers). Consequently, clear communication and engagement across the supply chain is critical.

**Bureaucracy and customer mindset:** Inertia around safety, regulation and standards is preventing rapid decarbonization of the sector. The use of carbon-intensive Portland cement, the gold standard material used to make concrete, is baked into virtually every building code on the planet. The engineers that write these codes, along with architects, construction companies and their real estate clients, are often risk averse – for good reason – and fear that SCMs or concrete produced using materials and processes other than those used in traditional Portland cement might not prove as safe. The status quo is hard to shift and requires coordinated action by policy-makers, regulators and private sector players.

## First Suppliers Hub

For the reasons explained above, FMC is focusing on a broader value-chain approach to cement and concrete, as well as strengthening the all-important demand signal. For example, in January 2024 the coalition launched the [First Suppliers Hub](#) – an online portal for suppliers whose projects currently meet or are working to meet the thresholds established in the FMC commitments. The hub is a place where suppliers can present their projects and connect with buyers (see Chapter 10.2).

Cement has become one of the First Suppliers Hub's fastest growing sectors. There are many entries from start-ups and SMEs reimagining cement manufacture around new processes and materials, from electric kilns to replacing carbon-intensive clinker with carbon-free calcium silicate rock. More established players have also shown interest in the hub, for example those already heavily invested in Portland cement that are looking to decarbonize using CCUS.

Both approaches are needed. Only the legacy players will be able to produce low-carbon cement and concrete in significant quantities by 2030. But equally, innovation will be crucial in the coming decades to bring down emissions further and reach near-zero levels around the world. The database is proving particularly useful for the cement and concrete sector, given the regionally dispersed nature of the market.

Early adopters to join the Forum's First Suppliers Hub include [Brimstone](#) and [Sublime Systems](#), which are also members of the innovative [Decarbonized Cement & Concrete Alliance](#) (DC2). At the time of writing, the cement and concrete sector has 18 suppliers and 39 projects included in the First Suppliers Hub, including other DC2 companies.

## Flagship report: *Cement and Concrete Procurement Guide*

In January 2024, the Forum published the [First Movers Coalition Cement and Concrete Procurement Guide](#), in collaboration with Boston Consulting Group. The guide emerged as the result of member requests during working groups. It is aimed at those who are procuring low-carbon cement, concrete and related products. Rather than attempting to solve questions of standards and measurement, the guide sketches out the current lie-of-the-land for low-carbon cement and concrete procurement. In the absence of global standards on low-carbon materials in this sector, the guide, produced with input from BCG and partners from the wider ecosystem, will give FMC members a stronger grasp on what they should be asking of their suppliers.

In particular, the paper offers the following:

- Language that can be inserted into contracts to ensure that near-zero carbon cement and concrete purchased is in line with FMC thresholds.
- Information on wider considerations relevant to the procurement of low-carbon cement and concrete.
- Advice on carbon accounting issues around, for example, CCUS, use of alternative fuels and recarbonation.



**By actively collaborating with industry leaders through the First Movers Coalition, General Motors can support innovation, foster the widespread adoption of low-carbon cement and concrete solutions, and make significant strides towards achieving our overarching goal of a zero-emissions future.**

Jason Harris, Design Project Manager, Sustainable Workplaces, General Motors



## 5.3 Insights from in-country workshops



### Findings from India workshop

Without efforts to decarbonize the sector, emissions from cement production in India are expected to double to around 440 Mtpa by 2040, driven by the country's ever-increasing demand for housing and infrastructure. The industry has already reduced its emissions intensity by 36% since 1996 to 720kg CO<sub>2</sub>e/t, meaning India's cement plants are more thermally and electrically efficient than in the US. The sector makes better use of SCMs to replace carbon-intensive clinker. But FMC's threshold for near-zero emission cement of 184kg CO<sub>2</sub>e/t was seen as unrealistic by some workshop participants as it is dependent on CCUS technologies. Nevertheless, RMZ, an Indian real estate company, has committed to FMC's sector target.

#### Challenges

- Uncertain supply of commercially viable CCUS – a key technology to decarbonize the sector.
- Insufficient supply of SCMs, especially fly ash and blast furnace slag. As by-products of carbon-intensive industries, FMC puts them out of scope after 2035. Nevertheless, they are likely to play an important role for the Indian cement sector beyond 2035.
- Lack of demand, given the likely higher price of near-zero emission cement.
- Inertia around modifying building codes and adopting new practices.
- High cost of capital.

Read the India in-country workshop [here](#).

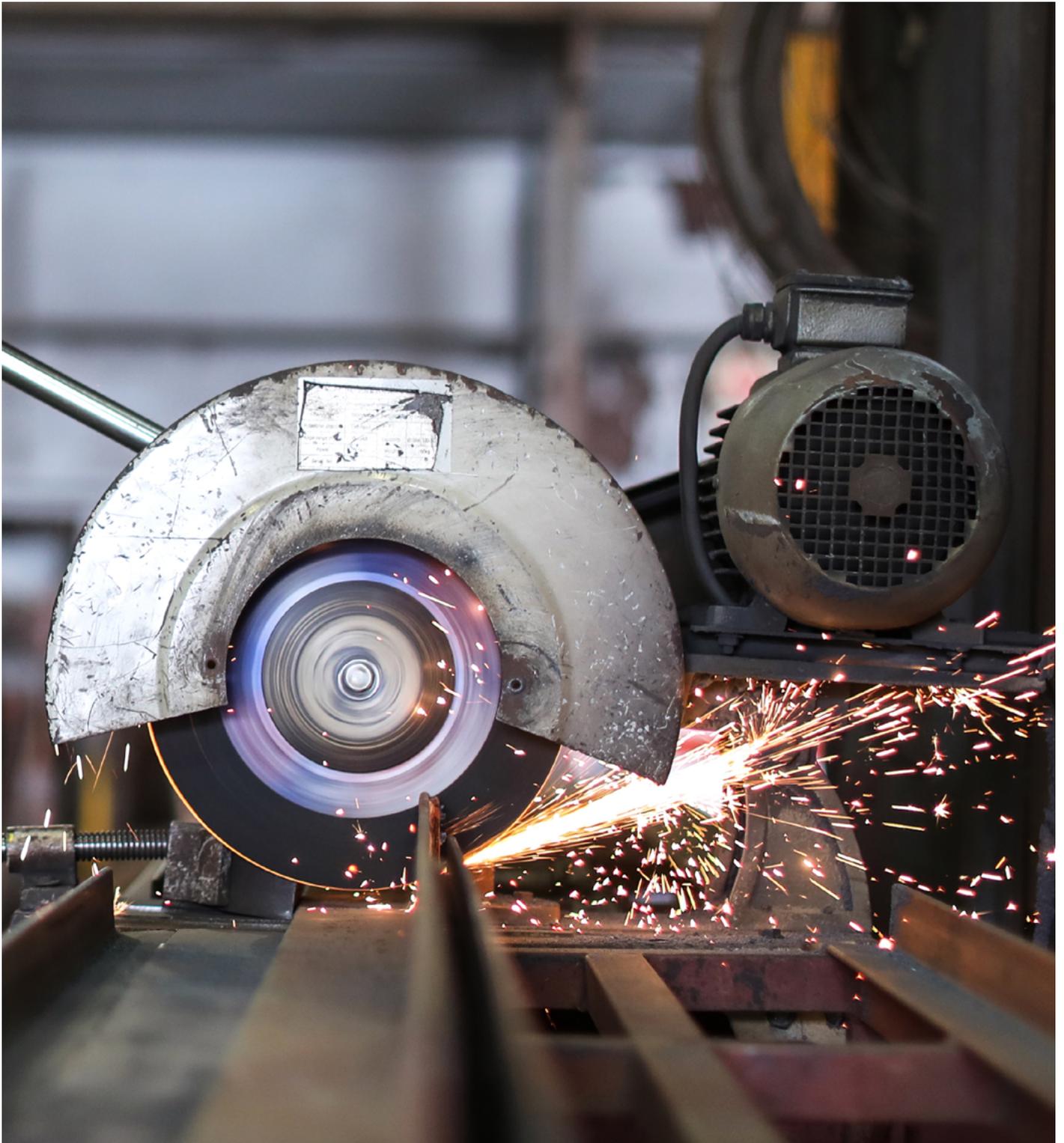
#### Solutions

- India's offshore oil and gas industry can provide carbon storage capacity.
- The most promising alternative SCM is calcined clay, found across the Global South. Some estimates suggest that if this material became the dominant way to make cement, it could reduce the sector's emissions by 30-40%.
- Build demand through public procurement, which is responsible for 40-60% of global concrete sales and can leverage policy to ensure a broad application of decarbonization targets.
- The Bureau of Indian Standards could either raise the proportion of SCMs permitted or expand the approved uses of different cement types.
- Clarify the criteria and indicators that assess the environmental performance of cement and concrete projects and how these criteria influence access to green finance.

6

# Steel

Steel is a critical material for transition technologies like wind turbines and EVs. Renewables and hydrogen hold the key to reducing the sector's annual 3.7 billion tonnes of emissions.



## 6.1 Sector overview

Steel production is one of the world's most carbon-intensive industries, accounting for roughly 8% of annual global GHG emissions.<sup>24</sup> The sector's emissions have averaged approximately [3.7 billion tonnes of CO<sub>2</sub> per year](#) since 2019. As the power sector decarbonizes, steelmaking is expected to become the single largest source of industrial emissions, especially given the global [demand for steel is expected to rise by up to 30% by 2050](#).

There are many routes towards decarbonization, such as electrifying heat generation, greater efficiency and more use of scrap steel. However, to decarbonize deeply and reach net zero, breakthrough technologies are needed to eliminate the emissions from coal's role as a reducing agent in ironmaking. These include direct reduced iron (DRI) using hydrogen instead of coal, carbon capture utilization and storage (CCUS), electrowinning and electric arc furnaces (EAF) – when powered by renewables.

### BOX 16 Steel sector overview

- ~8% of annual global GHG emissions.
  - Global demand forecast to increase 30% by 2050.
  - 27 corporate members of FMC's steel commitment, across different sub-sectors
- (e.g. construction, energy, automotive, original equipment manufacturers).
- 109 submissions to FMC's Near-Zero Steel Challenge to buyers, suppliers and enabling technology innovators.

## 6.2 Progress and impact of FMC

### Corporate members and commitment

In the two years since FMC was launched at COP26, 27 leading global companies have joined the steel sector commitment, to ensure at least 10% of steel purchased by 2030 will embody near-zero emissions (see Box 17). The prevalent method of making steel using the blast furnace-basic oxygen furnace (BF-BOF) process releases around [two tonnes of CO<sub>2</sub> for every tonne of steel](#) produced. FMC's target, in line with the [International Energy Agency \(IEA\)](#), is just 0.4 tonnes (when no scrap is used).

FMC's target falls to a mere 0.05 tonnes of CO<sub>2</sub> per tonne of steel produced if 100% scrap inputs are used. Scrap provides an important alternative transition pathway, by avoiding the need to produce primary iron using highly carbon-intensive blast furnaces. When combined with an EAF process (powered by renewables) to produce steel, the scrap-EAF approach can deliver low-carbon steel.

### BOX 17 FMC's Steel commitment

"At least 10% (by volume) of all our steel purchased per year will be near-zero emissions (as per FMC definition\*) by 2030."

#### \*FMC criteria:

- Crude steel from breakthrough technology production facilities.
- As per IEA guidance, the steel should emit <0.4t (0% scrap inputs) to <0.05t (100% scrap inputs) of CO<sub>2</sub>e per tonne of crude steel produced, from cradle-to-gate.

Leading analysis identifies that FMC's goals for steel production are most likely to be accomplished by using nascent and advanced green technologies, including but not limited to:

- DRI-EAF using zero-carbon hydrogen.
- Electrowinning.<sup>25</sup>
- Electrolysis-based production processes.
- CCUS (carbon capture, utilization and storage).

Learn more about the FMC Steel commitment [here](#).

## FMC member progress and impact

FMC steel members have already started translating their commitments into action, engaging in a number of offtake agreements and investments since 2022. Some stand-out achievements by FMC members in driving deep decarbonization of the steel sector forwards include the following:

**Consolidated Contractors Company (CCC)**, the Middle East's largest construction company, is targeting the integration of 10% near-zero emissions steel in its civil and mechanical projects across the Middle East and North Africa region by 2030. The company plans to source steel produced locally with reduced carbon emissions. Construction is a highly significant sector in steel consumption, accounting for [more than 50% of world steel demand](#).

**Ford** and **GM**: Ford has signed an MOU with Tata Steel Nederland to supply the carmaker with green steel, while General Motors has signed a deal with ArcelorMittal to provide recycled and renewably produced steel.

**Fortescue** is partnering with Primetals Technologies, Mitsubishi Corporation and voestalpine to design and engineer an industrial-scale prototype plant with a new process for net-zero-emission ironmaking at the voestalpine site in Linz, Austria. The new ironmaking process will be based on Primetals Technologies' HYFOR and smelter solutions. HYFOR

is the world's first direct reduction process for iron ore fines that will not require any agglomeration steps, like sintering or pelletizing.

**HYBRIT** is a collaboration between FMC members SSAB and Vattenfall, as well as the mining company LKAB, to eliminate carbon emissions from the entire steel manufacturing value chain. The project, which uses hydrogen direct reduced ironmaking (DRI), will reach commercial scale by 2026, aiming to produce 1.3 million tonnes of clean iron per year. The plant is already delivering low-carbon steel (500 tonnes in 2022) to key customers such as Volvo Group, a member of the FMC Steel sector (see Box 18).

**Ørsted**, the world's largest offshore wind developer, is establishing partnerships across the supply chain to build net-zero wind farms. A large offshore wind turbine can use [more than 3,000 tonnes of steel](#) in its tower and foundations. Ørsted has committed to procuring 25% low-emissions steel turbine towers for all joint offshore projects with turbine manufacturer and fellow FMC member Vestas. Towers will be made from scrap steel manufactured with onsite renewable electricity, reducing carbon emissions from heavy steel plates by up to 70%. The company has also partnered with Dillinger, long-term supplier of heavy plate steel for offshore wind turbine foundations, to develop the first-ever low-carbon steel for foundations.



**By committing to offtake lower emissions solutions, we give our partners the certainty they need to invest in them. In this way, by working together with our suppliers, we can lead our industry towards net-zero.**

Virginia Dundas, Director of Climate & Nature, Ørsted

**Scania**: FMC member and truck maker Scania's announcement that its stable of heavy-duty trucks will be manufactured almost entirely from hydrogen-based steel by 2030 is a major milestone in the sector. In June 2023, Scania placed its [first order with Sweden-based H<sub>2</sub> Green Steel](#), with deliveries of the first fully decarbonized steel expected in 2027. In November 2023, Scania signed a [letter of intent with FMC member SSAB](#) to deliver 100% fossil-free steel for Scania's heavy-duty trucks, starting in 2026.

**SSAB**, the Swedish steel manufacturer (and FMC trucking sector member), announced its decision in June 2023 to invest SEK 6.2 billion in a new electric arc furnace in its Oxelösund steelmaking plant. This is the first major step in SSAB's plan to transform its entire Nordic steel production into a fossil-free process by around 2030. Last year, the

company also introduced SSAB Zero, a carbon emission-free steel based on recycled steel and made using fossil-free energy. When the Oxelösund mill is converted, it will be able to use a flexible mix of fossil-free sponge iron and scrap as the raw material to produce steel without CO<sub>2</sub> emissions.

**Volvo Group**, one of the world's largest vehicle manufacturers, has partnered with SSAB to build the world's first fossil-free trucks – an important step given that over 70% of the weight of their trucks comes from steel and cast iron. The first prototype articulated hauler made from fossil-free steel supplied by HYBRIT was delivered in 2021. Volvo Group is now expanding the collaboration with other partners, including Sweden's [H<sub>2</sub> Green Steel](#) that will produce steel with 95% less CO<sub>2</sub> emissions compared to traditional steelmaking.



**This is fast-tracked innovation at its very smartest, and a testament to the sort of well-orchestrated collaboration FMC is calling for.**

Andrea Fuder, Chief Purchasing Officer, Volvo Group

ZF Group, Marcegaglia and Scania have all independently reached offtake agreements with Swedish steelmaker H<sub>2</sub> Green Steel for future near-zero steel supply. ZF Group, one of the biggest suppliers to the automotive industry, has signed an agreement worth €1.5 billion over seven years

to secure deliveries of near-zero emissions steel starting in 2026. Italian steel group Marcegaglia has signed a similar offtake agreement worth €1.79 billion. Meanwhile, Scania's agreement is part of the truck maker's goal to phase out the main sources of CO<sub>2</sub> from its supply chain by 2030.

BOX 18

## SUCCESS STORY – HYBRIT

HYBRIT ([Hydrogen Breakthrough Ironmaking Technology](#)) is a collaboration between steel producer and FMC trucking member SSAB, mining company LKAB and power producer and FMC member Vattenfall. The project uses zero-carbon electricity and hydrogen to eliminate emissions from the steelmaking process. The project opened a pilot plant for hydrogen-reduced sponge iron in Luleå in August 2020 and the following July, SSAB rolled the first steel produced using HYBRIT technology.

In September 2022, HYBRIT announced the launch of a new hydrogen storage facility – a

significant step, given large-scale hydrogen storage can reduce the variable cost of hydrogen production by 25-40%.

In November 2023, the project applied to the Swedish Energy Agency for state aid of SEK 3.7 billion to help LKAB build a [new demonstration facility in Gällivare](#). HYBRIT's aim is to develop a fossil-free value chain for iron and steel production, where LKAB produces sponge iron from fossil-free iron ore pellets, Vattenfall produces fossil-free energy and SSAB produces fossil-free steel. The demonstration facility is a key step from successful pilot phase to industrial-scale production.

## Near-Zero Steel 2030 initiative (“Steel Challenge”) and First Suppliers Hub

In 2023, along with the Rocky Mountain Institute (RMI), ResponsibleSteel, Deloitte and Greenhouse, FMC ran a “Steel Challenge” known as the [Near-Zero Steel 2030 initiative](#) to catalyse the emergence and commercialization of near-zero emissions innovations in the steel sector. The initiative, which was aligned with the FMC's near-zero steel criteria, comprised three interlinked challenges:

- **Near-Zero Steel Demand:** invites steel buyers to express interest in purchasing near-zero emissions steel by 2030. The aim is to quantify the demand for FMC-compliant steel by 2030 and identify where that demand exists geographically.
- **Near-Zero Steel Supply:** invites iron and steel makers to express interest in supplying near-zero emissions steel or iron by 2030. The aim is to identify which companies are producing FMC-compliant steel and where.
- **Near-Zero Steel Enabling Technologies:** invites innovators to share breakthrough technologies that could support near-zero emissions steel or iron by 2030. The aim is to surface new technology providers and connect them with iron and steel makers.

The initiative aims to overcome some of the major obstacles impeding the rapid implementation of near-zero emissions steel production, including:

- **Lack of technology at commercial scale,** despite significant progress in developing pathways and pilots that could lead to decarbonization.
- **Insufficient demand signal,** especially at the green premium to justify the investment required in producing near-zero emissions steel.
- **Insufficient collaboration between suppliers,** financiers, demand-side buyers, innovators and others in the value chain.
- **Insufficient access to renewable energy,** significant amounts of which are needed (e.g. to produce green hydrogen or power an electric arc furnace).

Submissions for the three interlinked challenges – which were open to non-FMC members – closed on 31 January 2024. The demand challenge attracted 21 entries and 17 companies claimed they could supply near-zero emissions steel by the end of the decade. Meanwhile, the enabling technology challenge attracted 71 submissions, with 17 submissions deemed to be Top Innovators across the seven technology categories (low-carbon hydrogen, carbon capture, direct reduction, electrolysis, electrowinning, furnace technology and renewable energy for hydrogen).

Appropriate demand-side applicants will be invited to join FMC's steel sector commitment, while North American demand-side applicants will be connected with RMI's Sustainable Steel Buyers Platform where applicable.

Following evaluation processes by independent experts identified by FMC and Greenhouse, credible suppliers are being entered into the [First Suppliers Hub](#) database as "final product suppliers" and credible enabling technology providers have been designated as "value chain product suppliers" or "cross-sector enablers," such as alternative fuel

suppliers. At the time of writing, the steel sector of the First Suppliers Hub has five final product suppliers and 13 value chain suppliers. For more information on the First Suppliers Hub, see Chapter 10.2.

FMC and Greenhouse support entrants to the NetZero 2030 Steel Challenge from all three pillars (supply, demand and enabling technologies) to increase their visibility through "First Connection Events" hosted by Greenhouse. The objective is to explore opportunities for collaboration and further sector decarbonization.

## Lessons from the FMC process

Steel is the world's most important engineering and construction material, critical for many technologies that will deliver decarbonization, such as wind turbines, electric vehicles and advanced manufacturing processes. The collaborations between FMC's steel, cement and trucking sector members in recent years are particularly notable. For example, last year concrete manufacturer [Holcim placed orders for 2,000 electric trucks from Volvo](#) by 2030, truck maker Scania has committed to using 100% green steel in all its heavy-duty trucks by the end of the decade, and energy

company [Vattenfall is using SSAB's low-carbon steel for its wind turbine towers](#).

One of the challenges that FMC has helped members tackle is to build greater understanding around products such as the near-zero heavy plate steel required to make wind turbines. The cost of this is far higher as a proportion of the total turbine capex build cost than, say, the proportion of the cost of sheet steel in automobiles. FMC also consults with suppliers and financiers to understand what would be required for greater offtake of these products to occur.



## 6.3 Insights from in-country workshops



### Findings from Brazil workshop

As demand for steel grows, emissions from Brazil's iron and steel sector could soar 30% by 2050. Despite the prevalence of legacy BF-BOF technology, the sector's emissions intensity of 1.3 tonnes of CO<sub>2</sub>e per tonne of crude steel produced is well below the 2.0t CO<sub>2</sub>e averaged by major producers. Nevertheless, given FMC's target of <0.4t CO<sub>2</sub>e, steel decarbonization remains a top priority. Brazil has one of the cleanest grids in the world with 85% of electricity powered by renewables. This, combined with its vast iron ore reserves and capacity for green hydrogen production, positions the country as a potential global leader in decarbonized iron- and steel-making.

The country already has a national hydrogen programme and the world's largest green hydrogen plant is due to open in Brazil in 2025. This could enable it to produce near-zero emission direct reduced iron (DRI) as well as low-carbon steel in conjunction with electric arc furnaces powered by renewables.

Major steel players active in Brazil have already committed to carbon neutrality by 2050 or earlier and are exploring various pathways to decarbonize production both inside and outside Brazil. ArcelorMittal is planning a pilot green hydrogen DRI plant in Hamburg for 2024-25, Ternium is piloting DRI methods in its Mexico operations, Vale is expanding its use of charcoal reductants in cold-briquetted iron, and Ternium and Vale have signed an MOU to conduct joint feasibility studies into DRI and other low-carbon pathways.

#### Challenges

- Limited willingness to pay a green premium that could be 15% higher than traditional steel.
- Access to affordable finance for capital-intensive projects such as CCUS and H<sub>2</sub>-DRI plants, given Brazil's benchmark lending rate of 12.75% (September 2023).
- Limited recycling of steel scrap.
- Overcapacity of highly emissive BF-BOF plants.
- Expense of retrofitting carbon capture technology to existing BF-BOF plants.

Read the Brazil in-country workshop report [here](#).

#### Solutions

- Coalitions such as FMC encouraging stronger demand signals from buyers willing to pay a green premium for low-carbon steel (e.g. from the automotive, construction and energy sectors).
- Greater value chain collaboration between leading companies to demonstrate to the wider market their willingness to change and to lead on decarbonization
- [Industrial clusters](#) could provide opportunities for scale, sharing risks and resources, aggregation and optimization of demand.
- The government needs to create a policy environment that helps the steel industry decarbonize, through carbon taxation, tax rebates, subsidies, grants and other incentives. Setting a [price for carbon at \\$36-72/t CO<sub>2</sub>](#) would make the H<sub>2</sub>-DRI process competitive with traditional production.
- International financial institutions, domestic development banks and commercial banks need to cooperate and accelerate efforts to offer financial products that de-risk investments, including blended finance, concessionary loans, sustainability bonds and first-loss insurance.
- Government and industry must work together to create a more efficient municipal scrap system, investing in infrastructure to capture, recycle, clean and use the maximum scrap possible
- Brazil has all the ingredients to become a global leader in green hydrogen production. The steel industry must seize the opportunity to collaborate with the government on its national hydrogen plan and green hubs.
- Long-term planning is needed to map out the roles of different stakeholders, including industry, government and investors, as well as to embrace Brazil's potential global role of exporting decarbonized iron.



## Findings from India workshop

Surging domestic demand will more than triple CO<sub>2</sub> emissions from India's steel industry to 800 Mtpa by 2050, without efforts to decarbonize. To date, there are no projects in India capable of producing steel that clears FMC's threshold. The government's policy to promote green steel up to 2030 focuses on energy and resource efficiency, but this will not deliver the level of decarbonization envisaged by FMC.

Despite these challenges, three Indian companies (Mahindra & Mahindra, ReNew and Bharat Forge) in addition to international companies with manufacturing activities in India, have committed to FMC's target to ensure at least 10% of their steel purchases will be near-zero emissions by 2030.

### Challenges

- Capital expense is the major challenge. The cost of converting a large blast-furnace plant to produce near-zero emission steel can exceed \$1 billion, before considering the cost of additional upstream infrastructure.
- Uncertain availability of essential upstream technologies, such as renewable energy, green hydrogen, CCUS and efficient scrap recycling.
- Reluctance of Indian buyers to pay a green premium.
- Economies of scale favour the traditional and highly carbon-intensive blast furnace method of production.
- Domestic investors face high borrowing costs.

### Solutions

- India's government has a target to increase the capacity of its renewable energy sector to 250GW by 2030 while its National Green Hydrogen Mission, backed by a \$2 billion incentive plan, aims to deliver 5 Mt of production per year by 2030.
- Investment to develop India's scrap supply chain could help decarbonize near-term steel demand and enable the sector to delay deployment of new capacity until green hydrogen is ready.
- Given the dominance of blast furnace production, CCUS will be critical to decarbonize the sector. The government needs to provide incentives and streamline regulations to drive CCUS deployment.
- Joint efforts from the government and financial institutions are essential to provide comprehensive, affordable financial support to help MSMEs achieve their decarbonization goals.
- Collaboration between the government and major steel manufacturers should focus on innovative pilot projects and R&D spending to ensure availability of breakthrough technologies.
- Policy measures needed include: an efficient carbon market, government funding for capital expenditure, tax credits for new technologies, public procurement of near-zero emission steel and streamlined permitting.
- Finance sector measures include more blended finance to lower the cost of capital in India (e.g. the World Bank's \$1.5 billion loan announced in June 2023 to support India's low-carbon transition).

Read the India in-country workshop report [here](#).

7

# Carbon dioxide removal (CDR)

To hit the Paris climate goals will require 10 billion tonnes of CO<sub>2</sub> removal every year by 2050. The majority of that will have to come from durable CDR.



## 7.1 Sector overview and status

In 2024, the world experienced its warmest January on record, marking the [first 12-month period in which temperatures averaged more than 1.5°C \(2.7°F\) above pre-industrial times](#). Following years of insufficient climate action it is becoming increasingly evident that the Paris Agreement to limit global warming to well below 2°C and pursue all efforts to limit it to below 1.5°C could be in jeopardy.

As the planet approaches these thresholds, it is vital not to forget that every fraction of a degree of warming carries greater risks of cascading climate tipping points, which society must do all it can to mitigate. Carbon dioxide removal (CDR), especially scalable and durable options that can [lock away CO<sub>2</sub> for over 1,000 years](#), is increasingly seen as a critical decarbonization tool.

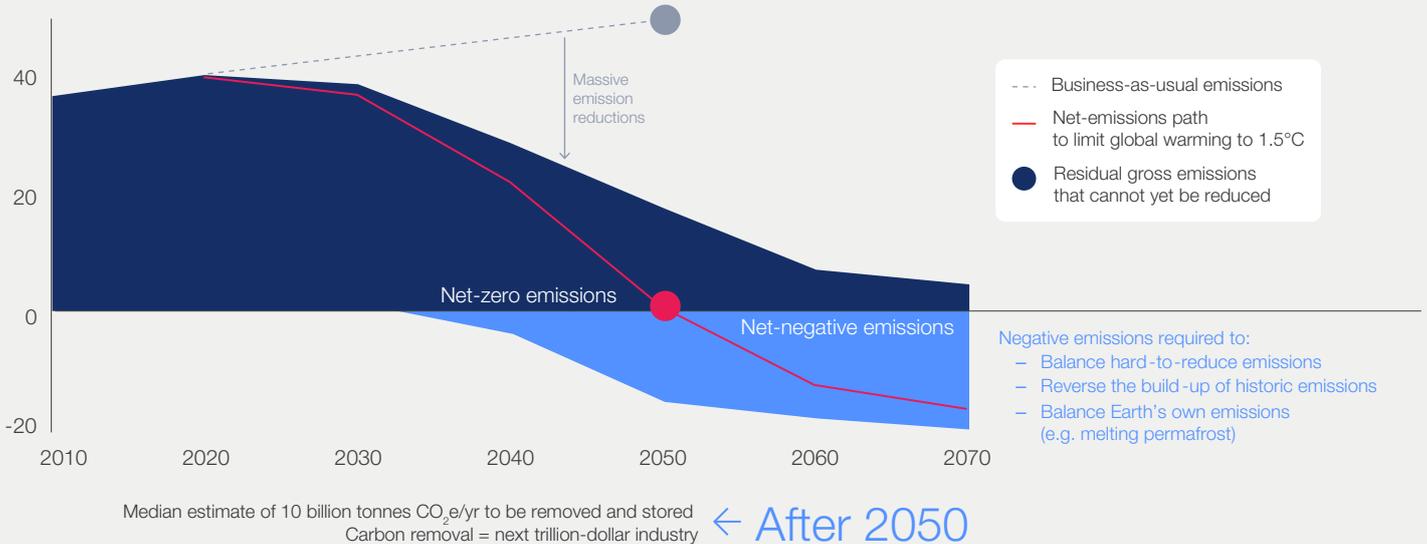
CDR is required for three reasons:

1. Compensate for the last 10% of “hard-to-abate” emissions
2. Draw down Earth’s own emissions from natural feedback loops exacerbated by global warming (e.g. melting of Arctic permafrost, savannization of the Amazon rainforest)
3. Reverse the accumulation of historic emissions

As a result, up to [10 billion tonnes \(10 Gt\) of CDR per year](#) is expected to be needed by 2050, according to the median estimates of scenarios considered by the Intergovernmental Panel on Climate Change (IPCC). Then, throughout the second half of the century, global emissions have to stay net-negative, where more CO<sub>2</sub> is removed than emitted (see Figure 9).

FIGURE 9 Beyond net zero – negative emissions required through carbon removals

### Global greenhouse gas emissions (billion tonnes CO<sub>2</sub>e per year)



The total amount of carbon dioxide currently removed by all CDR options totals 2 Gt CO<sub>2</sub>/yr, of which 99.9% comes from natural climate solutions (NCS) such as afforestation. While only 0.1% results from “engineered” CDR, it has more potential to scale-up, because the space required for NCS is limited by other land uses. To remove 10 Gt of CO<sub>2</sub> a year by 2050 requires ramping up all solutions, whether engineered or nature-based. Success depends on **integrity** (delivering an additional, durable and quantifiable impact) and **scalability** (fast and replicable enough to make a difference).

Scalable and durable ways to remove CO<sub>2</sub> from the atmosphere include engineered solutions – such as bioenergy with carbon capture and storage

(BECCS), biomass with carbon removal and storage (BiCRS) and direct air capture with carbon storage (DACCS) – and hybrid natural processes, such as enhanced rock weathering (ERW) and mineralization. Biochar is only in-scope for FMC if proven to provide 1,000+ years of permanent CO<sub>2</sub> storage. Most biochar is expected to fall short of this requirement, though specific solutions may reach the threshold.<sup>26</sup>

While engineered CDR scores highly on integrity, its scalability is hampered by high costs – due to the technology’s nascent nature; lack of mature measurement, reporting and verification (MRV) standards; and low support from policy-makers.



**Since 1990, humanity has emitted more greenhouse gases than in all recorded history before that date.**

Institute for European Environmental Policy

BOX 19

### Carbon dioxide removal sector overview

- Need to remove 10 billion tonnes of GHG emissions a year by 2050.
- Advance purchases for engineered CDR total just 11 million tonnes.
- FMC members and implementation partners account for over 80% of these purchases.



## 7.2 Progress and impact of FMC

### Corporate members and commitment

A group of 11 leading companies from various sectors, including technology, finance, heavy industry and professional services, have joined FMC’s CDR commitment, to contract for at least 50,000 tonnes or \$25 million worth of durable and scalable CO<sub>2</sub> removal by 2030 (see Box 20).

As part of research for a Forum white paper conducted in late 2023, FMC members offered their insights into why it is so important to start on engineered CDR now and why “wait and see” is not an option. The interviewees gave different reasons, as follows:

- Engineered CDR offers greater certainty on delivering corporate net-zero targets, especially as nature-based solutions are likely to deplete towards mid-century.
- CDR offers companies opportunities to develop new business models and co-benefits, such as creating new jobs.
- Companies need to step up and take a leadership role, since the world cannot afford to delay any longer.

“In addition to our maximal direct emissions reduction efforts, we commit to contract for at least 50,000 tonnes of **durable and scalable** (see definitions\*) net carbon dioxide removal to be achieved by the end of 2030.”

As an alternative to contracting for 50,000 tonnes, companies joining FMC can contract for at least \$25 million of durable and scalable (see definitions\*) net carbon dioxide removal to be achieved by the end of 2030.

**\*FMC definitions:**

Carbon removal solutions that satisfy the following are in-scope:

- Durable solutions that can demonstrably store captured carbon for a minimum of 1,000 years.
- Scalable solutions that have the potential to reach Mt scale (millions of tonnes) by 2030 and Gt scale (billions of tonnes) by 2050.

Learn more about the FMC Carbon dioxide removal commitment [here](#).

## FMC member progress and impact

Member companies of FMC’s CDR sector have already started translating their commitments into offtake and action, engaging in a number of offtake agreements and investments since 2022. [FMC members and implementation partners represent more than 80% of all engineered CDR credits](#) purchased globally to date, with the majority accounted for by Microsoft.

Some notable achievements of FMC members in accelerating CDR include the following:

[Boston Consulting Group](#) (BCG) has secured a five-year purchase agreement with CarbonCapture for 40,000 tonnes of CO<sub>2</sub> removal credits, delivering one of the largest direct air capture (DAC) deals within the professional services industry. Credits are tied to CarbonCapture’s Project Bison facility in Wyoming, which is forecasted to capture and store 5 million tonnes of atmospheric CO<sub>2</sub> per year starting in 2030. In late 2023, BCG signed a [15-year offtake deal for 80,000 tonnes of CO<sub>2</sub>](#) with DAC company ClimeWorks.

[Frontier](#), an advance market commitment to buy more than \$1 billion in durable CDR between 2022 and 2030, has FMC member Alphabet as a founding member. In 2023, they made advance purchases of 120,000 CDR credits across 15 companies. In late 2023, Frontier signed an offtake deal with DAC companies CarbonCapture and Heirloom, totalling [\\$47 million for the removal of 72,000 tonnes of CO<sub>2</sub>](#), on behalf of a group of buyers including Alphabet.

[Google](#) is matching the US Department of Energy’s Carbon Dioxide Removal Purchase programme and will buy \$35 million of carbon removal credits within the next year.

[Microsoft](#): In 2020, Microsoft committed to make its own operations and its entire supply chain carbon-negative within a decade, through a 55% reduction

in emissions plus carbon removals. The same year, it phased out its avoided emissions offsets and began to embrace CDR. The company also pledged to remove all the carbon it has ever emitted, both directly and through its electricity consumption since it was founded in 1975. The company’s target is 5.5 million tonnes of carbon removals per year by 2030. Microsoft now accounts for ~64% of all engineered CDR purchases made to date.

In 2023, Microsoft partnered with fellow FMC member Ørsted and Aker Carbon Capture, committing to one of the [world’s largest carbon removal agreements of 2.76 million tonnes](#) of durable CDR credits over 11 years (see Box 21). Additionally, Microsoft has signed a long-term [contract with Heirloom to purchase up to 315,000 of CO<sub>2</sub> removal](#), one of the world’s largest bankable direct air capture and storage deals. In early 2024, Microsoft signed an [offtake deal for 27,600 tonnes of CO<sub>2</sub>](#) over six years with Neustark, using BECCS and mineralization.

[NextGen CDR Facility](#) is a buyers’ club that aims to build a market for credible, scalable CDR by committing to purchase over 1 million CDRs by 2025. In April 2023, it kickstarted this process by purchasing [200,000 CDR credits spread across three projects](#), including 1PointFive’s DACCS project in Texas and Summit Carbon Solutions’ BiCRS project in the US Midwest. FMC members BCG, Mitsui O.S.K. Lines (MOL) and Swiss Re were founding buyers in NextGen and FMC is a strategic partner.

[Salesforce](#), as part of its FMC commitment, has made a \$25 million investment pledge for permanent carbon removals delivered by Frontier, an initiative that aims to accelerate the development of carbon removal technologies with guarantees of future demand. Frontier also vets suppliers, with a focus on solutions with the potential to achieve high volume and low cost.

[Swiss Re](#) has pioneered the role of carbon pricing to secure the budget for high-quality CDR. In 2021, the company introduced an internal carbon price of \$100 per tonne of CO<sub>2</sub>. This “carbon steering levy” applies to all the firm’s scope 1-3 emissions. The funds collected are spent on a mix of high-quality carbon avoidance and carbon removal certificates to compensate for these emissions. Between 2021 and 2030, the carbon price will increase from \$100 to \$200 per tonne of CO<sub>2</sub> and at the same time the

share of carbon removals will grow from 10% in 2021 to 100% by 2030. By 2030, Swiss Re aims to neutralize all its in-scope residual emissions through high-quality removals that can cost on average \$200 per tonne.

[Trafigura](#) has recently signed an offtake deal from 1PointFive’s first industrial-scale DAC facility, STRATOS, which is currently under construction in Texas.



**Suppliers of carbon removals need real loans; they can’t scale-up out of their equity pocket. They need a guaranteed income from creditworthy offtakers to get the project finance.**

Mischa Repmann, Senior Sustainability Risk Manager, Swiss Re

BOX 21

## SUCCESS STORY – Microsoft and Ørsted

In May 2023, [Microsoft signed an offtake agreement with FMC member Ørsted to purchase around 2.7 million tonnes of durable CDR](#) credits over 11 years, representing one of the largest carbon removal offtake deals by volume to date. The agreement was part of the Ørsted Kalundborg CO<sub>2</sub> Hub, where ~430,000 tonnes of biogenic CO<sub>2</sub> per year will be captured and stored, from 2026. In May 2024, Microsoft agreed to purchase an [additional 1.0 million tonnes of carbon removal](#) over 10 years from the same hub.

Ørsted has partnered with Aker Carbon Capture to establish a carbon capture facility at two of its combined heat and power plants running

on sustainable straw and wood chips. Once captured, the biogenic CO<sub>2</sub> will be shipped to a storage reservoir in the Norwegian part of the North Sea.

By capturing carbon from biomass-fired heat and power plants and storing it underground, it is possible to deliver not just carbon reduction but also carbon removal (“negative emissions”), as biogenic carbon from sustainable biomass is part of a natural carbon cycle.

Given the nascent nature of this industry, Microsoft’s contract and Danish state subsidies were critical for Ørsted to make this project viable.



**Microsoft’s rules of thumb for carbon removal are simple: contract for a mix of technologies, suppliers and countries.**

Rafael Broze, Lead, Engineered Solutions for Carbon Removal, Microsoft

## Flagship report: *Carbon Dioxide Removal: Best-Practice Guidelines*

In January 2024, the Forum published a white paper entitled [Carbon Dioxide Removal: Best-Practice Guidelines](#), drafted by FMC’s CDR sector lead. The report is for sustainability professionals who are in the process of adding CDR to their companies’ climate strategy. It covers the specifics of different types of engineered CDR and seeks to lower entry barriers to the nascent removals market.

The report shares lessons learned by eight FMC members, interviewed specially for the report, and provides best-practice guidelines for companies looking to enter the engineered carbon removal space. It seeks to answer questions such as: Why enter the engineered CDR market when the technologies are so unproven? Why not wait and see if the prices come down before committing?

The report, which is aimed to be a practical how-to guide, is organized in four parts:

- Overview of the carbon removal challenge.
- Introduction to engineered CDR and its nascent market.
- Why companies should engage in engineered CDR now, with rationales to make the case to corporate decision-makers.
- Insights from FMC members on how to access the engineered CDR market (e.g. securing the budget, choosing a market access model, communicating in-house and externally).

## Lessons from the FMC process

Different pathways into CDR work for different companies. Most approaches involve purchasing CDR credits, where a single unit equals one tonne of CO<sub>2</sub>e removed from the atmosphere. After a carbon credit has been bought from a CO<sub>2</sub> removal project, it is permanently retired so others cannot reuse it.

FMC members interviewed for the best-practice guidelines told the Forum about the following ways they have engaged in driving CDR offtake:

- **Direct deal-making with CDR developers:** this allows buyers to negotiate the exact contract terms but comes with substantial transactional effort. Suited to large companies with big offtake volumes looking to build in-house competency and relationships with strategic partners.
- **Aggregated demand facilities:** these aggregate demand from individual buyers into a managed portfolio of engineered CDR. Members sign one contract with the intermediary and secure diversified removals at competitive prices. Suitable for companies sourcing smaller volumes through long-term offtakes.
- **Over-the-counter purchases:** when engineered CDR certificates are traded among suppliers, brokers and buyers. Prices per tonne are often fixed and carry heavy overheads, but transactions are fast, low-effort and flexible.
- **Consultants:** for companies with limited experience of CDR, who can seek support from a specialist consultant to provide technical advice on access routes and help build a meaningful strategy.



**We are proud of our transparency around the price per tonne we are paying for carbon removals. We've heard it's helpful for project developers and their funding partners because they know there will be buyers at those levels.**

Antoine Poulallion, Director of Sustainability, Boston Consulting Group

While the examples highlighted above show progress, the sobering reality remains that [advance purchases for engineered carbon dioxide removals are only at a total of ~1.1 million tonnes](#) today, so a minuscule fraction of the 10 billion tonnes per year needed by 2050.

Also, the set of buyers is relatively concentrated, with Microsoft alone representing around two-thirds of the purchases and the top 10 buyers combined representing ~92%, demonstrating the need for many new participants to join the space to deliver on the 2050 needs.

In the view of Swiss Re, “a lack of demand rather than a shortage of supply” is the key problem. The company’s aim in helping to establish the NextGen facility was to build demand by making it easier for more buyers to access the removals market. Meanwhile, Swiss Re’s internal carbon price of \$200 per tonne of CO<sub>2</sub> is also the company’s marginal abatement cost in 2030 – so any abatement measure cheaper than \$200 per tonne should come before paying for removals. “The higher the price, the more reductions are prioritized over removals,” says Mischa Repmann, of the company’s sustainability team.

FMC’s process of convening companies prepared to go public with a CDR commitment has led to an unusual level of openness around the cost of removals that brings its own benefits. BCG, for example, has stated it is ramping up its average spend on carbon removals from \$16 per tonne in 2022 to \$80 per tonne by 2030. As the company’s Antoine Poulallion explains: “We are proud of our transparency around the price per tonne we are paying for carbon removals. We’ve heard it’s helpful for project developers and their funding partners because they know there will be buyers at those levels.”

## 7.3 Building a broader ecosystem to support CDR

During 2024, the engagement criteria for the CDR sector are undergoing a thorough review process to ensure FMC is setting the membership bar at the right level for best practice and the terms of the commitment are up to date with market progress regarding the latest taxonomy, technological innovations, standards, MRV systems and so on.

FMC’s CDR sector has focused mainly on building its membership through individual buyers that can afford 50,000 tonnes or \$25 million of carbon removal. However, the coalition is actively

considering more creative models as part of its ongoing commitment review.

In addition to strengthening the demand signal, FMC has worked to identify high-quality suppliers for DAC, BECCS, biochar and enhanced rock weathering. The team is also working with implementation partners that can provide CDR solutions for buyers aligned with FMC’s criteria for durability and scalability. In this way, FMC is not simply building demand, but helping to increase the visibility of suppliers of CDR solutions.

8

# FMC Finance

FMC Finance works to de-risk and unlock cross-sector investment in zero-emission technologies through engaging with actors in the capital stack to accelerate public-private collaboration.



## 8.1 Overview

Decarbonizing the hard-to-abate industry sectors entails enormous upfront capital investment and ongoing production premiums, compared to incumbent fossil-powered alternatives. For example, if India is to reach net-zero emissions by 2070, the International Energy Agency (IEA) estimates that \$160 billion per year is needed across the country's energy economy between now and 2030. That's three times today's investment levels.

The climate-critical technologies needed to produce near-zero emission fuels and materials not only have high capital needs, they are also high-risk. Typically first-of-a-kind projects bring higher technology and delivery risks than most investors are used to.

Unlocking capital flows requires overcoming this tension between venture-like risk and infrastructure-

sized cheques. Concessional capital, blended finance and de-risking mechanisms are essential to open the way for private capital to enter and scale-up this market.

Collaboration is needed to bring different sources of public, private and philanthropic capital together. Capital providers must each play a unique role, consistent with their risk-return frameworks and financing objectives. Ultimately, the greatest returns in terms of carbon reductions, operational risk mitigation and financial management often require external financing or partnerships between anchor investors, multilateral development banks and institutional investors to unlock capital more quickly and de-risk investments.

## 8.2 Focus and priorities of FMC Finance

FMC's finance pillar has been active since October 2022, engaging with a wide range of financial stakeholders to build an ecosystem in support of

FMC's goals. Some of the pillar's key priorities, impacts and insights are detailed below.

### Priorities to address around the capital stack

The key priorities FMC Finance is addressing can be framed around the following questions in relation to the capital stack required to mobilize finance for breakthrough technologies sufficient in speed and scale to fuel the transition of hard-to-abate industries:

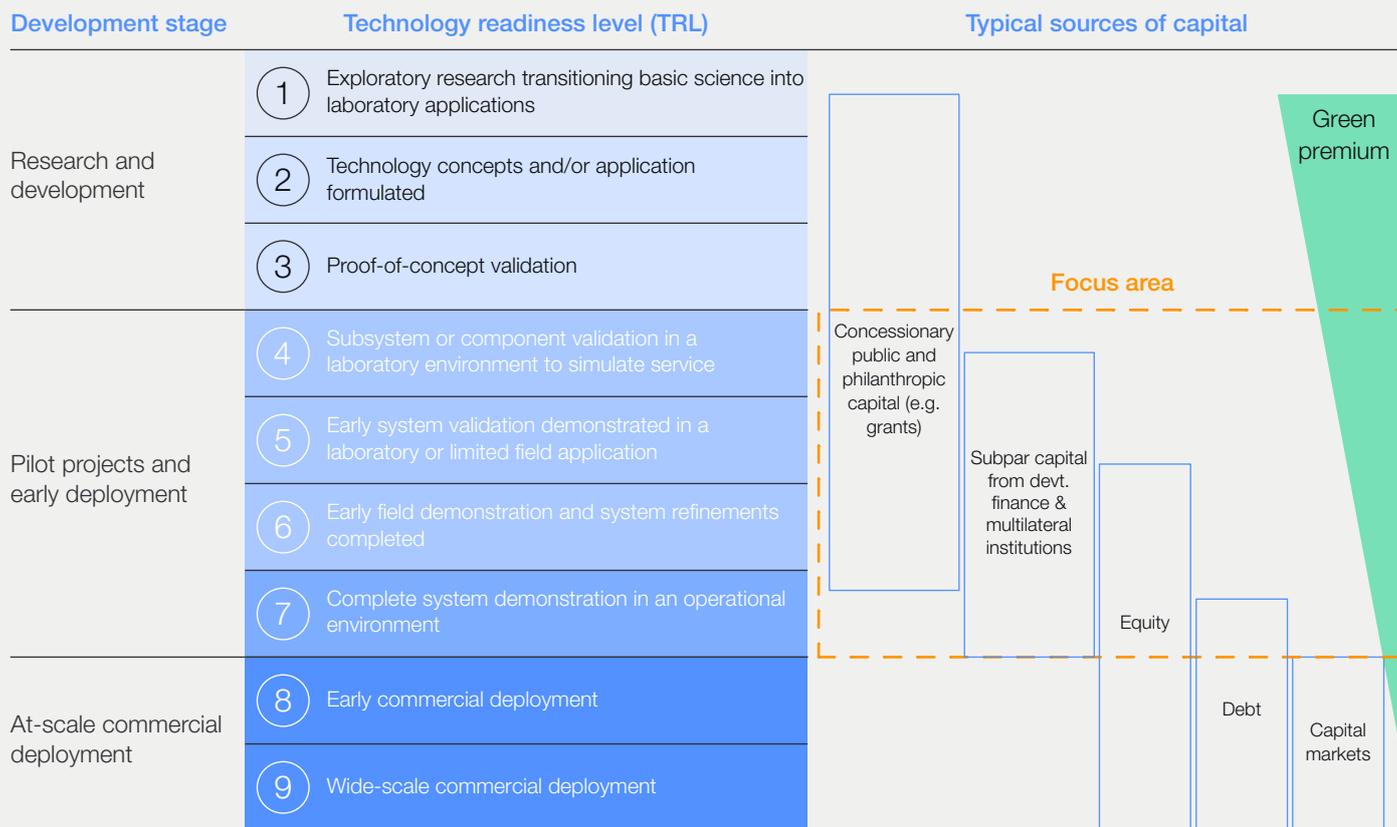
1. How can financial institutions act upon their net-zero targets, enabling the transition for hard-to-abate sectors? Can they, for example, divest from their fossil fuel portfolios?
2. How can effective de-risking solutions, incentives, private public partnerships and innovative financing mechanisms be replicated at scale, including in emerging economies?
3. What are the system changes and new architecture needed across private financial institutions, multilateral development banks (MDBs), development finance institutions (DFIs) and policy-makers to scale-up financing for the transition? How much risk can these institutions take on their balance sheets? What types of

models can we develop that allow them to share risks in an acceptable manner? How can they fill the gaps using concessional capital?

FMC Finance has analysed the typical sources of capital that come into play at different stages during the development of innovative technologies, from the exploratory stage through to wide-scale deployment (see Figure 10). For FMC's finance pillar to be most effective, it has focused its role on the "pilot projects and early deployment" phase, when the technological readiness level is 4-7 out of 9. This so-called "valley of death" is reached when public and philanthropic capital is beginning to run out but concessionary capital from DFIs and more adventurous equity is yet to kick in.

As one participant at the South Africa in-country workshop put it: "In infrastructure finance the real gap is in the early phase – pre-feasibility to financial close. As we head towards net zero, it will be super important for the finance sector to unlock early stage, pre-financial-close and blended finance solutions."

FIGURE 10 | Capital stack: different sources of private and public capital must be brought together to help develop and scale-up breakthrough technologies



“ In infrastructure finance the real gap is in the early phase – pre-feasibility to financial close. As we head towards net zero, it will be super important for the finance sector to unlock early stage, pre-financial-close and blended finance solutions.   
 Sam Mokorosi, Head of Origination and Deals, Johannesburg Stock Exchange

### 8.3 Actions and impacts

#### Flagship report: *Scaling Demand for Offtakes: A Playbook for Corporate Action*

In May 2024, FMC Finance published a new report, [Scaling Clean Technology Offtakes: A Corporate Playbook for Net Zero](#), co-authored with knowledge partner Oliver Wyman. The report presents a playbook for businesses to stimulate demand for two decarbonizing technologies: sustainable aviation fuels (SAF) and green hydrogen (GH<sub>2</sub>).

According to the International Energy Agency, SAF could cut aviation emissions by up to 65%, while

GH<sub>2</sub> could make up 8% of total energy use by 2050. Yet, their development is well off-target and production must be ramped up to meet the 1.5°C climate goal.

Research for the report, based on interviews with more than 20 suppliers, offtakers, financiers and public sector actors, found that the scaling-up of low-carbon technologies cannot be solved by the mobilization of capital towards producers alone.

The most important determinant of the bankability of a SAF or GH<sub>2</sub> project is proven demand. This demand should take the form of offtake agreements from large corporates that cover the majority if not all of the production capacity, with revenue sufficient to support the existing cost structures for the duration of financing.

A further insight from this upcoming report is that existing policy incentives – including the production and investment tax credits envisaged under the US Inflation Reduction Act (2022) or the various policy incentives contained in the European Union's hydrogen policy framework – are not in themselves sufficient to eliminate the green premium that these innovative technologies carry.

In this context, corporate action to participate in early low-carbon technology offtake is vital to bring down the cost of the green premium and create a voluntary market with sustainable demand and production growth to achieve the Paris target. Offtake agreements cannot be left only to the very largest corporates, many of whom are FMC members. There is a vital role for middle-market companies to aggregate demand for project developers by participating in pre-buying SAF or green hydrogen.

The report outlines the key challenges that businesses face in creating sustained and growing demand for SAF and GH<sub>2</sub>. Further, it proposes three key levers for large corporates to better support SAF and GH<sub>2</sub> demand acceleration:

**1. Navigating the policy landscape of SAF and GH<sub>2</sub>:** Demystifying varying economic incentives and regulations allows corporate buyers to better leverage the public support available and minimize the cost of offtake where possible.

**2. Articulating the business case for SAF and GH<sub>2</sub> adoption:** Key rationales include regulatory compliance, progress against net-zero commitments, commercial opportunities, especially through securing a competitive advantage as early adopters in a fast-growing market, and process optimization and capability development.

**3. Identifying commercial models for corporate offtake:** Recognizing and assessing the range of options available for SAF and GH<sub>2</sub> offtake enables corporate buyers to select the best model based on business need, decarbonization ambition and risk appetite.

While the route to sustained at-scale demand for these technologies will likely be complex and will not achieve targets overnight, a tangible business case exists for corporate participation by leveraging a range of commercial models. By charting the course, this report seeks to equip companies with the necessary tools to assess their decarbonization options in light of disclosed net-zero commitments, and to mobilize demand for SAF and GH<sub>2</sub> in the race to a net-zero future.

## Promoting investment in breakthrough technologies to boost supply

As FMC evolves, the coalition is working to surface a robust supply pipeline and foster collaborative, cross-industry procurement channels, in addition to its work on signalling demand. As a result, FMC Finance's focus will be on market formation activities such as:

- **Identifying and promoting investment opportunities in breakthrough technologies** through collaboration with industry players, project developers and investors, thereby attracting capital into the market.
- **First Suppliers Hub**, launched at the Forum's Annual Meeting in Davos in January 2024, features suppliers' projects that meet or are working to meet FMC commitment thresholds, which can be leveraged by finance organizations as a method to identify potential investment opportunities in breakthrough technologies.
- **Promoting innovative financial instruments tailored to the unique needs of breakthrough technology** projects, such as risk-sharing

mechanisms, advanced market commitments, revenue-sharing agreements or green bonds, to mitigate investment risks and attract capital.

- **Advocating for supportive policies and regulatory frameworks that incentivize investment** in breakthrough technologies, such as tax incentives, subsidies or carbon pricing mechanisms, to stimulate market demand and accelerate deployment.
- **Building trust and confidence among investors** by promoting transparency, standardization and best practices in financing breakthrough technology projects, thereby reducing perceived risks and uncertainties associated with such investments. The companies developing these innovative solutions will not only have an immense impact but will also accrue significant value over the transition and it is imperative to highlight this narrative.

## Added value of FMC Finance pillar

The finance pillar's core role has been to assist FMC members in driving bankable offtake agreements, through ensuring that financial institutions engage with both demand and supply side companies to mobilize the necessary capital at scale.

Collaborating with FMC industry members, project developers, financiers and policy-makers is crucial for aggregating capital from multiple sources, both private and public.

To kickstart the flywheel, it is essential to identify financial blueprints that address risk-sharing among stakeholders and mobilize commercial capital. Equally important is to demonstrate these breakthrough models through various workshops and to document the de-risking mechanisms and policy levers that enable such projects to gather speed. The efforts of FMC Finance aim to create an industry roadmap for operationalization and scale-up.

As can be seen by the discussion below on finance insights from the in-country workshops, the pillar acts as both a thought leader on financing the deep decarbonization of hard-to-abate sectors and as a convener of the key stakeholders required to drive that transition forward in different geographies and sectors.

The collaborative ecosystem that FMC is able to create informs investment focus areas and fosters trust among financial players. Over time, these investors begin to exchange insights and, crucially, provide feedback to policy-makers – an aspect often missing in similar platforms. The true value-add emerges when governments, policy-makers, development banks and investors come together – and when this collaborative effort begins to unlock the financing and policy challenges required.

The ripple effect of FMC's in-country workshops extends far beyond the three days on which they occur. For example, the workshop in India paved the way for a financing roadshow in mid-2024 focusing on green hydrogen. The workshop in South Africa surfaced opportunities for engagement with an emerging economy platform aimed at driving the development of green industrial value chains through a robust demand-side mechanism. These ongoing engagements exemplify the lasting impact and strategic alliances fostered through the collaborative efforts of FMC.



## 8.4 Finance insights from in-country workshops



The finance pillar has also been active in bringing public and private sector finance actors together to participate in the workshops held in India, Brazil and South Africa. Many of the key insights from these in-country workshops cut across

geographies and are explored further in the sections below. The insights are divided into three themes: finance risks and challenges, finance opportunities and finance solutions.

## Finance risks and challenges

The pathways towards decarbonizing FMC industries in emerging economies are strewn with the kinds of obstacles that would deter most traditional investors. Below are summarized some of the multifaceted risks and challenges to consider, as highlighted during FMC's in-country workshops. FMC Finance has further subdivided these risks in terms of their relevance to different stakeholder groups – shareholders, developers, lenders and offtakers – in order to identify the right de-risking and financing measures to address them.

- **Market uncertainty:** Will there be sufficient domestic demand for green products? Will buyers be willing to pay a green premium? This is a particular concern in price-sensitive emerging economies. The premium becomes more of a problem if there is existing over-capacity in existing carbon-intensive production methods, as seen in Brazil's steel industry.
- **Technology and delivery risk:** Will a particular technology prove to be the final pathway, or will it just be transitional – leading to a different path altogether? Will the project deliver what it promises, on a timescale aligned with market demand?
- **Political risk:** Changing governments bring changing policies and mandates, while bureaucratic permitting processes and lack of clarity around standards and regulations for emerging technologies can derail the timelines to execute major infrastructure projects.
- **High borrowing costs:** Emerging economies are grappling with exceptionally high capital costs. In Brazil, interest rates soared to 12.75% in September 2023, compared to 5.25% in the US. Meanwhile, 30% of India's GDP

is generated by micro, small and medium enterprises (MSMEs), many of which lack access to formal credit and cannot secure the financing they need to decarbonize, despite playing an important role in India's net-zero ambitions.

- **Foreign exchange risk:** The volatility of the Brazilian real, the Indian rupee and the South African rand expose investors to risks from swings in forex rates. DFIs can provide currency hedges to reduce these risks.
- **Huge investments and slow returns:** The projects themselves are often very capital-intensive infrastructure investments, each costing more than a billion dollars and taking a decade or more to show a return. One of the challenges facing South Africa's Just Energy Transition Investment Plan (JET IP) programme is lower than usual returns on investment compared to non-green projects.
- **Capital stack not understood:** The need for the capital stack to evolve as technologies mature is not clearly understood. The threshold for the level of concessionality that best unlocks private capital remains unclear, and the best use of value chain subsidies both upstream and downstream is not understood.
- **The just transition is a sensitive issue:** This poses a complex challenge, particularly in South Africa, where heavy industries – such as the country's 78 operating coal mines – play a significant role in employment and the economy. Balancing the need for decarbonization with socio-economic considerations, such as job losses, community impacts and social equity, requires careful planning and stakeholder engagement.



**We have seen the extractive nature of capital before, below ground, and we cannot let that happen on our continent when it comes to our above-ground capital.**

South Africa in-country workshop participant

## Finance opportunities

Despite the obvious risks however, emerging economies also offer investors attractive opportunities:

Brazil, for example, is an attractive destination for both private capital and development finance. In his keynote address at the Brazil workshop, Joachim Levy, former Brazilian Finance Minister and now a director at Banco Safra, argued that by leveraging

Brazil's renewable grid, vast natural resources and reserves of strategic minerals, the country has the potential to become a Western hemisphere hub for the production of clean hydrogen, sustainable biofuels and decarbonized iron, steel and aluminium. By integrating these industries into global value chains, Brazil could make a significant contribution to both the global economy and to the capacity of other countries to decarbonize.



## The main driver will not be a tax break here or there, but the comparative advantage of the Brazil market for what we can deliver for the world.

Joachim Levy, former Brazilian Finance Minister, speaking at FMC's in-country workshop

South Africa is already the world's biggest producer of grey hydrogen. Supported by the multi-billion dollar JET IP financing package, the country is now positioning itself as a future global leader in the green hydrogen economy, with 19 projects under consideration, worth over \$20 billion, targeting a GH<sub>2</sub> production capacity of 10 million tonnes by 2050. South Africa is partnering with Namibia to consolidate GH<sub>2</sub> production and drive down price margins. Meanwhile, a consortium of multinational partners is exploring the opportunity of a "green corridor" to export decarbonized iron ore and green ammonia by ship from Southern Africa to Europe for use in steelmaking and other carbon-intensive industries.

Turning to Asia, Singapore has the potential to play a leading regional role in producing sustainable aviation fuel. Projections from publicly announced projects to date total 1.4 million tonnes of SAF production capacity per year by 2030, with jet fuel demand at around 6 Mt/year. India, meanwhile, is particularly well-placed to become a global leader in low-carbon technologies, including green hydrogen, which could create a market worth up to \$80 billion by 2030, according to the IEA.

## Finance solutions

Huge levels of concessionary capital are needed to de-risk the decarbonization of hard-to-abate sectors. Workshop participants called for more patient capital, to match 10-year project cycles and offtake agreements. Multiple financing mechanisms (e.g. debt, equity, government grants) from multiple sources will be needed.

Solutions identified at FMC's in-country workshops are outlined further below. Some of the most potent financing opportunities will arise through blending these sources, so that public money and patient capital de-risk investments to a point where private players feel safe enough to engage.

- **National development banks**, such as the Development Bank of South Africa (DBSA) and the Brazilian Development Bank (BNDES) play an important role in concessionary financing. BNDES, for example, is the country's leading low-cost lender. Since 2000, the bank has enabled \$200 billion worth of power and infrastructure projects in Brazil and financed over 70% of the power and renewables expansion in the country, making it one of the largest financiers of renewable energy in the world. DBSA has increased its renewable energy investment exposure, which now stands at 42% of the bank's energy portfolio and is expected to grow to 50% of the bank's total portfolio. Workshop participants called on development banks to streamline approval processes and relax some of their requirements to make concessional lending easier.
- **World Bank's concessional loans**: International financial institutions have billions of low-cost finance available for climate-related projects, useful to catalyse private investment, mitigate forex risk and support pre-feasibility studies.

Last year, the World Bank approved a \$1.5 billion loan to help the Indian government scale-up renewable energy, develop its green hydrogen sector and encourage climate finance for low-carbon energy investments. In 2022, the World Bank agreed to lend state-controlled Banco do Brasil \$500 million of concessional finance to help the country meet sustainability goals.

- **International Monetary Fund's Resilience and Sustainability Trust**: This trust finances green public-private frameworks for Costa Rica, Barbados, Rwanda, Bangladesh and Jamaica. The loans have a long maturity of 20 years with a grace period of 10.5 years and are provided on highly concessional terms.
- **Consortia of countries**: In 2021, a consortium of countries put together the Just Energy Transition Investment Plan (JET IP) for South Africa, worth \$8.5 billion. In September 2023, additional pledges of nearly \$3.5 billion increased the overall envelope of concessional debt and grant funding to \$11.9 billion. Donors include the US, European Union, UK, Germany, France, Denmark, Netherlands and Spain.
- **Private capital**: Private equity, investment banks and sovereign wealth funds can invest, while capital markets could introduce more sustainability-linked debt instruments. Such third-party financing options include green bonds or sustainability-linked loans. These can offer companies a lower-cost alternative to deploying internal capital, while aligning their corporate finance activities with sustainability goals. Private capital must redefine its appetite for risk and create balanced portfolios that balance long-term, high-risk bets in evolving technologies with short-term, lower-risk decarbonization levers.

- **Philanthropic capital**, more patient than commercial capital and driven by purpose rather than by profit, can be additional in its effect. “Philanthropies can play a catalytic role by creating evidence, developing cross-border partnerships and supporting the formation of cleantech unicorns”, said one participant at the India workshop. Philanthropy could play an important role in early stage funding to increase project viability and reach a final investment decision. The World Economic Forum initiative, [Giving to Amplify Earth Action \(GAEA\)](#), is working with 100+ philanthropic, public and private partners to unlock catalytic funding at speed and scale to accelerate the shift towards climate and nature solutions.
- **Innovative risk-management products**: for example, non-recourse financing, senior debt arrangements, government-backed green bonds, first-loss pools, loan guarantees, concessionary debt for projects with guaranteed offtakes, insurance underwriting, and low-cost hedging can all overcome gaps between risk appetite and investment requirements. The political risk insurance offered by the World Bank’s Multilateral Investment Guarantee Agency (MIGA) is one example.
- **Carbon trading** can drive a gradual shift towards more efficient reductions in emissions, while promoting innovation across all sectors and players. Carbon pricing can be combined with revenue recycling, so that the proceeds generated from a carbon tax are earmarked for green spending initiatives. Brazil and India do not currently have functioning carbon markets, but proposals to create them are working their way through each country’s legislature.
- **Support for MSMEs**: Micro, small and medium-sized enterprises need financial support to help them with the low-carbon transition, especially in India. The barriers to MSMEs accessing commercial finance include stiff lending policies with high collateral requirements, small project ticket sizes and high transaction costs. In the absence of viable financial solutions, MSMEs need government intervention to raise debt at a reasonable rate.
- **Oil and gas R&D levy**: Currently, oil and gas producers in Brazil have a legal obligation to reinvest 1% of their gross revenues to support R&D in Brazil, with at least 50% of the levy going to academic research institutes. This levy could prove a significant source of untapped catalytic capital (worth hundreds of millions of dollars per year) to support high-risk decarbonization technologies and projects.
- **Public finance**: Government support can include subsidies, grants and tax breaks for green technologies. In January 2023, the Indian government issued its first pair of green bonds, joining a growing list of countries to issue sovereign thematic bonds. The bonds raised approximately \$980 million to fund investments in solar power, wind and small hydro projects, as well as other public sector projects to help reduce the economy’s carbon footprint.
- **Partnerships**: A key takeaway from the in-country workshops is that the financing challenge is far too large for just one entity to take on. Collaborations and partnerships between governments, banks and other financial institutions are essential.



**In infrastructure finance the real gap is in the early phase – pre-feasibility to financial close. As we head towards net zero, it will be super important for the finance sector to unlock early stage, pre-financial-close and blended finance solutions.**

South Africa in-country workshop participant

For a fuller discussion of the role of governments in financing the transition, see Chapter 9.

9

# FMC Government engagement

FMC Government engagement works with policy-makers to boost supply and demand for zero-emission technologies across sectors, through leadership, risk-sharing and supportive policies.



## 9.1 Overview

The economics of both supplying and purchasing near-zero emissions fuels and materials in hard-to-abate sectors is extremely challenging. This is particularly the case for emerging economies with a priority to deliver cost-efficient growth to meet the burgeoning needs of a rapidly growing population. Governments therefore have a pivotal role to play in creating a policy environment that can maximize the effectiveness of private sector innovation and capital. Supportive policies, incentives, standards and mandates introduced by host governments can greatly accelerate the market for climate-critical technologies.

While many of the challenges to the development, financing and adoption of these technologies are shared across continents and industries, the policy solutions are typically country-specific. To address this challenge, during 2023-24 FMC convened three in-country workshops to discuss relevant context- and sector-specific policy measures, as well as meetings on the side-lines of other milestone events, such as Clean Energy Ministerial meetings, Singapore's Ecosperity Week 2023, and COP27 and COP28. The insights from these workshops and meetings inform much of the progress and impact of FMC's Government engagement pillar.

## 9.2 Goals and objectives

### Goals and focus areas

A key part of FMC's work is to engage with committed governments to complement and build on their ongoing efforts to decarbonize hard-to-abate sectors as part of the wider race to net zero. In particular, FMC has leveraged the unique convening power of the World Economic Forum and the leadership of the Office of the US Special Presidential Envoy for Climate to bring policy-makers around the same table as the major corporations and financial institutions that are able to make a difference.

The overarching goal of FMC's Government engagement pillar is to facilitate a deeper understanding between public and private sector actors of the policy levers that might prove most effective to accelerate industry decarbonization in specific country contexts. The pillar also aims to demonstrate to its private sector members that there is significant public support for FMC's work.

The pillar's work is focused on three areas that complement FMC's wider mission:

1. **Accelerate demand for near-zero emission technologies** by reaching out to companies in partner countries.
2. **Help surface supply of these technologies** in partner countries and make that supply more visible, for example through the First Suppliers Hub.
3. **Analyse existing policy levers**, listen to the views of the private sector and create common ground between public and private sector players in partner country contexts.

### Objectives

The pillar aims to support governments in driving forwards the policy changes necessary under three overarching objectives that have been identified together with FMC member companies:

1. **Political ambition:** Include 2030 targets to scale-up near-zero emission or low-carbon breakthrough technologies across heavy manufacturing (aluminium, concrete/cement, steel), long-haul transportation (aviation, shipping, trucking) and carbon dioxide removals.
2. **Demonstrate best practice policy solutions:** Drive domestic critical policy levers to scale-up breakthrough technologies, including through aggregated demand, finance and infrastructure.
3. **International collaboration:** Drive international collaboration efforts to scale-up breakthrough technologies, including through aggregated demand, finance and infrastructure, as well as sharing solutions in global forums aimed at strengthening the demand signal for low-carbon technology.

## 9.3 Government partners and actions

### FMC government partners

In the two or so years since FMC was launched, the number of government partners has increased from one – the US, FMC Co-Chair – to 13 countries that collectively account for around 50% of global GDP (see Figure 11).

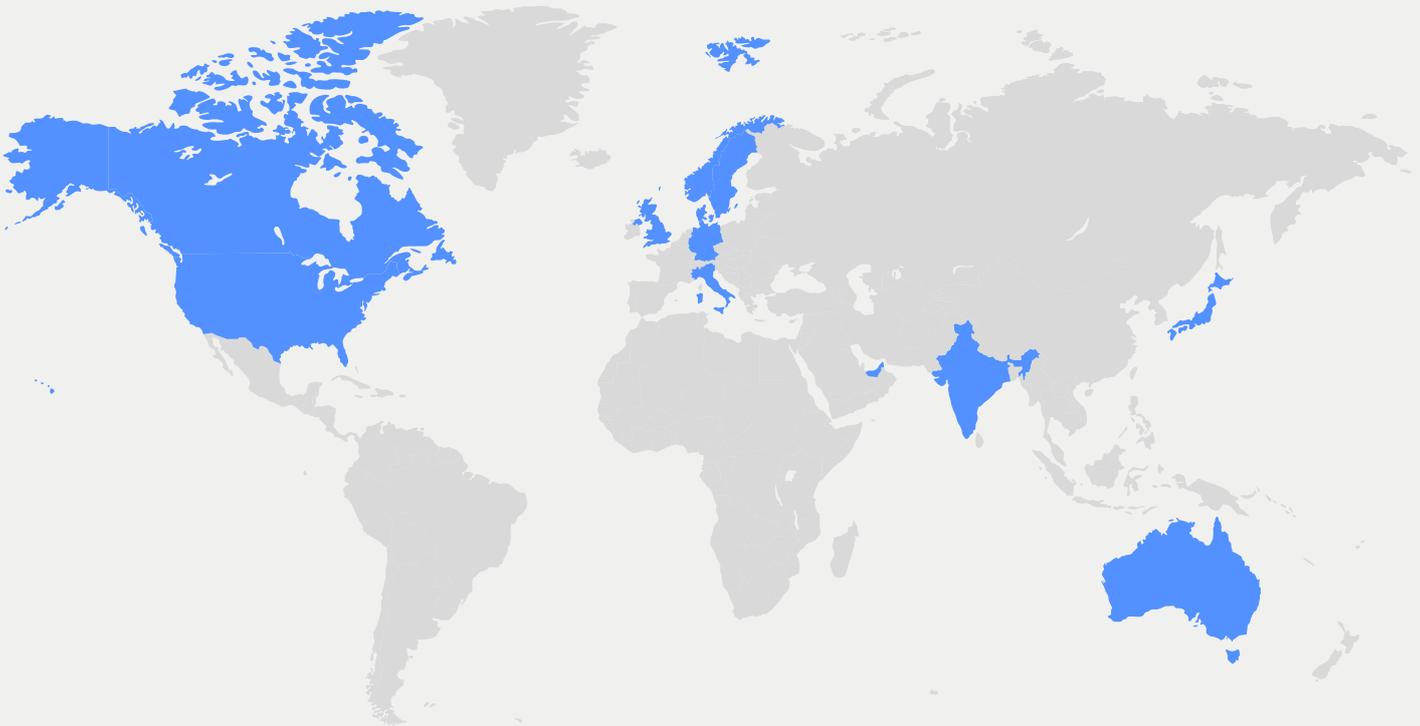
All 13 of FMC's government partners support the scaling-up of low carbon technologies across their

jurisdictions and markets internationally. FMC's Government engagement pillar, through its 2023-24 workplan, has addressed public-private policy levers to help create an enabling environment to accelerate large-scale, transformational low-carbon FMC technologies and thereby to support FMC's 99 global corporate members to realize their sector commitments.

FIGURE 11 FMC's government partners

### Meet the 13 FMC global partners

FMC government partners are high-ambition governments committed to the rapid scaling of emerging technologies by 2030



It is clear from the figure that governments in South America, Africa, the Middle East and Southeast Asia in particular are not represented. FMC has addressed this challenge directly by holding in-

country workshops during 2023 and 2024 in India, Brazil and South Africa, which have been well-attended by policy-makers, as well as a session on SAF at Singapore's Ecosperity Week 2023.

The latest information on FMC government partners can be found [here](#).

## Actions by partners

In terms of practical action, FMC government partners have mobilized key demand players under the priority sectors in their countries. They have consulted on high-impact actions with FMC corporate members and other government partners at regional and global meetings including recent COPs and the Clean Energy Ministerial platform. And they have explored opportunities for collaboration with other FMC government partner countries, for example:

- Norway, Sweden and Denmark have engaged in discussions to align on the Nordic region.
- The UK government has engaged with Brazil on industry decarbonization and green hydrogen

in the lead up to and after the Sao Paulo in-country workshop, culminating in December 2023 with the launch of the [Brazil Industrial Decarbonization Hub](#).

- Similar to the cooperation between UK and Brazil, Sweden and India launched the [India-Sweden Industry Transition Platform](#) at COP28 to strengthen collaboration on industry decarbonization.
- A number of government partners engaged during the South Africa workshop in March 2024 via roundtable discussions.



## 9.4 Added value of FMC Government engagement pillar

### FMC's convening power

In its [Climate Change 2023: Synthesis Report](#), released March 2023, the Intergovernmental Panel on Climate Change (IPCC) emphasized that clear, bold and concerted government policies to further unlock the transformative power of financial markets, industry and innovators are key to achieving climate goals. The report highlights the power of governments to help scale-up the transformative low- and zero-emission technologies across the hard-to-abate sectors of long-haul transport, heavy manufacturing and carbon dioxide removal.

While voluntary action by the private sector has had an enormous impact, it is not enough to achieve the goals of the Paris Agreement. A particular benefit of FMC is its ability to convene government partners and private sector members, and in so doing to gain crucial collective insights that promote a better understanding of the key barriers, enablers and critical actions needed to unblock obstacles and exploit opportunities.

FMC's Government engagement pillar has facilitated two particular areas of value and progress over the past two years:

- **Joint consultative process for policy levers.** This process resulted in the identification of three high-priority levers that governments can apply, as well as the enabling actions under each of those levers, defined on a sector-specific basis in FMC's forthcoming Briefing Paper, *Sector Conversations on Government Enablers and Barriers*. The next step is for government partners to implement these high-priority actions within their own decarbonization journeys.
- **Direct engagement of FMC government members** with corporate members. FMC has facilitated this valuable engagement through working group calls that enable government partners to share information on new policy instruments and garner direct feedback from companies in both their own countries and across all countries represented in the coalition.

## High-priority levers and sector-specific actions

Through multistakeholder engagement with its members and government partners, FMC's Government engagement pillar has identified three high-priority levers and sector-specific actions that governments can take to help realize the wider

objectives of FMC, its corporate members and the transition to a low-carbon economy: 1) Demand and supply aggregation, 2) Enabling finance ecosystem, 3) Enabling infrastructure ecosystem (see Figure 12).

FIGURE 12 Three high-priority policy levers that can support FMC's objectives



## Impact of in-country workshops



During 2023-24, FMC organized in-country workshops in India, Brazil and South Africa. The act of bringing committed participants from the public and private sectors into the same room for a few days seems to be able to unlock conversations and insights that are less easy to access virtually. Participants highlighted the value

of convening workshops where early investors in green technologies are willing and able to give their feedback to policy-makers. The process of bringing governments, policy-makers and development banks together with investors starts to unlock challenges.

In-country workshops can also plant seeds that may bear future fruit. For example, the São Paulo workshop deepened the Forum's engagement with the Brazil government and led to FMC helping the government with some of its G20 working groups in the lead up to Brazil's presidency. Following the Brazil in-country workshop, FMC and the Brazilian government co-hosted the first meeting

of the Brazilian government's working group on decarbonization and energy transition for industry, building on the outcomes of the multi-stakeholder workshop. In addition, FMC shared key learnings with the government as part of the launch of the [Brazil Industrial Decarbonization Hub, supported by the UK government](#).



**Singapore is pleased to be a partner of the First Movers Coalition. We are committed to decarbonization and achieving net-zero ambitions by 2050. The government believes that public-private partnerships are critical in piloting and scaling innovative clean energy technologies.**

Grace Fu, Minister for Sustainability and the Environment of Singapore

## 9.5 Lessons learned and next steps

FMC's government partners all join the coalition for different reasons and engage in different ways. The challenge is to understand national agendas more clearly so that the coalition can engage more effectively with government partners on the specific policy challenges they are facing.

To generate effective government engagement and traction, FMC's approach must be closely aligned to each country partner's current priorities, resources and capacities. This is especially critical in developing countries, where, for example, one individual could hold multiple portfolios and will not have the capacity for new work, or where other external resources are critical for financing the transition.

It is therefore vital to integrate with existing decarbonization priorities in ways which do not

add workload or costs but support ministries in achieving existing plans. A good example can be seen in FMC's engagement with Brazil and FMC's support for the sub-committee working group for industry that was identified as a clear mechanism by the President of Brazil to support the implementation of the country's decarbonization priorities. Another example is that of Australia, which joined FMC as a result of the Steel Challenge which met one of the country's specific sector decarbonization priorities.

Going forwards, it will be important for FMC to keep on top of what is a priority for each government partner and how synergies can be generated between partners to drive continued and greater impact towards fostering a policy environment that enables the transition.

### Inter-governmental collaboration

All 13 government partners had representatives participating in discussions at the South Africa in-country workshop in March 2024. This workshop highlighted the challenges faced by emerging economies in driving the transition towards low-carbon heavy industries and, in turn, highlighted the critical need for governments from the Global North and South to collaborate in ensuring the transition is both swift and just.

For example, South Africa's export-led economy, based on sectors such as internal combustion engine vehicles, is facing risks from emerging regulations including the EU's Carbon Border Adjustment Mechanism (CBAM) and forthcoming fuel standards. Germany's development agency

GIZ is commissioning a study this year to examine the impact of CBAM on South Africa's economy. Equally, governments in the Global South cannot compete with initiatives such as InvestEU or the US Government's Inflation Reduction Act (IRA), which offer generous concessions and incentives to develop domestic breakthrough technologies.

More inter-governmental collaboration is needed to understand how measures such as CBAM and IRA can bring positive impacts to the transition of emerging economies, rather than simply risks. Equally, FMC's in-country workshops offer the opportunity for South-South sharing of best practice, for example between India, Brazil and South Africa.



## Improving engagement

FMC is actively looking at ways to improve its capacity to support and leverage the influence of this growing community, for example through a strategy and framework that allows government partners to become more integrated into FMC's regular programmatic actions. Challenges include the following:

- How can we better engage with governments around national and regional milestones and events?
- How can we facilitate greater engagement between government partners and provide useful spaces for counterpart national ministries to collaborate on industry decarbonization?
- How can we engage with governments on innovation procurement in a way that is relevant to helping FMC members achieve their sector commitments? Furthermore, in doing so, how can we ensure any policy actions supported or adopted are inclusive and relevant to local and regional decarbonization contexts (e.g. in relation to the empowerment of Indigenous communities, women and young people)?

## 9.6 Policy insights from in-country workshops



The in-country workshops that FMC held in India, Brazil and South Africa have proved to be the most effective way of engaging with policy-makers, by bringing them into the same room as companies and financial institutions to identify barriers to deep industrial decarbonization and drive the change needed at a country level. The workshops

brought a special focus to surfacing solutions that can accelerate domestic supply of breakthrough technologies in key markets.

This section outlines some of the principal policy risks, opportunities and solutions identified by workshop participants.

## Industrial strategy and investment

To deliver transformation at the pace and scale required, every government requires a clear and coherent industrial strategy that applies the various policy levers outlined below in a coherent and timely way. The top policy priority at the India workshop, for example, was for the government to implement a cross-sectoral industrial cluster strategy to support the growth of essential upstream technologies such as CCUS and green hydrogen in a way that facilitates collective action. Such a strategy could increase the impact of the government's recently launched \$2 billion National Green Hydrogen Mission.

The Brazil workshop highlighted a similar need for the government to create green technology hubs to coordinate supply and demand while sharing investment costs. Meanwhile, the South African

government is looking at developing a green shipping corridor to export green ammonia to Europe.

Given the huge demand for clean power that green technologies will drive, governments need to frame industrial strategies that define how allocations of critical inputs, such as green hydrogen, are decided by industry sector.

Workshop participants also saw it as a government responsibility to invest directly in critical early-stage research, development and piloting of new technologies, as well as in wider infrastructure upgrades around, for example, renewable energy capacity, grid upgrades, EV-charging infrastructure and fuel bunkering at ports, which are essential enablers for near-zero emissions technologies.

## Government as coordinator

A key insight from the South Africa in-country workshop was the role of the government in making the landscape easier to navigate for industry players through a stronger coordination role. This starts with the national government making colleagues in different ministries aware of their responsibility to decarbonize their sectors. Building on that, the government also has a key role in structuring relationships between the public sector and the various key industries around the full range of

challenges from environmental assessments, feasibility studies and pilots through to boosting demand, supply and offtake.

One of the South African participants pointed to the gap between project developers and financiers, and the role the government needs to play in de-risking breakthrough technologies to increase certainty for investors and offtakers alike.



**Everyone is waiting for the price to fall. The government plays a critical role in bringing in other entities – including foreign investment – to connect with project developers.**

South Africa in-country workshop participant

## Streamlined regulation to attract more FDI

The innovations needed to decarbonize heavy industry risk being choked by bureaucracy. Participants at all workshops called for consistent, “single-window” clearance processes to expedite green development projects. Clear regulations are urgently needed for emerging technologies, such as for processes to produce, transport and store green hydrogen, as well as standards for fuelling with zero-emissions fuels (ZEFs) in ships and vehicles.

Governments need to send a clear signal to the market by publishing unambiguous definitions of near-zero emission materials and processes. Alignment between national and global standards is essential. For example, common standards around book and claim could accelerate the update of SAF, while updated building codes could allow for greater use of SCMs in low-carbon cement and concrete.



**There is a need to define green products to help buyers make informed choices.**

Ruchika Drall, Deputy Secretary (Climate Change), Ministry of Environment, Forests and Climate Change, Government of India

To develop these technologies to commercial scale in emerging economies will require huge amounts of foreign direct investment (FDI). For example, it will take about \$223 billion to reach India's ambitious

2030 goal for renewables – three times the amount of investment over the last seven years. This investment can be hampered by too much red tape, such as rules on 100% FDI.



**Clear regulations on carbon capture could make it more worthwhile for international capital and expertise to come to India.**

India in-country workshop participant

## Carbon markets

The failure to price in the “negative externalities” of fossil-fuel intensive industries is putting innovative, climate-friendly technologies at a clear cost disadvantage. Member companies of FMC have highlighted how government action to put a price on carbon would have a significant impact on their demand commitments.

In both India and Brazil, legislation is under consideration to establish national carbon markets. For example, in Brazil's steel sector, H<sub>2</sub>-DRI could compete on price with traditional production, but only with a carbon price of \$36-72/t CO<sub>2</sub>. By adding

revenue recycling to carbon pricing, the proceeds generated from a carbon tax can be earmarked for green spending initiatives.

It is essential to ensure that technologies to produce near-zero emissions fuels and materials are included in the remit of carbon markets. In addition, cap-and-trade initiatives should be aligned with the EU's Emissions Trading Scheme (ETS) and CBAM, to increase the export potential of green goods. The CBAM, for example, is expected to put around 10% of all South Africa's exports at risk from 2024 onwards.



**We need give the correct value for carbon to push industries in the right direction. We're in a make-or-break moment and good legislation will help.**

Brazil in-country workshop participant

## Tax breaks and incentives

Workshop participants called on governments to provide nascent green technologies with a wide range of incentives, including tax breaks and subsidies along the lines of President Biden's 2022 Inflation Reduction Act. The Indian government has successfully incentivized solar PV manufacturing under the Production Linked Incentive (PLI), a scheme which could equally be applied to the domestic production of near-zero emissions steel, cement and SAF. The South African government has an Automotive Production and Development Programme (APDP) that incentivizes the domestic vehicle manufacturing sector – for example, from 2026, investors in EV production will be able to claim 150% of qualifying investment spending in the first year.

Tax breaks could include, for example, incentives to recycle motor vehicles and scrap internal combustion vehicles. Governments could also waive electricity tax on the power used to produce green cement, as well as taxes on the final product. The Brazilian government could look at repurposing its existing levy on oil and gas industries, which requires them to spend 1% of their gross revenues on R&D, while the South African government could look at reducing import tariffs on electrolysers and zero-emission vehicles.



**At some stage governments and offtakers will have to think carefully about incentives to industry – unless they do this, there will be no traction.**

South Africa in-country workshop participant

## Concessional lending and international donor finance

Concessional lending is another key incentive, especially in emerging economies that have faced double-digit interest rates in recent years. State-backed banks such as the Brazilian Development Bank (BNDES), the Reserve Bank of India (RBI) and the Development Bank of South Africa (DBSA) already have strong track records in this area. They could consider providing greater access to cheap debt for green projects with guaranteed off-takes, offering credit guarantees to de-risk such debt and setting up programmes for government-backed green bonds.

On an international scale, financial support from both international financial institutions and donor countries can catalyse significant change. For example, as described in the Finance chapter, a consortium of donors including the US, European Union, UK, Germany, France, Denmark, Netherlands and Spain put together the Just Energy Transition Investment Plan (JET IP) for South Africa – an envelope of concessional debt and grant funding worth \$11.9 billion aimed at transforming the country's energy system, which is currently 80% dependent on fossil fuels.

## Public procurement and mandates

Public procurement is responsible for 40-60% of all global concrete sales, so encouraging governments to set mandates for procuring near-zero emissions materials is a major opportunity. Given that an estimated 80% of cement and 90% of steel is produced in around 10 key countries, the adoption of green public procurement commitments in even a handful of these countries would make a significant impact on reducing emissions.

FMC is collaborating with the UN's Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (IDDI), one of whose goals is to encourage a minimum of 10 governments to make public procurement commitments for low-carbon steel and cement within the next three years. According to the host organization, the UN Industrial Development Organization (UNIDO), green public procurement commitments are essential in signalling to the market: "If you make it, we will buy it."



**Green public procurement commitments are essential in signalling to the market: "If you make it, we will buy it."**

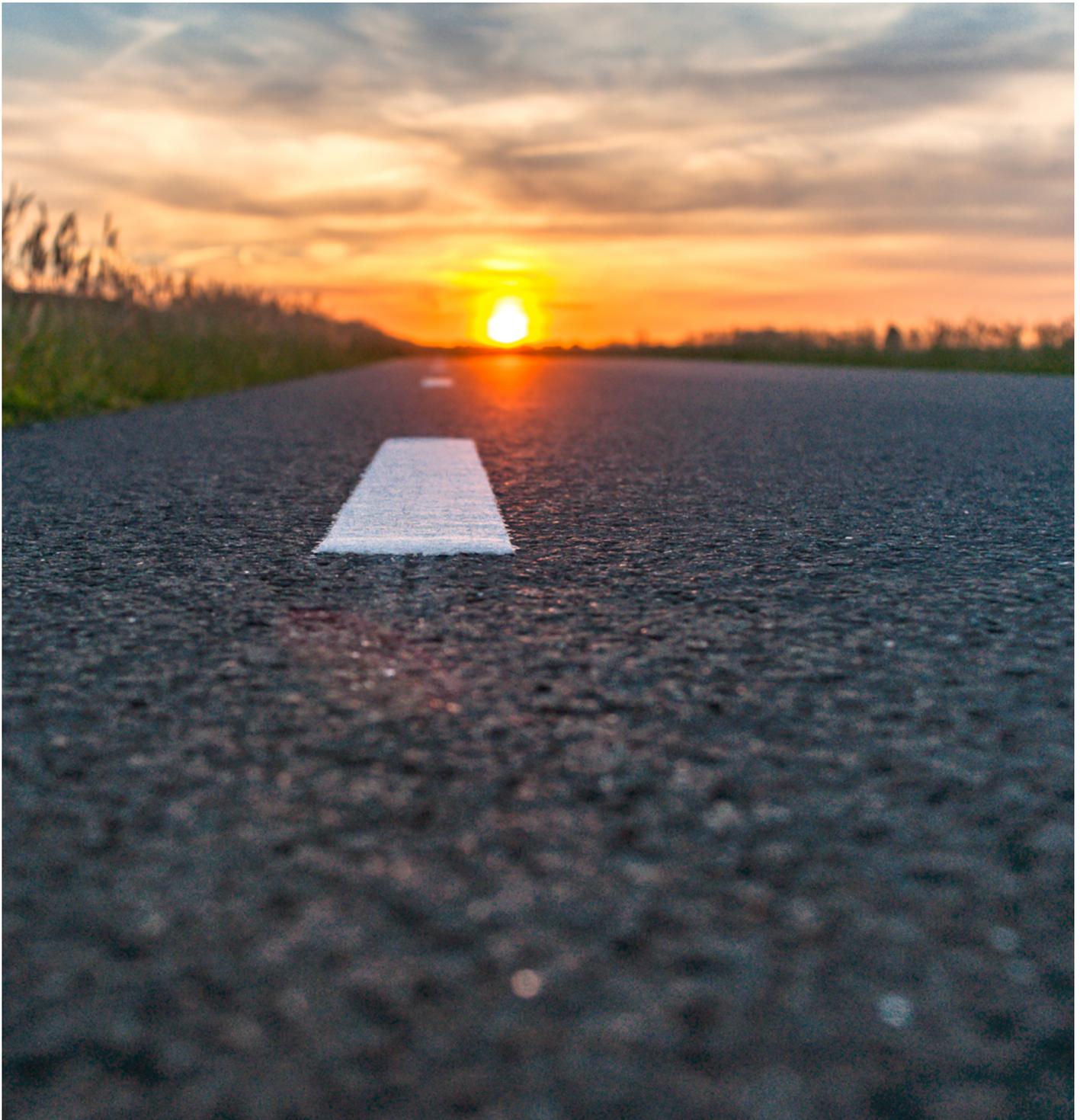
UN Industrial Development Organization

Governments can also set mandates for the private sector, but these must be aligned. For example, Brazil's proposed mandate for aviation fuel, which starts with 1% reduction in carbon intensity from 2027 rising to 10% by 2037, is out of sync with the

existing mandate for a 12% biodiesel blend for road transportation that may increase to 15%. Resolving this mismatch would address the skewed incentive to produce biodiesel over SAF. Fuel blending mandates could also be considered for ZEFs in shipping.

## 10 Way ahead

FMC's work will continue to boost credible demand for deep decarbonization products and push the industry towards the offtake agreements that new near-zero emission technologies urgently need in order to scale.



## 10.1 From commitment to offtake

Since its launch less than two and a half years ago, the First Movers Coalition has nearly tripled its membership from 35 to 99 corporate members. Spread across seven sectors, these far-sighted member companies have made 125+ commitments, which together represent an annual demand signal of around \$16 billion for near-zero technologies and an estimated 31 million tonnes (Mt) of carbon dioxide-equivalent (CO<sub>2</sub>e) in annual emissions reductions by 2030. FMC will continue to seek credible companies capable of committing to large-scale purchases of near-zero fuels and materials – because suppliers and investors in all seven sectors need that strong demand signal from leading businesses.

However, demand signals alone are not enough to create a market. For FMC's commitments to make a difference, they must be translated into specific contracts and offtake agreements. Advance offtake is critical because, without it, suppliers cannot get the financing they need to invest in near-zero technologies. On the dancefloor of decarbonization, it takes two to tango – the buyer and the supplier. Both partners need courage to step onto the stage, but equally, each needs to feel confident the other can deliver.

The good news is that, increasingly, FMC members are moving from commitment to action, announcing around 100 offtake agreements and investments

that will help them meet their targets. So as it enters its third year of existence, the coalition aspires to be not only the place where members make their public commitments, but also where they can find the tools and partners they need to make good on those commitments.

FMC will continue to organize in-country workshops (US and Japan are scheduled for 2024), as well as convene meetings on the sidelines of milestone events (e.g. COP) to facilitate collaboration between partners to advance the mission. Quarterly sector working groups will continue to give a space for FMC members to discuss opportunities and challenges, feature initiatives from implementation partners, surface promising suppliers and offer a platform for FMC's government partners to share relevant initiatives.

In addition, FMC has recently launched three initiatives focused on helping members get to offtake agreements, addressed in more detail in the following sections:

- First Suppliers Hub
- Procurement guides
- Procurement innovation dialogues

## 10.2 First Suppliers Hub

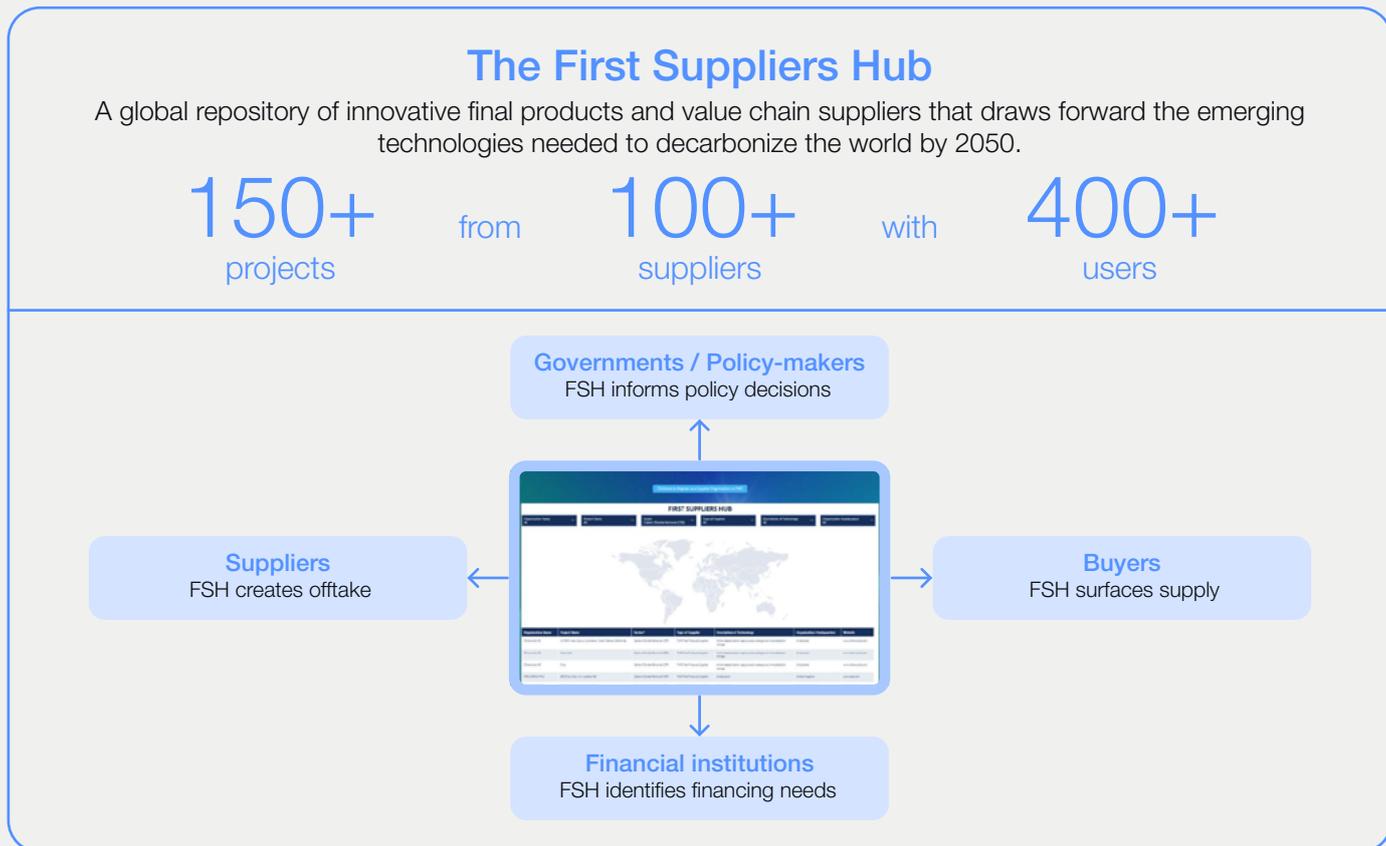
The [First Suppliers Hub](#) is a global online repository where companies can find developers and suppliers of innovative emerging technologies that meet the FMC's ambitious thresholds. It is a tool that surfaces current and future projects across FMC sectors to accelerate procurement and partnerships. The hub provides a platform through which coalition members can explore the landscape of zero-emission technologies and begin offtake conversations with ambitious suppliers.

Suppliers that meet or plan to meet the FMC commitment criteria can submit their low-carbon projects as well as value chain technologies and projects across all seven sectors to the First Suppliers Hub via an intake form. Projects that appear to align with FMC's high performance thresholds and timelines are published online through the hub, where buyers and other interested parties can browse projects and connect with suppliers as required. The hub features both projects that will aim to produce the final product (e.g. low-carbon steel, sustainable aviation fuel) and enabling technologies (e.g. feedstocks, electric

calciners, electrolysis) that can accelerate action across the entire value chain.

Launched at the World Economic Forum's Annual Meeting in Davos-Klosters in January 2024 with strategic advice from Deloitte Consulting, the First Suppliers Hub already features over 150 projects from more than 100 registered suppliers (see Figure 13). Over 400 users have registered on the portal, including FMC members, governments, financial organizations, universities and researchers.

As FMC continues to explore ways it can help facilitate and accelerate action, the team is exploring improvements to the First Suppliers Hub that will further help suppliers and enable FMC members to make good on their commitments. More than 25 suppliers recently responded to a survey to provide feedback on the hub and how FMC can support suppliers more broadly. These suggestions, such as technology features that allow direct connection between users and suppliers, will be evaluated and incorporated into the next phase of work.



#### Suppliers currently available in the First Suppliers Hub

CARBON DIOXIDE REMOVAL	AVIATION	CROSS-SECTOR
<ul style="list-style-type: none"> <li>• Climeworks</li> <li>• Drax</li> <li>• Eion</li> <li>• Heimdal</li> <li>• Holy Grail</li> <li>• Nellie Technologies</li> <li>• Charm</li> <li>• Novocarbo</li> <li>• Pacific</li> <li>• Biochar</li> <li>• Snam S.p.A.</li> <li>• Standard Gas</li> <li>• 1PointFive</li> </ul>	<ul style="list-style-type: none"> <li>• Lanza Tech</li> <li>• Air Company</li> <li>• Ampaire</li> <li>• Azzera</li> <li>• Beyond Aero</li> <li>• Cemvita</li> <li>• Fluxart</li> <li>• H3X</li> <li>• Hybrid Air Vehicles</li> <li>• INERATEC</li> <li>• Infinitum</li> <li>• Joil</li> <li>• Zero Petroleum</li> <li>• World Energy</li> <li>• Mercurius Biorefining</li> <li>• Multiverse Computing</li> <li>• Spark e-Fuels</li> <li>• Stratus 9</li> <li>• Sylphaero</li> <li>• Synhelion</li> <li>• Twelve</li> <li>• Universal Fuel Technologies</li> <li>• VerdeGo Aero</li> <li>• Verne</li> <li>• World Energy</li> </ul>	<ul style="list-style-type: none"> <li>• Amogy</li> <li>• ANEMEL</li> <li>• ASCON Group</li> <li>• Calix</li> <li>• Coolbrook</li> <li>• Elogen</li> <li>• Hadean Energy</li> <li>• Hydrogen Waves</li> <li>• Hygenco Green Energies</li> <li>• INERATEC</li> <li>• Jolt</li> <li>• Invenergy</li> <li>• KC8 Carbon Tech</li> <li>• Latent Drive</li> <li>• MCI Carbon</li> <li>• Orcan Energy</li> <li>• Plenesys</li> <li>• Power to Hydrogen</li> <li>• Reverion</li> <li>• Standard Gas</li> <li>• TES</li> <li>• Xi'an LONGi Hydrogen</li> </ul>
SHIPPING		
<ul style="list-style-type: none"> <li>• Yara</li> <li>• Liquid Wind</li> <li>• ABEL Energy</li> <li>• Carlsun Energy Solutions</li> <li>• Hero Future Energies</li> <li>• Hyphen Hydrogen Energy</li> </ul>		
ALUMINIUM		
<ul style="list-style-type: none"> <li>• CBA</li> <li>• Hydro</li> </ul>		
TRUCKING		
<ul style="list-style-type: none"> <li>• Maersk</li> <li>• Keen</li> <li>• Forum Mobility</li> <li>• KDG Logistics</li> </ul>		
	CEMENT / CONCRETE	STEEL
	<ul style="list-style-type: none"> <li>• Cemex</li> <li>• Alcemy</li> <li>• Brimstone</li> <li>• Carbonaide</li> <li>• CarbonBuilt</li> <li>• Cemvision</li> <li>• Chement</li> <li>• Concrete4Change</li> <li>• Ecocem Materials</li> <li>• Holcim</li> <li>• Fortera</li> <li>• Material Evolution</li> <li>• Novocarbo</li> <li>• Saferock</li> <li>• SaltX</li> <li>• Standard Gas</li> <li>• Sublime Systems</li> <li>• Titan Cement</li> </ul>	<ul style="list-style-type: none"> <li>• GravitHy</li> <li>• 8 Rivers</li> <li>• BioCarbon</li> <li>• Charm Industrial</li> <li>• Electra</li> <li>• Element Zero</li> <li>• Helios Project</li> <li>• LanzaTech</li> <li>• Molten</li> <li>• Plug Power</li> <li>• Boston Metal</li> <li>• Pyrochar</li> <li>• Univ. of New South Wales</li> <li>• Gerdau</li> <li>• Hydnum Steel</li> <li>• Aço Verde do Brasil</li> <li>• Green Steel WA</li> <li>• Emirates Steel</li> </ul>

Over the last six months, the Forum and Deloitte have also been working on a report, *High-Emitting Sectors: Challenges and Opportunities for Low-Carbon Suppliers*, which captures key lessons learned from FMC's engagement with emerging

suppliers. The authors have interviewed over 30 suppliers to understand the unique challenges and opportunities they face, across all seven sectors.

## 10.3 The power of procurement

The hard decisions around which materials or products to buy often come down to a company's procurement function. In a recent article on this subject, [First Movers Coalition: Unlocking the power of procurement to meet net zero](#), the authors argue that at the heart of industry transition lies an important actor whose ability to drive the net-zero agenda is often underacknowledged: the Chief Procurement Officer (CPO).

As the company's primary interface with the value chain, the CPO is uniquely positioned to lead the company's decarbonization efforts. But to do this, the CPO function as well as company leadership need to transform their approach from the traditional risk-averse approach focused on price, quality and time, towards embracing "new technologies, suppliers and business models at a speed and scale as never before".

FMC is engaging with companies procurement processes in two ways, guides and dialogues, outlined below.

### Procurement guides

During 2023-24, FMC published four reports aimed at equipping procurement functions with the know-how for adopting clean energy technologies to decarbonize some of the most hard-to-abate sectors:

**Aviation** – [Sustainable Aviation Fuels: Offtake Manual](#), aimed at making the procurement of SAF offtakes and scope 3 credits more accessible for corporate buyers, while providing suppliers with a better understanding of the fuel purchaser's needs.

**Carbon Dioxide Removal (CDR)** – [Carbon Dioxide Removal: Best-Practice Guidelines](#). The report is for sustainability professionals looking to add CDR to their companies' climate strategy. It makes the case for procuring engineered CDR and seeks to lower entry barriers to the nascent removals market.

**Cement and Concrete** – [First Movers Coalition Cement and Concrete Procurement Guide](#). Aimed at the CPO function, the guide sketches out the

lie-of-the-land for low-carbon cement and concrete procurement. In the absence of global standards in this sector, the guide will help FMC members evaluate what their suppliers are providing.

**Trucking** – [Procurement Playbook Toward Zero Emissions Logistics Services](#) – developed by the Smart Freight Centre and Implement Consulting Group in collaboration with the members of the Sustainable Freight Buyers Alliance.

### Procurement innovation dialogues

Procurement can play a critical role in tackling the climate emergency. Companies are setting organizational net-zero goals that are only achievable if procurement departments undergo a fundamental shift in several aspects: mindset, strategy, organization, processes and capabilities.

FMC's Procure Innovation Dialogues aim to identify and share innovative procurement practices from leading companies. Their format is unique in that, to attend, the Chief Procurement Officer (CPO) is requested to bring another member of the company's leadership team, or in the case of the 2024 edition, a CPO from one of their supply chain partners. This is in recognition that transforming the procurement function requires high-level engagement and support, as well as collaboration across supply chains.

The 1st Procure Innovation Dialogues in September 2023 brought together a community of 35 CPOs and their C-suite partners, recognizing the power of procurement in achieving the global net-zero goal.

The 2nd Dialogues scheduled for September 2024 aim to unlock that power, identify innovative procurement best practices from leading companies, and foster strong partnerships between CPOs and their senior partners.

FMC is also exploring how it can help bring innovative start-ups and SMEs that may be pioneering critical decarbonization technologies and products into the procurement orbits of its members.

# Contributors

## US Department of State

### **Annie Hills**

Senior Advisor, United States Special Presidential Envoy for Climate

## Deloitte Consulting

### **Jordan Woll**

Manager

## World Economic Forum

### **Jelena Aleksić**

Lead, Industry Decarbonization, Aluminium and Non-Ferrous Metals

### **Mette Asmussen**

Lead, Maritime Sector Initiatives

### **Laia Barbarà**

Head, Climate Strategy

### **Mandy Chan**

Procurement Specialist, First Movers Coalition

### **Rosa Esi Ennison**

Specialist, FMC Freight Decarbonization

### **Takahiro Furusaki**

Project Fellow, Shipping Sector, First Movers Coalition

### **Pelayo Gonzalez Escalada Mena**

Aluminium Sector, First Movers Coalition

### **Ginelle Greene-Dewasmes**

Community Specialist, Global Shapers Community; Lead, Government Engagement, First Movers Coalition (2022-2023)

### **Mathilde Haccart**

Lead, Government Engagement, Climate Action

## Boston Consulting Group

### **Ciara Corbeil**

Principal

### **Jay Hawkins**

Communications Lead, Climate and First Movers Coalition

### **Eneida Licaj**

Lead, Finance Pillar, First Movers Coalition

### **Charles Pacini**

Lead, Industry Decarbonization, Metals Sectors (2022-2023)

### **Giorgio Parolini**

Aviation Sector, First Movers Coalition

### **Nasim Pour**

Lead, Carbon Dioxide Removal Sector, First Movers Coalition

### **Julia Franchi Scarselli**

Lead, Regional Decarbonization, First Movers Coalition

### **Rob van Riet**

Programme Head, Climate Action and First Movers Coalition

### **Daniel Boero Vargas**

Materials Sector Specialist, First Movers Coalition

### **Thibault Villien de Gabiole**

Lead, Trucking Sector, First Movers Coalition

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In addition to the Contributors listed above, we would like to thank the following individuals for their contributions:

## US Department of State

### Reed Brown

Foreign Affairs Officer

### Angela M. Enriquez

Foreign Affairs Officer

### David Livingston

Former Senior Advisor, United States Special Presidential Envoy for Climate

### Ambassador David Thorne

Former Senior Advisor, United States Special Presidential Envoy for Climate

## Boston Consulting Group

### Andrew Alcorta

Partner

### Justin Baker

Consultant

### Katherine Duff

Principal

### Juan Farfan

Senior Associate

### Martin Feth

Managing Director and Partner

### Zachary Kaplan

Consultant

### Rich Lesser

Global Chair

### Cornelius Pieper

Managing Director and Senior Partner

### Tina Zuzek-Arden

Managing Director and Partner

## Deloitte Consulting

### Mayank Agarwal

Senior Manager

### Jordyn Albano

Consultant

### Oliver Cenedella

Consultant

### Soumya Choudhary

Senior Consultant

### James Kahn

Consultant

### Adysti Kardi

Consultant

### Dilip Krishna

Managing Director

### Shobhana Selvaraj

Manager

### Tharun Sudhamala

Consultant

### Akash Tripathi

Senior Consultant

## **Oliver Wyman**

### **John Colas**

Partner; Vice-Chairman, Financial Services Americas, Global Co-head of Climate and Sustainability

### **Ilya Khaykin**

Partner; Head, Climate Risk and Sustainable Finance, Americas

### **Michelle Lu**

Associate

## **Editorial and Design**

### **Bianca Gay-Fulconis**

Designer, 1-Pact Edition

### **Tanya Korniiichuk**

Illustrator, 1-Pact Edition

### **Jonathan Walter**

Freelance writer

# Endnotes

1. World Economic Forum, Net-Zero Industry Tracker: 2023 Edition, November 2023, Fig. 3, p.10, [https://www3.weforum.org/docs/WEF\\_Net\\_Zero\\_Tracker\\_2023\\_REPORT.pdf](https://www3.weforum.org/docs/WEF_Net_Zero_Tracker_2023_REPORT.pdf).
2. World Economic Forum, Net-Zero Industry Tracker: 2023 Edition, November 2023, Fig. 3, p.10, [https://www3.weforum.org/docs/WEF\\_Net\\_Zero\\_Tracker\\_2023\\_REPORT.pdf](https://www3.weforum.org/docs/WEF_Net_Zero_Tracker_2023_REPORT.pdf).
3. A “book and claim” system is a chain of custody or certificate trading model, which supports the uptake of SAF even though supply chains are limited in geographical scope and volumes are low. The system permits airlines, corporate flyers and purchasers of air freight to buy the environmental attributes of SAF and signal demand for SAF without necessarily flying on it physically. Book and claim enhances transparency and accountability of sustainable fuels by ensuring that the emission reductions associated with each credit are accurately transferred and verified by a third party. In the aviation industry, the certificates for sustainable fuel are known as SAFc.
4. Sources: Boston Consulting Group; Aeroflap Brazil, Government of São Paulo Signs ICMS Reduction on Aviation Kerosene, January 2023, <https://2baviation.com/tax-regulations/brazil/>.
5. Sources: Boston Consulting Group; Global Data, Oil and Gas Supply Demand Analytics, 2023.
6. International Maritime Organization (IMO), Fourth IMO Greenhouse Gas Study 2020, 2021, <https://www.imo.org/en/OurWork/Environment/Pages/Fourth-IMO-Greenhouse-Gas-Study-2020.aspx>.
7. World Economic Forum, Net-Zero Industry Tracker: 2023 Edition, November 2023, Fig. 3, p.10, [https://www3.weforum.org/docs/WEF\\_Net\\_Zero\\_Tracker\\_2023\\_REPORT.pdf](https://www3.weforum.org/docs/WEF_Net_Zero_Tracker_2023_REPORT.pdf).
8. FMC will allow book and claim when available for cargo owners so long as it occurs on the same carrier (also known as group-level mass balance). FMC also encourages the continued development of a book and claim framework for the transition period.
9. FMC will assess and align with IMO’s life-cycle analysis methodologies, standards and overall guidance once it is released, likely in 2025. Also, technologies considered in scope will be reviewed over the course of the 2020s and potentially be updated based on new evidence. The review of new fuels will consider life-cycle emissions and scalability as well as the availability/supply of new fuels and the quantum of the commitment for different actors. The current list assumes in-scope fuels are used in accordance with generally accepted safe handling/use standards and assumes mitigation of other potentially negative environmental and social impacts. In some cases, such standards are under development.  
FMC allows book and claim when available for cargo owners as long as it occurs on the same carrier. FMC also encourages the continued development of a book and claim framework for the transition period.  
Sources: S&P Global Platts; UMAS; Getting to Zero Coalition; Cargo Owners for Zero Emission Vessels; Energy Transitions Commission; Mission Possible Project; Boston Consulting Group analysis.
10. Ricardo and Environmental Defense Fund for the P4G Getting to Zero Partnership, South Africa: fueling the future of shipping, June 2021, [https://www3.weforum.org/docs/South\\_Africa\\_fueling\\_the\\_future\\_of\\_shipping.pdf](https://www3.weforum.org/docs/South_Africa_fueling_the_future_of_shipping.pdf).
11. S&P Global, Global Trade Atlas Forecasting South Africa Seaborne Trade Volume, 2024
12. South African Reserve Bank (SARB), SARB Occasional Bulletin of Economic Notes, April 2024, <https://www.resbank.co.za/content/dam/sarb/publications/occasional-bulletin-of-economic-notes/2024/occasional-bulletin-of-economic-notes-combined-2401-01.pdf>.
13. World Economic Forum, Net-Zero Industry Tracker: 2023 Edition, November 2023, Fig. 3, p.10, [https://www3.weforum.org/docs/WEF\\_Net\\_Zero\\_Tracker\\_2023\\_REPORT.pdf](https://www3.weforum.org/docs/WEF_Net_Zero_Tracker_2023_REPORT.pdf).
14. Mission Possible Partnership, Making Zero-Emissions Trucking Possible: An industry-backed, 1.5°C-aligned transition strategy, 2022, <https://3stepsolutions.s3-accelerate.amazonaws.com/assets/custom/010856/downloads/Making-Zero-Emissions-Trucking-Possible.pdf>.
15. The Presidency of the Republic of South Africa, South Africa’s Just Energy Transition Investment Plan (JET IP) 2023-2027, November 2022, <https://www.climatecommission.org.za/south-africas-jet-ip>.
16. National Business Initiative (NBI), Decarbonising The South African Transport Sector, March 2023, [https://www.nbi.org.za/wp-content/uploads/2023/03/Decarbonising-the-South-African-Transport-Sector\\_Final\\_17March\\_023.pdf](https://www.nbi.org.za/wp-content/uploads/2023/03/Decarbonising-the-South-African-Transport-Sector_Final_17March_023.pdf).
17. Ibid.
18. Wiedenhoff, P. et al., What the Shift to Zero-Emission Vehicles Means for Commercial Transportation, Boston Consulting Group, 22 March 2022, <https://www.bcg.com/publications/2022/what-the-shift-to-zero-emission-vehicles-means-for-commercial-transportation>.
19. World Economic Forum, Net-Zero Industry Tracker: 2023 Edition, November 2023, Fig. 3, p.10, [https://www3.weforum.org/docs/WEF\\_Net\\_Zero\\_Tracker\\_2023\\_REPORT.pdf](https://www3.weforum.org/docs/WEF_Net_Zero_Tracker_2023_REPORT.pdf).

20. International Aluminium Institute (IAI), Aluminium industry reports decline in greenhouse gas emissions, 28 February 2024, <https://international-aluminium.org/aluminium-industry-reports-decline-in-greenhouse-gas-emissions/>. According to the IAI, for primary aluminium this includes the unit processes bauxite and/or other ores mining, alumina production (hydrate production & calcination), anode production, electrolysis, ingot casting, raw materials transport, electricity generation, and waste processing. It also includes the production of ancillary materials and fuels required for primary aluminium production. It does not include the stages of “production of semi-finished products from raw material”, “use” and “end-of-life”.
21. World Economic Forum, Net-Zero Industry Tracker: 2023 Edition, November 2023, Fig. 3, p.10, [https://www3.weforum.org/docs/WEF\\_Net\\_Zero\\_Tracker\\_2023\\_REPORT.pdf](https://www3.weforum.org/docs/WEF_Net_Zero_Tracker_2023_REPORT.pdf).
22. ZGF, Concrete: A Pragmatic Approach to Lowering Embodied Carbon, September 2023, <https://www.zgf.com/ideas/5474-download-low-carbon-concrete-guidelines>.
23. US Department of Energy, Pathways to Commercial Liftoff: Low-Carbon Cement, September 2023, <https://liftoff.energy.gov/wp-content/uploads/2023/09/20230918-Pathways-to-Commercial-Liftoff-Cement.pdf>.
24. World Economic Forum, Net-Zero Industry Tracker: 2023 Edition, November 2023, Fig. 3, p.10, [https://www3.weforum.org/docs/WEF\\_Net\\_Zero\\_Tracker\\_2023\\_REPORT.pdf](https://www3.weforum.org/docs/WEF_Net_Zero_Tracker_2023_REPORT.pdf).
25. Electrowinning is a steel production process that uses electrochemical devices similar to batteries to produce pure iron at temperatures well below the boiling point. Iron ore is dissolved into an aqueous solution, then an electric current run through the solution separates and collects pure iron molecules while removing impurities with no fossil fuels or hydrogen required.
26. The CDR commitment conditions are currently being revised and will be updated by the end of 2024.



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**World Economic Forum**  
91–93 route de la Capite  
CH-1223 Cologny/Geneva  
Switzerland

Tel.: +41 (0) 22 869 1212  
Fax: +41 (0) 22 786 2744  
contact@weforum.org  
www.weforum.org