

THE BREAKTHROUGH AGENDA REPORT **2024**



Accelerating Sector Transitions Through
Stronger International Collaboration

INTERNATIONAL ENERGY AGENCY (IEA)

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UN CLIMATE CHANGE HIGH-LEVEL CHAMPIONS

The UN Climate Change High-Level Champions mobilise non-state actors for stronger and more ambitious climate action. Mandated by Parties of the Paris Agreement, and working with the Marrakech Partnership, the two serving HLCs Ms. Razan Al Mubarak and Ms Nigar Arpadarai build on the legacy of their predecessors to engage with non-state actors and activate the 'ambition loop' with national governments, connecting policy with the many voluntary and collaborative actions taken by cities, regions, businesses and investors, and nations. Their work is fundamentally designed to encourage a collaborative shift across all of society towards a decarbonised economy so that we can all thrive in a healthy, resilient and zero carbon world. The Climate Champions Team (CCT) is the delivery arm of the UN Climate Change High-Level Champions.

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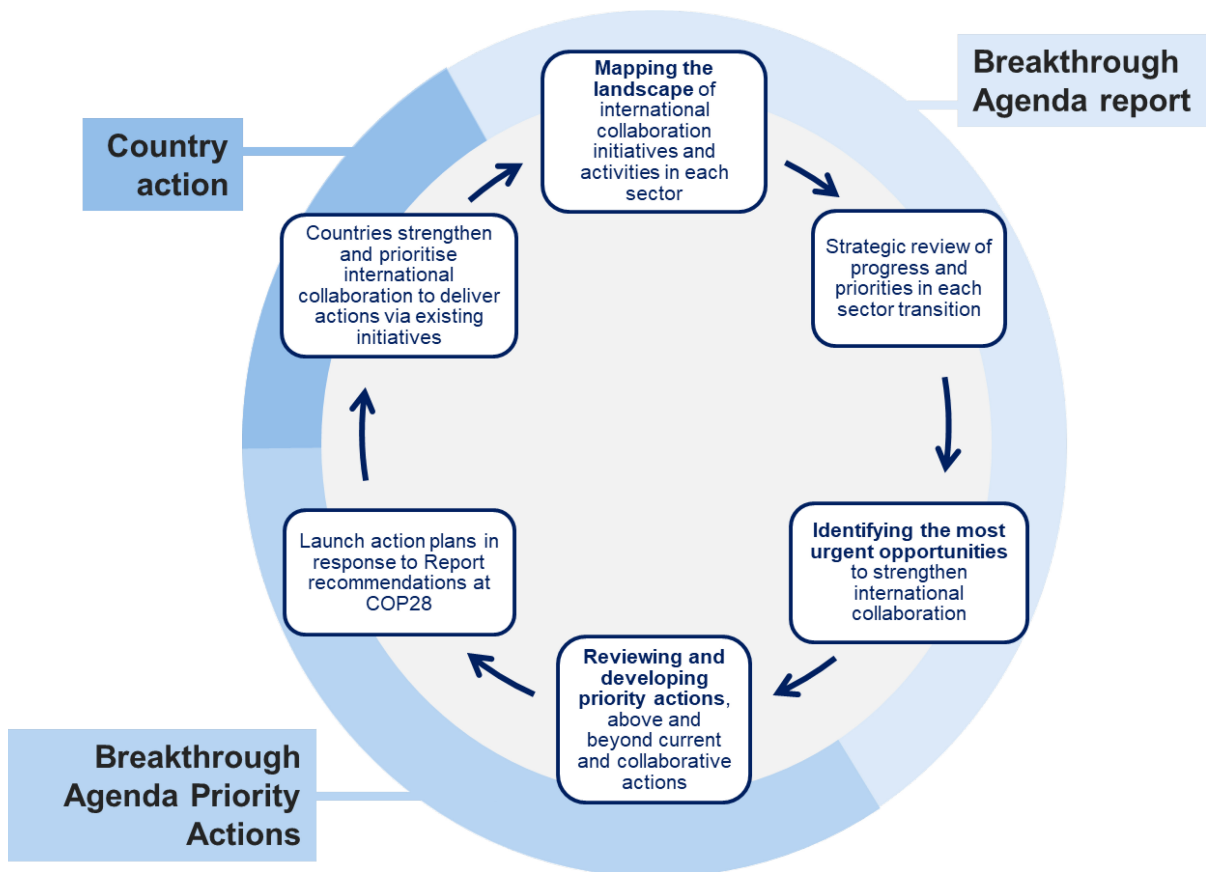
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ABOUT THIS REPORT

Since its launch at COP 26, the Breakthrough Agenda has become established as an annual collaborative process centred around the Conference of the Parties (COP) meetings of the United Nations Framework Convention on Climate Change (UNFCCC). It is currently supported by 59 countries representing over 80% of global GDP, and by over 150 initiatives

working to enhance collaboration within major emitting sectors. Countries can endorse Breakthrough goals to make clean technologies and sustainable practices more affordable, accessible and attractive than their alternatives by 2030 in the power, road transport, hydrogen, steel, cement, buildings and agriculture sectors. This report covers six of the seven sectors, with agricultural covered in a separate report.

The Breakthrough Agenda establishes an annual cycle to track developments towards these goals, identify where further coordinated international action is urgently needed to accelerate progress and then galvanise public and private international action behind these specific priorities in order to make these transitions quicker, cheaper, and easier for all.



To initiate this cycle, world leaders tasked the IEA and the UN Climate Change High Level Champions to develop an annual Breakthrough Agenda report to provide an independent evidence base and expert recommendations for where stronger international collaboration is needed.

This document, the 2024 Breakthrough Agenda Report, is the third of these annual reports. It provides an assessment of progress against the recommendations made last year, updating recommendations for what more needs to be done.

FOREWORD

Over the past year, growth in clean energy deployment has accelerated rapidly with technologies such as solar PV, wind, electric vehicles, electrolysers and batteries leading the way. Investment is also surging. Two out of every three dollars of global energy spending are set to go to clean energy technologies this year. Yet, despite these encouraging trends, the expansion of clean energy is uneven, moving at different speeds across regions, sectors and technologies. Effective international collaboration and well-targeted policies are critical enablers to drive innovation, stimulate investment and ensure level playing fields for countries and industries alike.

The Breakthrough Agenda Report 2024, the third in an annual series, assesses progress on international collaboration in six major emitting sectors – power, hydrogen, road transport, steel, cement and buildings. This report is a joint product of the International Energy Agency (IEA) and the UN Climate Change High-Level Champions. Each organisation has brought its own expertise to deliver clear recommendations on how governments and non-state actors can work together. It also draws on global experience generously shared by governments, businesses and civil society organisations active in each of the sectors covered.

Overall, the report finds that ‘moderate’ progress on international cooperation has been made within some of the sectors reviewed. Good progress has been observed in the hydrogen sector on developing standards and certifications and financing, and in the road transport sector on supply chains. But stronger international collaboration through coordinated research and development, adoption of harmonised standards, market creation, infrastructure deployment, financing and technical assistance is required in other sectors to accelerate the clean energy transition.

Meeting internationally agreed climate goals, including the commitment to triple renewable energy capacity and double energy efficiency by 2030 as set in the UAE Consensus at COP28, requires rapid and deep cuts in global emissions already by the end of this decade. Many clean energy technologies are already cheaper than fossil fuel-based options, but others that will be vital to reducing emissions have not yet reached the technological maturity needed to be cost competitive. Moreover, building the supporting infrastructure and supply chains to scale up these solutions takes time, but time is running out.

That’s why international cooperation must be fully leveraged to ensure the transition to lower emissions technologies is faster, cost effective, and more accessible and inclusive for all countries. Mitigating the impacts of climate change should be viewed as an opportunity for policymakers and industry leaders to advance progress on clean and sustainable development. Tangible measures delivered through international cooperation can help countries take advantage of that development opportunity, as well as driving a more equitable and effective response to the climate crisis.

This report provides practical and actionable recommendations for stronger international collaboration to make clean technologies and sustainable solutions the most affordable, accessible and attractive option in key sectors and in all regions by 2030. We will continue to engage with governments, businesses and civil society organisations in their efforts to implement the recommendations of this report.

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EXECUTIVE SUMMARY

STRENGTHENING INTERNATIONAL COLLABORATION TO ACCELERATE TRANSITIONS

Deployment of clean energy technologies is growing at a rapid pace, though global emissions continue to rise. Annual deployment of several key technologies has reached new heights, driven by policy support and continued cost declines. In 2023, one out of every five cars sold was electric, and annual capacity additions in solar PV and wind grew by 85% and 60%, respectively. While these technologies and others have helped avoid around 2.2 billion tonnes of CO₂ emissions per year in the last 5 years, deployment is concentrated in some regions, and progress is uneven across sectors.

Well-targeted international collaboration can accelerate clean energy transitions at a global scale. Action by individual governments and businesses is necessary but not sufficient to reach global net zero emissions by mid-century. Aligned and co-ordinated international action can amplify the effect of individual action, helping to accelerate innovation, create stronger demand, provide investment signals to create new markets and reach economies of scale, and share best practices to support widespread adoption of effective policies and available technologies.

The Breakthrough Agenda is designed to strengthen international collaboration where it is most needed. Participants in this process, launched in 2021, are working to make clean technologies and sustainable solutions the most affordable, accessible and attractive option in each major sector by 2030. Supported by 59 countries and over 150 initiatives, the Breakthrough Agenda has established an annual process to track developments towards 2030 goals in the power, hydrogen, road transport, steel, cement, buildings and agriculture sectors, which together represent over 60% of global emissions. This report assesses progress made in international collaboration in the past year across six of the seven sectors, which contribute to around three-quarters of cumulative emissions reductions by mid-century in the IEA Net Zero Emissions by 2050 Scenario, and offers recommendations to accelerate action through strengthened international collaboration. A [separate report](#) assesses progress in agriculture.

GOOD PROGRESS HAS BEEN MADE IN SOME AREAS, BUT THERE IS MUCH MORE TO GAIN FROM INTERNATIONAL COLLABORATION

In the past year, some sectors have made notable progress through international co-operation, but more widespread efforts are needed to achieve the ambitious goals of the Breakthrough Agenda. The hydrogen sector saw good progress in key areas as countries worked together to move forward discussions on standardisation and scale up financial support for new projects. The landmark agreement at COP 28 on tripling renewable energy and doubling energy efficiency marked a positive step forward in the power sector; translating this high-level signal into action will be an important next step, including for the implementation of the sectoral details of the efficiency target. Progress was more limited in other parts of the power sector, particularly in efforts to reduce the cost of capital of projects in emerging economies, and to target support in fossil fuel-dependent

communities to create local jobs and skills. In road transport, several new high-level agreements – such as under the Group of Seven (G7) or the United Nations Economic Commission for Europe (UNECE) – indicate clear commitments to decarbonisation, although they still fall short of setting a Paris-aligned trajectory by which all vehicle sales should be zero-emission. Some progress was also made in certain areas for the steel, cement and buildings sectors, as new agreements and partnerships were announced to boost financial assistance and establish shared objectives to decarbonise.

Progress on standards and certification across sectors points to a collective effort to lay the regulatory groundwork and establish market rules for low-emission products. In the steel and cement sectors, standards for low- and near-zero emission products are advancing as international industry and government initiatives are identifying areas of common ground on definitions and measurement methodologies, although deepened government engagement is still needed to rapidly reach broad international agreement. Ongoing work programmes at key initiatives in the hydrogen sector have made good progress in the effort to establish globally harmonised standards for renewable and low-carbon hydrogen and its derivatives, and nearly 40 governments signed a Declaration of Intent for mutual recognition of certification schemes at COP 28. In the buildings sector, there is progress towards agreeing on definitions and principles for near-zero and resilient buildings. In road transport, pilot projects to create digital passports for the traceability and sustainability of battery supply chains are making progress, and leading players in this space are calling for stronger collaboration among governments to ensure globally harmonised standards are adopted across markets. International discussions on standardising charging equipment are also taking place across major vehicle markets.

Demand creation and management remains a challenge across nearly every sector. While there have been some steps on creating demand for clean technologies in the hydrogen, steel and cement sectors – including new pledges by countries to procure low-emission steel and cement – there is an urgent need for governments to convert pledges into firm commitments and stronger policies in order to mobilise investment at the level required to meet the goals of the Paris Agreement and the Breakthrough Agenda. The private sector, through international initiatives and joint commitments, can be a key partner in accelerating demand creation for low-emission materials and fuels. In road transport, the accelerating uptake of electric cars is encouraging, but more efforts are needed to support demand for zero-emission vehicles in heavier segments, particularly vans, trucks and buses. In the power and buildings sectors, the launch of the Global Cooling Pledge at COP 28 saw 63 countries commit to work together to increase the global average efficiency of new air conditioners by 50% by 2030, and establish Minimum Energy Performance Standards and model building energy codes, amongst other objectives.

Support to and engagement with emerging markets and developing economies is a crucial element of international collaboration that urgently requires more focus. Key areas include greater and more effective financial and technical assistance to create enabling policy environments and support investment; demand-creation efforts that include a greater geographic and market diversity; and expanding the benefits of research and innovation programmes to developing economies to accelerate knowledge-sharing for faster commercial demonstration and deployment of clean technologies. Governments should ensure the financial and technical assistance provided to emerging markets and developing economies is fully aligned with the needs and specificities of recipient countries, and set more effective mechanisms to track funding and progress of ongoing projects, share learning, and set new priorities accordingly. The involvement of the largest emerging

economies is also likely to be important for the effectiveness of initiatives to align international trade with the objectives of the transition, in sectors such as steel.

Without a gear-shift in practical collaboration, climate goals will be increasingly hard to meet. The Breakthrough Agenda’s goals, though ambitious, are no more so than those of the Paris Agreement, which imply global GHG emissions [roughly halving by 2030](#). It is against this high bar of the Breakthrough Agenda goals that we assess progress in international collaboration.

Summary of progress in international collaboration						
	Power	Hydrogen	Road transport	Steel	Cement	Buildings
Standards and certification		↑		↓		
Demand creation and management	↑	=		↓		
Finance and investment	↓	↑	=	=		
Research and innovation	=	=		=		
Trade conditions			↓	=		
Infrastructure	=		=			
Social engagement	=					
Long-term vision			=			
Supply chains			↑			
Capacity and skills						

Notes: red = minimal progress; orange = moderate progress; yellow = good progress; green = strong progress; white = no recommendation in this area for this sector. The arrows indicate relative progress compared to last year’s assessment in the 2023 Breakthrough Agenda Report. “↑” indicates an improved assessment; “↓” indicates a downward assessment; “=” indicates the same assessment.

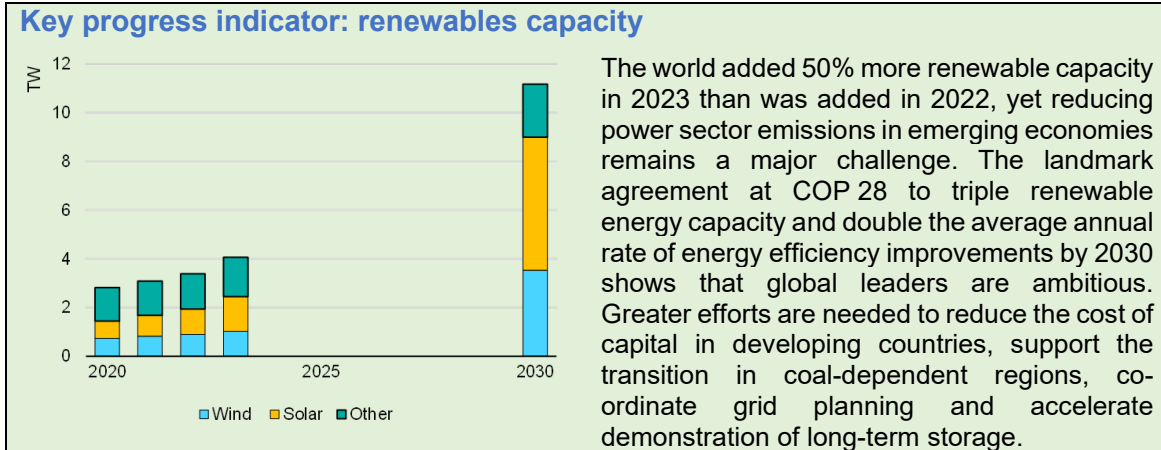
PRIORITIES TO STRENGTHEN INTERNATIONAL COLLABORATION

The summaries of progress outlined for each sector below show how international collaboration is already making efforts to accelerate transition, as well as how it could be further enhanced. Each summary contains the ambitious Breakthrough Agenda goals for 2030, which aim to accelerate international collaboration to make clean technologies and sustainable practices more affordable, accessible and attractive than their alternatives. The recommendations provide a clear pathway to continue accelerating the transition.

22%
of global GHG emissions

POWER

Clean power is the most affordable and reliable option for all countries to meet their power needs efficiently by 2030 – Power Breakthrough Goal



RECOMMENDATIONS

1. Donor governments, working with key institutions and funds, should ensure that international support is available at better terms, including grants at early investment stages for higher-risk projects. That includes creating de-risking mechanisms, tailored to the country's respective contexts – particularly for EMDEs – and technical assistance for finance and regulatory reforms across all clean energy technologies. This should focus on avoiding lock-in to high-carbon power generation, and instead aim to streamline its phase-out, all of which can help to mobilise private sector investments. Overall provision of resources should be significantly increased, particularly for technologies that have not achieved commercial maturity. International finance institutions should provide technical guidance to countries that explains and simplifies the breadth of financing streams available to stakeholders.
2. Donor governments and MDBs should work together to more strongly align development funding with targeted support for local jobs, skills and investment, for the repurposing of fossil fuel assets, economic diversification, and for environmental restoration, in fossil fuel-dependent regions and communities. Efforts should be made to ensure consistency with regional priorities and needs, and to ensure new clean energy infrastructure benefits and creates value for local communities. Clearer, more transparent, and fully independent monitoring, including progress reporting on social outcomes, should be incorporated within Just Energy Transition Partnerships, to build mutual confidence in implementation. Institutional capacities should be reinforced to be able to absorb the social components of clean energy finance programmes. Civil society, governments and industry should contribute to creating international centres of expertise on the just transition, within existing institutions
3. Governments should work through relevant initiatives to accelerate the identification and implementation of suitable demonstration projects across a broad range of power systems contexts, with a greater focus on deeply decarbonised systems that require long-term energy storage and balancing. Governments should resource these demonstrations appropriately and ensure high-quality knowledge-sharing structures are put in place. To facilitate knowledge-sharing among a wider set of countries and stakeholders, close collaboration with regional research and innovation networks will be required.
4. Governments should work together to reassess the opportunities for cross-border and regional power interconnection, increase their engagement with international efforts to identify top regional priorities, and focus on reaching new agreements to realise these opportunities. Countries should engage a much broader, whole-of-society coalition of public and private stakeholders to successfully appraise these opportunities and develop regional interconnections. Countries should also work together on the joint planning of grid infrastructure, supported by improved permitting processes, and speed up discussions on the alignment of regulation and markets for electricity and system services, including power pool integration.
5. Countries, in consultation with industry, should collectively agree to more ambitious Minimum Energy Performance Standards for energy-consuming appliances, including appliances for heating and cooling. Countries should also agree on interoperability and digital standards, which could be supported by awareness campaigns, improved labelling, or appliance retrofit programmes at the national level. Improved technical assistance should facilitate the implementation of effective standards in developing economies.

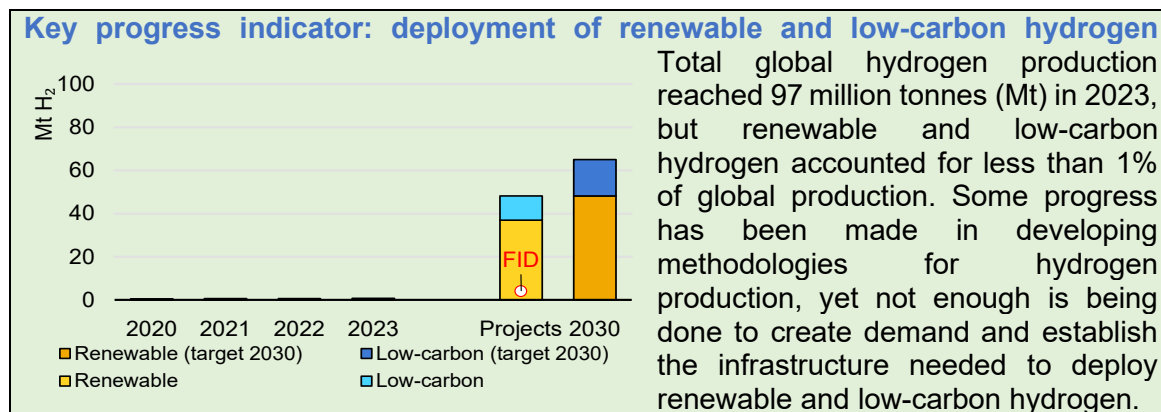
PROGRESS SUMMARY

	What key progress has been made?	What more needs to be done?
P1. Finance and Investment	<ul style="list-style-type: none"> Global clean electricity investment rose to over USD 900 billion in 2023, far outstripping fossil fuels, but almost all the recent growth has been in advanced economies and China. Enough investment has been made in existing and projected supply chain infrastructure for solar PV panels and batteries – but not yet for wind – to put manufacturing on track to satisfy needs under the NZE Scenario by 2030. The pace of divestment away from coal power remains far off track, with coal consumption for power generation growing worldwide in the first 6 months of 2024. 	<ul style="list-style-type: none"> Technical assistance efforts need to be strengthened and immediately focused on financing and de-risking clean power value chain development in EMDEs, and understanding the systemic implications of the energy transition for finance, beyond deployment. International collaboration efforts should also target regional disparities in the cost of capital. The cost of capital needs to be reduced where it is currently high, including countries in Africa, Latin America and Asia where solar energy resources are abundant and the need for energy is growing.
P2. Social engagement	<ul style="list-style-type: none"> Several initiatives advanced their remits, including the Energy Transition Accelerator and the JETPs. A smattering of local dialogues and engagements throughout 2023. The number of people without access to electricity in sub-Saharan Africa is not decreasing fast enough: it is currently stagnant, after rising for 3 consecutive years. 	<ul style="list-style-type: none"> Further clarity on just transition best practices for fossil fuel-dependent countries (e.g. through JETP), including better alignment with bilateral initiatives. Develop strategies to strengthen local value chains, using local expertise and international best practice, and creating value for local communities. Enhance knowledge-sharing and collaboration towards financing the phase-out of fossil power generation and economic diversification.
P3. Research and innovation	<ul style="list-style-type: none"> Good progress from key stakeholders in advancing region-specific research and innovation in power, including in ASEAN, India and Brazil. Increased participation from countries in key multilateral initiatives. 	<ul style="list-style-type: none"> Demonstrate fully-fledged, highly decarbonised systems at scale and in different national contexts. Most focus is on individual technologies or assets, but very few transferable demonstrations of advanced electricity systems exist today, and almost none in EMDEs. Develop and demonstrate technologies and processes for managing renewable-based systems that have largely phased out fossil fuel/thermal generation. Demonstrate long-term/seasonal storage and balancing at scale, and prove value of different options to manage seasonal

		balancing in different national conditions/environments.
P4. Infrastructure	<ul style="list-style-type: none"> • Moderate increase in engagement in regional bi- and multilateral initiatives. • Improved knowledge-sharing between TSOs, DSOs and regulators across borders. 	<ul style="list-style-type: none"> • Beyond interconnection, there is an immediate need for countries to enhance efforts in co-ordinated energy planning across borders, including renewable scale-ups, electrification plans, and grid planning. Very few economies today score highly in joint grid and low-carbon generation planning. • Enhance efforts in developing power pools and power pool integration and include longer-term grid resilience and adaptation in infrastructure planning. • Empower regional regulatory institutions to achieve the full benefits of cross-border power trading.
P5. Demand management and creation	<ul style="list-style-type: none"> • Increased membership and advanced remit of multilateral standards and efficiency initiatives. 	<ul style="list-style-type: none"> • Most claimed progress is in MEPS for technologies that deliver marginal gains today (LEDs, even electric motors). Further efforts are needed to extend the range of products covered by MEPS. • Extend standards to cover a larger share of the global market, particularly for energy-intensive loads. Even where best available technologies (BAT) and MEPS instruments are adequate, they only impact a small share of the market. • Beyond adopting MEPS, international co-operation effort is needed to create an enabling environment for efficient appliances, which includes international standards for technology neutral metrics, labels, and eventually MEPS, as well as for interoperability and digital rules and standards.

HYDROGEN

Affordable renewable and low-carbon hydrogen is globally available by 2030 – Hydrogen Breakthrough Goal



RECOMMENDATIONS

1. Governments working together through the international initiatives involved in the Hydrogen Breakthrough need to urgently present a well-articulated plan that defines resource needs for the development and implementation of a comprehensive portfolio of national and international standards for hydrogen and hydrogen-based fuels. Governments and businesses should provide financial and human resources in line with that plan to ensure the development of that portfolio. Governments should facilitate regulatory interoperability by committing to adopt, or ensuring consistency with, globally recognised international standards, such as the ones developed by the ISO Methodology, in their regulations, which is an important step to support the process of mutual recognition of certification schemes. Governments should anticipate building technical capacity of their national systems to verify compliance with international hydrogen standards.
2. Governments and companies should co-ordinate internationally to increase commitments for the use of low-carbon and renewable hydrogen and hydrogen-based fuels, particularly in sectors where hydrogen is already used, supported by the implementation of specific policies and the signing of solid purchase agreements, to collectively send a strong demand signal and mobilise investment in production. In new priority application sectors, countries should share learnings to accelerate early deployment. This should be done in a manner that ensures a level playing-field in international trade.
3. Governments and companies should work together to dramatically increase the number and geographical distribution of demonstration projects for hydrogen use and to ensure that these appropriately cover each of hydrogen's high-value end-use sectors, including maritime shipping, heavy industry and long-duration energy storage. Governments and the private sector should agree on minimum reporting principles to guide a deeper and more rapid sharing of knowledge among these demonstration projects and with the broader stakeholder community, including a commitment to share the lessons learnt from all publicly funded demonstration projects.
4. Governments, MDBs, DFIs and relevant technical partners should work to deliver and scale up support by financing instruments and de-risking mechanisms, particularly for viable projects that are being delayed by high costs of capital and other obstacles to investment. This should include appropriate and co-ordinated technical and financial assistance, particularly in developing countries, to assist governments with policy design.

PROGRESS SUMMARY

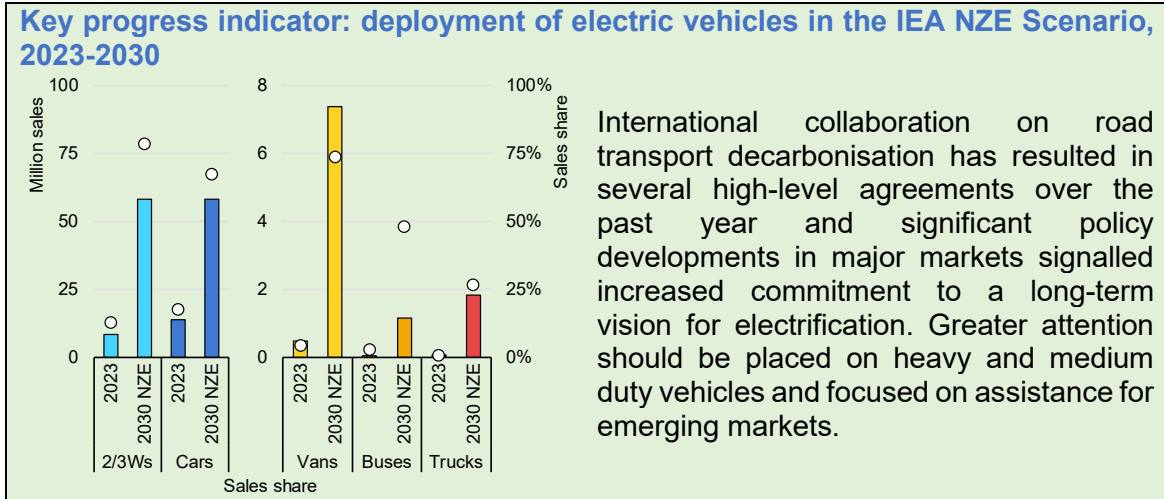
What key progress has been made? What more needs to be done?	
<p>H1. Standards and certification</p>	<ul style="list-style-type: none"> • ISO published a Technical Specification to determine well-to-gate GHG emissions associated with hydrogen supply chains. • 37 governments signed a Declaration of Intent for mutual recognition of certification schemes for renewable and low-carbon hydrogen and hydrogen derivatives. • The Hydrogen TCP “Task” for Certification of Hydrogen and Derivatives advanced the development of the technical mutual recognition framework for certification schemes.
<p>H2. Demand creation</p>	<ul style="list-style-type: none"> • Prepare a well-articulated plan to identify the resources required to develop a comprehensive portfolio of standards. • Provide the resources for developing and agreeing a portfolio of safety and operational standards. • Governments to refer to and/or seek consistency with the ISO Methodology in their regulations and certification schemes to facilitate mutual recognition. • Build domestic technical capacities needed in EMDEs to verify compliance with international standards.
<p>H3. Research and innovation</p>	<ul style="list-style-type: none"> • Creation of a working group of international initiatives under the umbrella of the Hydrogen Breakthrough. • Extensive analysis provided by international organisations, providing recommendations to facilitate demand creation. • Some countries began to implement regulations and support schemes to stimulate demand. • RMI launched a Sustainable Steels Buyers Platform, piloted a Maritime Book and Claim chain of custody system, and launched a Sustainable Aviation Fuels Registry. • Governments to commit to implement policies and market mechanisms that stimulate demand in priority sectors and to share lessons learnt in existing international forums. • Governments to co-ordinate efforts to create a level playing-field for applications in which hydrogen is used for the production of globally traded commodities. • Industry to move beyond announcements and MoUs to binding contractual agreements.
<p>H3. Research and innovation</p>	<ul style="list-style-type: none"> • CHM identified nearly 100 hydrogen valleys. • CHM and H2 TCP announced the development of a global research and innovation agenda. • Provide the necessary resources for CHM to move beyond identification of valleys and become an implementation platform. • Extend the reach of demonstration efforts to involve EMDEs. • Focus efforts on priority applications including heavy industry, shipping, aviation, seasonal electricity storage, and segments of heavy-duty trucking. • Develop a co-operation framework to define and agree minimum reporting principles and to guide knowledge-sharing.

<p>H4. Finance and investment</p>	<ul style="list-style-type: none"> • The Scaling Hydrogen Financing for Development report was published in early 2024 by the World Bank, ESMAP, OECD, G20 GIF, and the Hydrogen Council. • 10 GW Lighthouse Initiative is currently being established - including Governments, MDBs and DFIs. • The ITA was launched at COP 28 to support project delivery and policy design and implementation in selected countries. • Mapping efforts are underway to identify hydrogen projects. 	<ul style="list-style-type: none"> • Build on progress regarding information and knowledge dimensions to design and deliver financial de-risking mechanisms. • Focus on implementation of individual projects, including but not limited to those identified for the Lighthouse Initiative. • Ensure additionality in the delivery of support and assistance programmes, with a focus on EMDEs.
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10%
of global GHG
emissions

ROAD TRANSPORT

Zero-emission vehicles are the new normal and accessible, affordable, and sustainable in all regions by 2030 – Road Transport Breakthrough Goal



RECOMMENDATIONS

1. Governments should commit to a Paris-aligned timeline by which all new road vehicle sales should be zero-emission, particularly for trucks, buses, and vans, backed by interim targets and clear implementation plans by 2030 and 2035. Governments should put effective laws, policies and programmes in place to implement these commitments, such as ZEV mandates, and share learning throughout implementation, particularly with emerging markets and developing economies.
2. Governments should work to accelerate the pace of pilot projects seeking to increase access to low-cost financing for zero-emission vehicle adoption in emerging markets and developing economies, and to scale up availability of low-cost financing to a wider set of countries, particularly for buses and trucks. Governments should work with public authorities, corporates and financial institutions, including multilateral and national development banks, to provide funding and technical assistance, mitigate risks, and rapidly create a larger pipeline of projects.
3. Governments should agree on environmental, social and governance standards and metrics that are harmonised across regions, including battery carbon footprint and responsible sourcing, with the view to support international markets for more sustainable products. Governments should work towards enabling global interoperability, transparency, and harmonised data governance of digital battery passports (e.g. data collection, management, exchange, assurance, and verification standards). Further, governments should jointly address priority areas for secure, resilient, and sustainable value chains, and circularity-based product design and processing, including bottlenecks for battery materials, longer battery lifespan, recycling standards at the end of life, and technical assistance for emerging markets and developing economies on EV battery end-of-life management.
4. Governments should co-operate to accelerate the roll-out of charging infrastructure along international freight corridors for zero-emission trucks. Governments should strengthen joint planning and co-ordinated investment across the transport and power sectors to anticipate greater demand for zero-emission power generation, transmission, and distribution for charging, as well as with financial institutions to increase funding allocated to large-scale infrastructure projects.
5. Governments in exporting and importing countries should agree on minimum quality, environmental and safety standards for cross-border trade of used vehicles across all segments. Governments should improve data traceability for tracking cross-border used vehicle trade, such as through a publicly accessible database. Governments and companies should develop strategies to promote and enforce standards at ports of export, support cross-border trade of used zero-emission vehicles, and manage vehicle end of life in importing countries.

PROGRESS SUMMARY

	What key progress has been made?	What more needs to be done?
RT1. Long-term vision	<ul style="list-style-type: none"> National legislation in large markets, such as new CO₂ emissions standards for cars and trucks in the European Union and the United States, and ZEV regulation in Canada and the United Kingdom. Adoption of the UNECE global decarbonisation strategy for road transport (and other inland modes) by 2050 by a broad set of countries. 	<ul style="list-style-type: none"> Agree on a global decarbonisation pathway, with greater focus on trucks, buses and vans, learning from the successes for cars and 2/3Ws. Move towards implementation through policies that create demand, such as lower emissions standards and ZEV sales requirements. Expand global dialogue on industrial development, manufacturing, and trade of ZEVs, and their impact on the pace of the transition. Explore challenges associated with the increasing size of passenger vehicles.
RT2. Finance and investment	<ul style="list-style-type: none"> ZEV pilots in EMDEs are starting operations and expanding to more countries (e.g. Senegal, India, Peru, Ghana, Brazil, Chile). Up to 20% of targeted funds have been raised under the Global Facility to Decarbonise Transport so far, with aims to leverage USD 1.2 billion in World Bank financing by mid-2025. 25 EMDEs are eligible for technical assistance under the ZEV Rapid Response Facility. A governance framework for delivering the ZEV Transition Council roadmap is expected at COP 29. 	<ul style="list-style-type: none"> Expand the scale of financial and technical assistance by leveraging private sector collaboration, demand aggregation and blended finance. Accelerate pilot projects aiming to increase low-cost financing in EMDEs, scale them up, and expand to more regions. Enhance awareness of available funding for EMDEs and build capacity to develop projects that are eligible for funding and respond to local priorities. Improve mechanisms to collect data on funds and information on ongoing pilots to track progress and share learnings publicly.
RT3. Supply chains	<ul style="list-style-type: none"> High-level agreement and progress towards binding legislation relating to battery supply chains in major markets. Second wave of pilot projects for digital battery passports, with first learnings expected at COP 29. Increasing discussion of battery end-of-life strategies in EMDEs. 	<ul style="list-style-type: none"> Scale up battery passport pilots and work towards global harmonisation of standards. Set standards for battery recycling, ramp up recycling capacity and develop EV end-of-life strategies, especially in EMDEs, supported by financial and technical assistance. Assess and mitigate risks in battery supply chains to improve security and resilience.

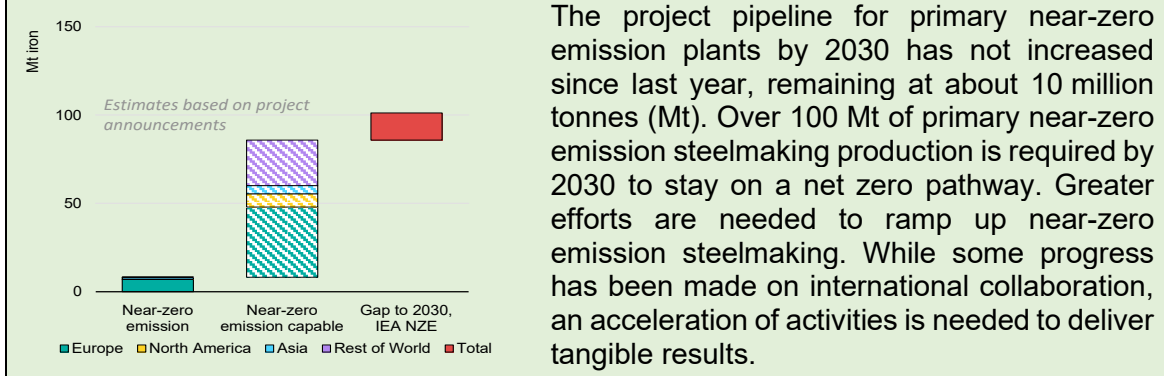
<p>RT4. Infrastructure</p>	<ul style="list-style-type: none"> • Shared vision on HDV charging technology and standards between the European Union and the United States. • Increasing support for charging infrastructure in national legislation, such as in the European Union and the United States. • Identification of pilot projects for ZEV freight corridors. 	<ul style="list-style-type: none"> • Bring transport, power and finance stakeholders together around infrastructure projects at the interface between power, grids, and charging, leveraging data and shared learnings to optimise infrastructure planning. • Accelerate pilots for HDV charging along freight corridors, especially those spanning borders, and expand them to more regions. • Decide on global charging equipment standards and interoperability requirements.
<p>RT5. Trade conditions</p>	<ul style="list-style-type: none"> • Local regulatory progress on used LDV imports in more EMDEs. • Moderate steps towards aggregation and publication of data on used LDV and HDV trade, although there are challenges relating to data scarcity. 	<ul style="list-style-type: none"> • Further discussions between importing and exporting countries to find consensus on global standards for used vehicle exports in order to take polluting vehicles out of international trade, and on standards for ZEV refuelling and end of life. • Set up harmonised mechanisms to assess and enforce compliance, with necessary support for developing technical capacity in EMDEs.

7%
of global GHG emissions

STEEL

Near-zero emission steel is the preferred choice in global markets, with efficient use and production established and growing in every region by 2030 – Steel Breakthrough Goal

Key progress indicator: near-zero emission steel production based on project announcements, 2030



RECOMMENDATIONS

1. Governments, industry and other relevant stakeholders should work through existing collaborative forums and with international standards bodies to identify by the end of 2024 and implement by the end of 2025 priority revisions for interoperability and net zero compatibility of steel GHG emissions accounting methodologies. Governments should collectively provide clarity on principles for near-zero and low-emission steel definitions, commit to adopting definitions within national policies by the end of 2025, select methods for determining equivalency of different certification schemes, and provide guidelines on chain of custody models.
2. Governments and companies should increase purchase commitments to cover a significant share of their future steel demand, joining relevant initiatives aggregating these commitments and ensuring high quality through appropriate legal and implementation frameworks, such as advance purchase commitments. Firm commitments for near-zero emission steel in particular, not only low-emission steel, should be increased. Governments should also look into adopting other mechanisms to support lead market scale-up, such as low- and near-zero emission material mandates or performance standards, and including the possibility of cross-border demand creation mechanisms.
3. Governments and companies should collaborate via existing initiatives to fast-track policy support, sharing of technology learning, business case development, and practical technology collaboration partnerships, towards rapid commercialisation of a portfolio of technologies that can achieve near-zero emissions. These partnerships should support the delivery of pilot and, most importantly, commercial-scale demonstration projects in all major emerging and developing countries well in advance of 2030. Increased open conversations are needed on the role of intellectual property rights in accelerating knowledge-sharing and technology collaboration.
4. Governments should deepen and expand strategic international dialogues on the role of trade in the steel sector's transition, with the purpose of agreeing ways to ensure near-zero emission steel can compete in international markets, including conversations both on carbon leakage and on enablers of near-zero emission iron and steel trade. Governments of all major steel producing and consuming countries should actively engage in international dialogue and explore possibilities for collaboration in this area.
5. Governments should increase support for, and engagement with, improved match making functions focused on steel deep decarbonisation that can better respond to developing country requests for financial and technical assistance. This should include donor countries, recipient countries, international financial institutions, national development banks, philanthropic organisations, private financial institutions and companies, with regular meeting of ministers. Governments should share best practices to enhance enabling policy frameworks, as well as collectively set guardrails for finance in collaboration with financial institutions, so that new capacity additions and major retrofits of existing capacity are suitable for future conversion to near-zero emission technologies and do not become stranded assets.

PROGRESS SUMMARY

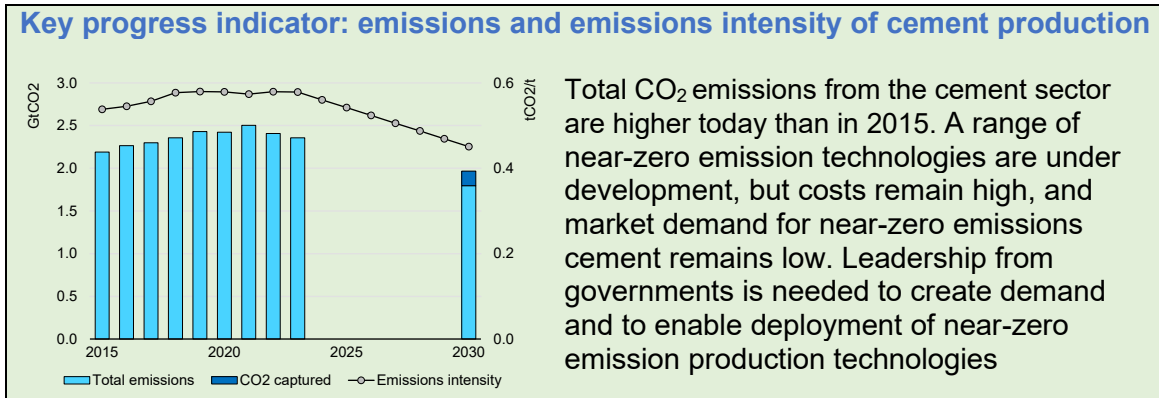
	What key progress has been made?	What more needs to be done?
S1. Definitions and standards	<ul style="list-style-type: none"> • Measurement methodologies: Steel Standards Principles launch and meetings, World Steel mapping exercise, IDDI PCR Harmonisation and priority accounting methods dialogues. • Definitions: LESS launch, ResponsibleSteel version 2.1, strategic exchanges towards identifying common ground on definitions in Climate Club and WPID. • Chain of custody: ResponsibleSteel consultation started. 	<ul style="list-style-type: none"> • Measurement methodologies: leadership on identifying and taking forward priority revisions. • Definitions: agreement on common principles for definitions and a process for determining equivalency of definitions. • Chain of custody: clarity around innovative chain of custody models.
S2. Demand creation	<ul style="list-style-type: none"> • Public sector: IDDI procurement pledges by four countries; exploration of regulatory policies to support scale-up by the European Union. • Private sector: increased membership in FMC and SteelZero; RMI Steel Buyers Platform and FMC First Suppliers Hub launched. 	<ul style="list-style-type: none"> • Public sector commitments to <i>near-zero</i> emission steel procurement; translation of pledges into firm policies; procurement by more countries; demand-creation policies beyond procurement (e.g. product standards/mandates). • Increased private-sector commitments, particularly in sectors other than automotive. • Commitments supporting demand in EMDEs.
S3. Research and innovation	<ul style="list-style-type: none"> • Mission Innovation Net Zero Industries Mission Award and webinar programme. • UNIDO A2D Facility launch. 	<ul style="list-style-type: none"> • More and strengthened practical partnerships between countries on technology collaboration, including at different stages of TRL. • Broad and high-quality knowledge-sharing and trust-building. • Open dialogue on the role of intellectual property rights in accelerating technology collaboration.
S4. Trade conditions	<ul style="list-style-type: none"> • Strategic Dialogues initiated under the Climate Club on understanding international spillover effects of climate policy. • Ongoing relevant discussions in WTO forums on trade (e.g. on CBAM, barriers to trade). 	<ul style="list-style-type: none"> • Open dialogue on enabling near-zero emission steel and “green” iron trade. • Active involvement of all major producers in carbon leakage dialogues, including the role of technical assistance to developing economies as an enabler.
S5. Finance and investment	<ul style="list-style-type: none"> • Key examples of direct country partnerships/platforms on industrial deep decarbonisation have been launched: UK-Brazil Industry Decarbonisation Hub (with UNIDO 	<ul style="list-style-type: none"> • Financial sector alignment towards the net zero goals, in order to channel funding appropriately and avoid stranded assets.

	<p>and LeadIT), Sweden-India Partnership (LeadIT) and Türkiye investment platform (EBRD).</p> <ul style="list-style-type: none"> • Global Matchmaking Platform is under development under the Climate Club. • CEFIM continued work on enabling conditions for finance (Indonesia and South Africa). • ITA launching national and regional project support programmes covering the steel sector. 	<ul style="list-style-type: none"> • Robust enabling policy frameworks to underpin net zero-aligned finance.
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6%
of global GHG
emissions

CEMENT

Near-zero emission cement is the preferred choice in global markets, with efficient use and near-zero emission cement production established and growing in every region of the world by 2030 – Cement and Concrete Breakthrough Goal



RECOMMENDATIONS

1. Governments and industry should work through existing collaborative forums and with international standards bodies to identify and implement by the end of 2025 priority revisions for interoperability and net zero compatibility of cement and concrete emissions accounting methodologies. Governments should collectively provide clarity on principles for near-zero and low-emission cement and concrete definitions, commit to adopting definitions within national policies by the end of 2025, select methods for determining equivalency of certification schemes and provide guidelines on chain of custody models. Governments should exchange best practices and the latest standards, so that building codes and public procurement practices undergo accelerated revisions by end of 2025 to facilitate maximum possible use of supplementary cementitious materials (SCMs).
2. Governments and companies should work through existing collaborative forums to co-ordinate and scale up early efforts to create a market for near-zero emission cement in particular, not only low-emission cement, including via high-quality, multi-year advance purchase commitments and/or direct policy support (including procurement and near-zero emission material mandates or performance standards), and including systems targeted at scaling up demand from projects in emerging economies.
3. Governments should work together with effective private sector collaborative forums to accelerate policy support, the pace of learning, business case development, and practical technology collaboration partnerships between a wider set of countries, towards rapid commercialisation of a portfolio of technologies that can achieve near-zero emissions. These partnerships should support the delivery of pilot and, most importantly, commercial-scale demonstration projects in all major emerging and developing economies well in advance of 2030. Increased open conversations are needed on how to protect intellectual property rights while accelerating knowledge-sharing and technology collaboration, as is knowledge-sharing on enabling policies for first-few-of-a-kind technology deployment.
4. Governments should increase support for, and engagement with, improved match-making functions focused on cement and concrete deep decarbonisation that can better respond to developing country requests for financial and technical assistance. This should include donor countries, recipient countries, international financial institutions, national development banks, philanthropic organisations, private financial institutions and companies, with regular meetings of ministers. Governments should share best practices to enhance enabling policy frameworks, as well as collectively set guardrails for finance in collaboration with financial institutions, so that new capacity additions and major retrofits of existing capacity are suitable for future conversion to near-zero emission technologies and do not become stranded assets.

PROGRESS SUMMARY

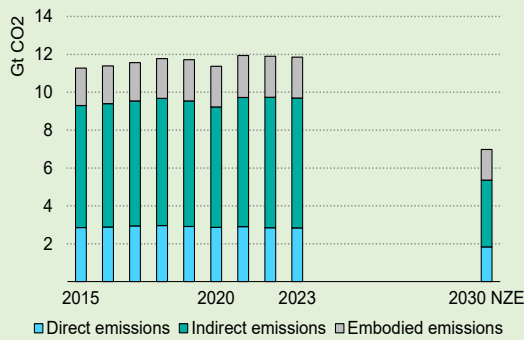
What key progress has been made?		What more needs to be done?
C1. Standards	<ul style="list-style-type: none"> • Measurement: GCCA methodology revisions underway to include innovative technologies, IDDI PCR Harmonisation and accounting methods dialogues. • Definitions: GCCA definitions proposal for concrete in the final stages of development, strategic exchanges towards identifying common ground on definitions in Climate Club and WPID. 	<ul style="list-style-type: none"> • Measurement methodologies: leadership on identifying and implementing priority revisions. • Definitions: agreement on common principles for definitions and a process for determining equivalency of definitions. • Chain of custody: clarity around innovative chain of custody models. • Construction standards: revisions to facilitate maximised uptake of SCMs.
C2. Demand creation	<ul style="list-style-type: none"> • Public sector: IDDI procurement commitments by four countries. • Private sector: FMC First Suppliers Hub launched; increased membership in ConcreteZero. 	<ul style="list-style-type: none"> • Public sector commitments to near-zero emission cement/concrete procurement; demand-creation policies beyond procurement. • Private sector commitments for near-zero emission cement/concrete. • Commitments in emerging markets and developing economies.
C3. Research and innovation	<ul style="list-style-type: none"> • GCCA Innovandi Open Challenge consortia creation and third open call; work on conditions for CCS first-of-a-kind projects. • Mission Innovation Net Zero Industries Mission Award and seminar programme. • UNIDO A2D Facility launch. 	<ul style="list-style-type: none"> • More and strengthened practical partnerships between countries on technology collaboration, including at different stages of TRL. • Enabling policy environment for first-few-of-a-kind innovative technology deployment. • Open dialogue on the role of intellectual property rights in accelerating technology collaboration.
C4. Finance and investment	<ul style="list-style-type: none"> • Key examples of direct country partnerships/platforms on industrial deep decarbonisation have been launched: UK-Brazil Industry Decarbonisation Hub (with UNIDO and LeadIT), Sweden-India Partnership (LeadIT), Türkiye investment platform (EBRD) and Canada-Thailand (with UNIDO). • Launch of the Climate Club Global Matchmaking Platform Initiative. • ITA launching national and regional project support programmes. 	<ul style="list-style-type: none"> • Expanded financial and technical assistance, matched to country needs. • Financial sector alignment towards the net zero goals, in order to channel funding appropriately.

6%
of global GHG
emissions

BUILDINGS

Near-zero emission and resilient buildings are the new normal in all regions by 2030 – Buildings Breakthrough Goal

Key progress indicator: CO₂ emissions from buildings



Despite a reduction in energy intensity, building emissions have grown at an average of 0.7% per year since 2015, and global growth in floor area looks set to continue, outpacing improvements in efficiency. Following the launch of the Buildings Breakthrough in December 2023, there has been moderate progress across several areas of international collaboration, but greater efforts are needed, particularly in expanding financial and technical assistance to emerging markets.

RECOMMENDATIONS

1. Governments should agree on shared qualitative definitions and principles for near-zero emission and resilient buildings, and agree on common guidelines for codes, standards and public disclosure certificates, including reporting indicators for performance assessment. Such guidelines should support comparability of performance, while allowing for flexibility to reflect local practices and context.
2. Governments should jointly create procurement and policy commitments for near-zero emission and resilient buildings, both new and existing, and strengthen commitments on near-zero and low-emission materials and appliances. Governments should co-ordinate policies, especially establish Minimum Energy Performance Standards, to improve efficiency of air conditioners in all markets. Countries should co-ordinate targets and regulatory trajectories, and share policy best practices, for clean and efficient heating technologies like heat pumps.
3. Countries should work together to expand international financial and technical assistance programmes that support investment in near-zero emission and resilient buildings, to address the following priorities more strongly: providing blended financial instruments, identifying policies and regulations that reduce private investment risk, building capacity among local banks and lenders, developing and aggregating project pipelines, and addressing key data gaps for financial risk assessments. These efforts must involve development banks, private finance, banks, and insurers.
4. Countries should work together to agree shared research priorities that support the implementation of international commitments. Countries should facilitate improved communication of high-quality research to inform the decision-making process and strengthen existing research networks to bring in new expertise, especially from emerging markets and developing economies. Countries should develop shared demonstration projects of key technologies, construction practices, tools and business models at scale, using government projects to lead the way.
5. Countries should strengthen the role of existing networks to share knowledge and provide methods, tools, guidance and resources to identify and address institutional and personnel capacity-building gaps across all regions. This includes a focus on supporting developing economies with developing, implementing and upgrading building and energy codes. Progress summary

PROGRESS SUMMARY

	What key progress has been made?	What more needs to be done?
B1. Standards and certification	<ul style="list-style-type: none"> Emerging platforms to build consensus on definitions and principles. Proposals to harmonise whole-life carbon assessment, and to emphasise the importance of comparable data. 	<ul style="list-style-type: none"> Agree on shared qualitative definitions and principles for near-zero emissions and resilient buildings. Develop common guidelines for codes, standards and public disclosure programmes aligned with such principles.
B2. Demand creation	<ul style="list-style-type: none"> Significant new intergovernmental commitments pave the way to increase demand for low-carbon materials via public procurement. 63 countries committed to improving air conditioner efficiency and establishing energy performance standards globally. 	<ul style="list-style-type: none"> Countries should work together to strengthen demand, via public procurement, through co-ordinated implementation of new commitments. Align policies and targets to accelerate clean heating and cooling adoption globally.
B3. Finance and investment	<ul style="list-style-type: none"> Several new assistance programmes were launched, yet overall financial support remains below the sector's needs. Annual global investment into energy efficiency of buildings has fallen in 2024. 	<ul style="list-style-type: none"> Collaborate to enhance financial assistance, focusing on de-risking private investment and building local capacity.
B4. Research and deployment	<ul style="list-style-type: none"> Research advances for sufficiency, heating, cooling and existing buildings. Testing of new cross-technology collaboration modalities. 	<ul style="list-style-type: none"> Agree research priorities that support the implementation of international commitments. Co-ordinated efforts on demonstration projects.
B5. Capacity and skills	<ul style="list-style-type: none"> Training opportunities from some initiatives. Launch of a dedicated initiative to support the Buildings Breakthrough. 	<ul style="list-style-type: none"> Methods, tools, guidance, and resources to systematically identify and address institutional and personnel capacity needs. Support to developing economies to develop, implement and upgrade building codes, including energy codes.

CHAPTER 1. INTRODUCTION

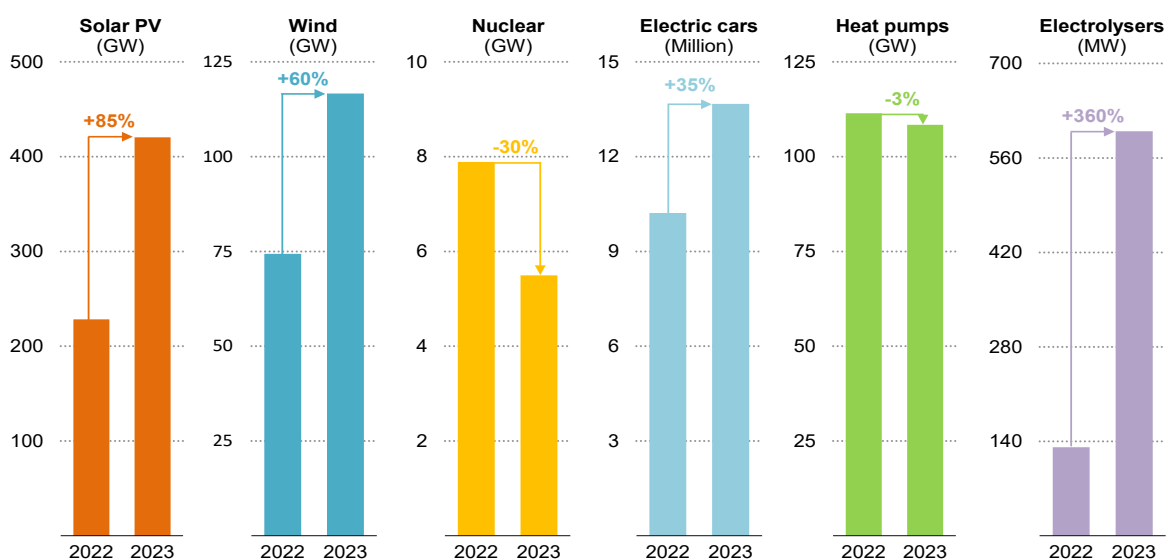
STATE OF THE TRANSITION

Investments in and deployment of certain clean energy technologies have surged since the [Breakthrough Agenda Report 2023](#). Total energy investment worldwide is expected to exceed USD 3 trillion in 2024 for the first time, with around USD 2 trillion set to go towards clean technologies – including renewables, electric vehicles, nuclear power, grids, storage, low-emissions fuels, efficiency improvements and heat pumps. This compares to around USD 1.8 trillion in investment in 2023 to these technologies.

In the power sector, clean electricity accounted for around [80% of new capacity additions](#) to the world’s electricity system in 2023, with more money going into solar PV than all other electricity generation technologies combined. Meanwhile, investments in battery storage are taking off and are set to reach USD 54 billion in 2024 as costs fall further, up from USD 40 billion in 2023. Global electric car sales are set to continue their robust growth in 2024, with [more than 1 in 5 cars](#) sold worldwide this year expected to be electric, up from 1 in 20 in 2020. Hydrogen electrolyser capacity additions grew by 360% in 2023, albeit from a very low base.

However, the IEA’s [latest assessment](#) shows that not all clean energy technologies progressed in 2023. Heat pump sales fell by 3% after 2 consecutive years of double-digit growth, as higher interest rates and inflation caused consumers to hold back on purchases, and nuclear capacity additions fell, although year-on-year capacity variations are less meaningful for a technology with long project development and execution times.

Figure 1.1 Annual deployment of selected clean energy technologies, 2022 and 2023



IEA. CC BY 4.0

Notes: GW = gigawatt; MW = megawatt; “Annual deployment” refers to sales or capacity additions; sales for electric cars.

Source: IEA (2024) [Clean Energy Market Monitor – March 2024](#)

[Progress is occurring faster](#) in those parts of the energy system for which clean technologies are already available and costs are falling quickly, such as for electricity

generation and passenger cars, but a full transition to net zero emissions will require decarbonising all areas of energy production and use. Targeted technology innovation and strong policies are needed to bring to market new clean technologies, in particular for those parts of the energy system in which emissions are harder to address, such as heavy industry and long-distance transport.

There has been some progress in clean energy innovation in recent years, particularly in battery chemistries, strengthening the market availability of technologies needed to reach net zero. In 2021, the IEA [assessed](#) that nearly half of the emissions reductions needed in 2050 to reach net zero would need to come from technologies not yet available on the market, and in 2023 an [updated assessment](#) found that this number has fallen to around 35%.

The clean energy transition is having a noticeable impact on macroeconomic indicators. In 2023, clean energy technologies added around [USD 320 billion to the world economy](#). This represented 10% of global GDP growth – equivalent to adding an economy the size of the Czech Republic to global output. Governments are recognising the economic opportunities and are boosting investment in [clean technology manufacturing](#), which grew by more than 70% in 2023 to around USD 200 billion. Investments in solar PV and battery manufacturing plants led the way, together accounting for more than 90% of the total.

However, this progress – while promising – is very uneven geographically. Global clean energy investment is highly concentrated in advanced economies and China, with only around 15% of clean energy investment flows going to emerging and developing economies (outside China), far below what is required to meet growing energy demand in many of these countries. Deployment is likewise highly concentrated, with advanced economies and China accounting for 90% of new solar PV and wind power plants globally, and 95% of sales of electric vehicles in 2023.

To stay on a net zero aligned path, as called for in the IEA's Net Zero Emissions by 2050 Scenario (NZE Scenario), the required increase in clean energy investment is particularly steep in emerging and developing economies outside of China, requiring a [fivefold increase](#) by 2030 relative to 2022 investment. The cost of capital remains one of the largest barriers to investment in clean energy projects and infrastructure in many of these countries, with financing costs at least twice as high as in advanced economies and China.

The impact of this imbalance can be seen on [global energy-related CO₂ emissions](#). Emissions increased by 410 million tonnes (Mt), or 1.1%, in 2023 – compared with a rise of 490 Mt the year before – taking emissions to a record level of 37.4 billion tonnes (Gt). Notably, however, this increase was weakened thanks to the continued expansion of solar PV, wind, nuclear power and electric cars that helped avoid greater use of fossil fuels.

Advanced economies saw a record fall in their CO₂ emissions in 2023 even as their GDP grew. Last year was the first in which at least half of electricity generation in advanced economies came from low-emissions sources like renewables and nuclear. In fact, the power sector shows the highest level of regional disparity, as reduced emissions in advanced economies were offset by increases in emerging and developing economies.

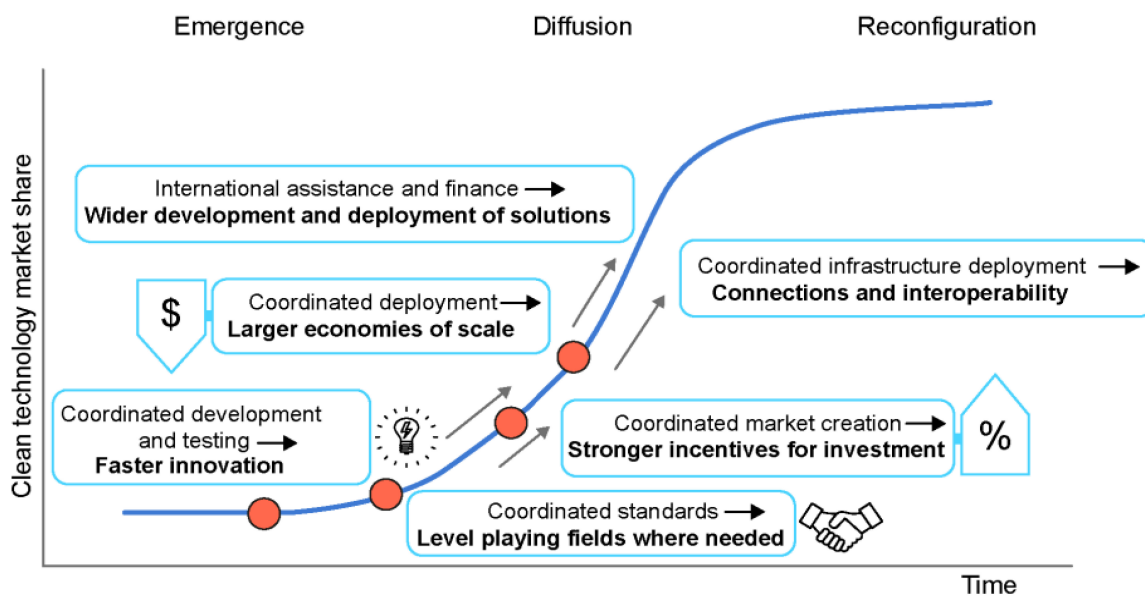
This imbalance underscores the need for greater support to emerging and developing economies to secure and share the benefits of clean energy transitions, while contributing to international climate goals. International collaboration plays a critical role in creating the conditions necessary for greater clean energy deployment and increased investment in these economies, which will be essential for clean energy transitions to succeed.

THE ROLE OF INTERNATIONAL COLLABORATION

International collaboration is vital to get the world on track with a net zero pathway. When countries co-ordinate their actions, they can change global markets in ways that no country can achieve individually. They can accelerate innovation, create stronger signals for industry to invest in new technologies, expand economies of scale, establish level playing-fields to avoid first-mover disadvantages, and ensure the interoperability of clean technology infrastructure across borders. The same goes for international collaboration with and within the private sector; all of this can help to make clean energy technologies more affordable and accessible to all. Without well-targeted international collaboration, the transition to net zero global emissions could be delayed by decades.

For international collaboration to be as effective as possible, it should be targeted at those areas where there are the greatest potential gains from co-ordinated action: innovation to drive down costs, deployment to reach economies of scale, demand creation to pull technologies to market, technical and financial support to reach wider adoption, and infrastructure co-ordination to ensure interoperability. It should be designed to address the challenges unique to each emitting sector, and should involve the participation of a critical mass of actors that are together capable of influencing the pace of the transition at the global scale.

Figure 1.2 How international collaboration can accelerate progress



Source: Adapted from Victor, Geels & Sharpe (2019), [Accelerating the Low Carbon Transition](#).

Dozens of valuable international initiatives exist to facilitate collaboration within sectors. Led by governments, businesses and/or civil society, these initiatives have increased both in number and diversity in recent years. Nevertheless, the potential to exploit further collaboration remains high. In all sectors, collaboration needs to extend beyond sharing of best practice towards deliberate alignment of action, and to include the participation of countries that together represent a majority of the global market.

Over the last 2 years, we have made recommendations on how international collaboration can achieve greater gains on the path to net zero emissions. This can take many forms,

such as collaboration on the development of international methodologies and standards for low-emission materials to prevent a fragmented global market; sharing best practices and commercialisation risk for R&D, leading to faster innovation; collectively improving the amount and accessibility of international technical and financial assistance to close geographic investment gaps; and creating platforms and dialogues for countries to establish more secure and resilient clean energy technology supply chains.

THE BREAKTHROUGH AGENDA

Since its launch at COP 26, the Breakthrough Agenda has become established as an annual collaborative process centred around the Conference of the Parties (COP) meetings of the United Nations Framework Convention on Climate Change (UNFCCC). It is supported by 59 countries representing over 80% of global GDP, and by over 150 initiatives working to enhance collaboration within major emitting sectors.

When the Breakthrough Agenda was first launched it covered five key emitting sectors where international collaboration could advance emissions reductions: power, road transport, steel, hydrogen and agriculture. Last year at COP 28, countries committed to two new Breakthroughs: buildings, and cement and concrete.

This Report provides an update on six of the seven sectors – power, road transport, steel, hydrogen, buildings, and cement. Together, these sectors account for around half of global GHG emissions. A [separate report on agriculture](#) is being published by CGIAR.

The Breakthrough Agenda is designed to make two important contributions to international collaboration on the clean energy transition: political commitments in each emitting sector to work together towards meeting goals that focus on tipping points at which clean energy technologies become the most affordable, accessible and attractive option; and a transparent process to track, focus and strengthen collaboration over time.

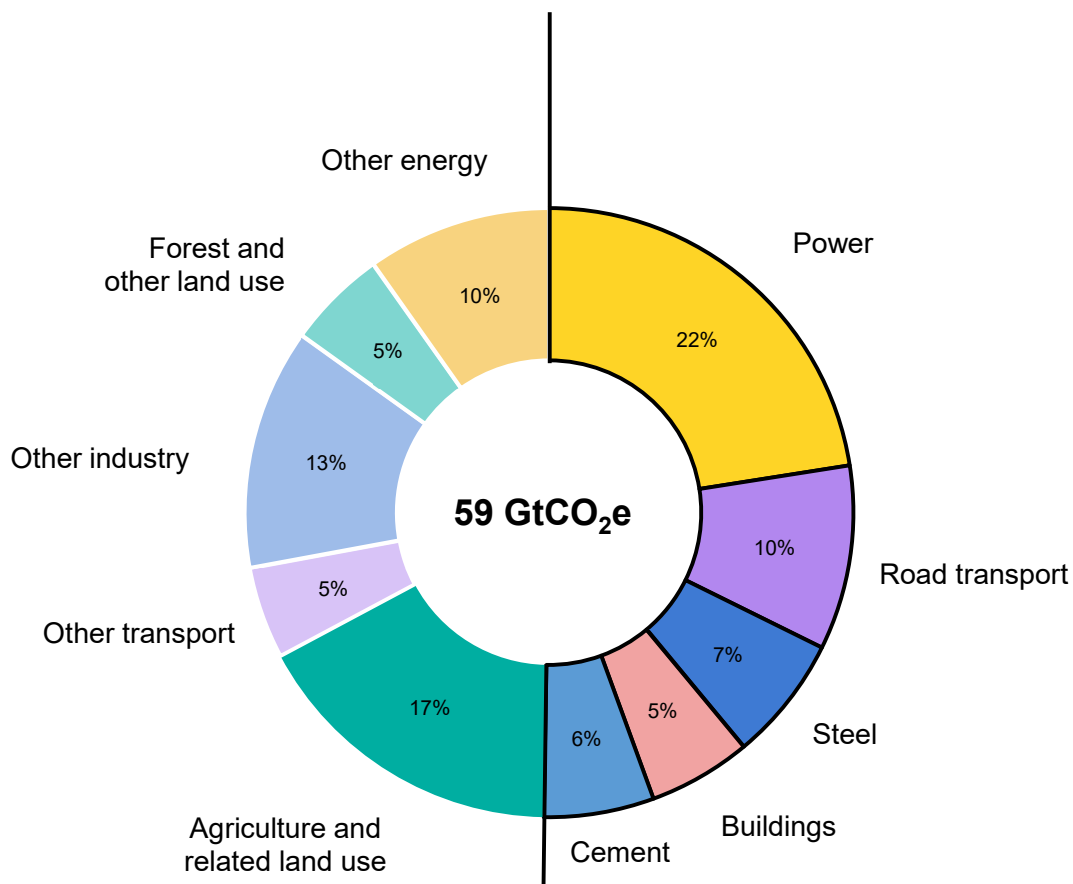
Each sectoral “Breakthrough” covered by the Agenda is led by groups of countries and sector-specific initiatives, who regularly meet throughout the year and collaborate with the private sector to advance efforts to achieve sector-specific goals. Countries within these Breakthroughs discuss and agree to priority actions that they will jointly take to meet those goals, which are usually implemented through existing initiatives. Landscape maps of the key international initiatives in each sector can be found in the Annex of this report and on the [Breakthrough Agenda website](#).

Breakthrough sector	Country co-leads	Breakthrough sector goal
Power	Morocco and the United Kingdom	Clean power is the most affordable and reliable option for all countries to meet their power needs efficiently by 2030
Hydrogen	The United States, India and the United Kingdom	Affordable renewable and low-carbon hydrogen is globally available by 2030
Road Transport	The United States, India and the United Kingdom	Zero-emission vehicles are the “new normal” and are accessible, affordable, and sustainable in all regions by 2030
Steel	Germany and the United Kingdom	Near-zero emission steel is the preferred choice in global markets, with efficient use and production established and growing in every region by 2030
Cement and Concrete	Canada and the United Arab Emirates	Near-zero emission cement is the preferred choice in global markets, with efficient use and near-zero emission cement production established and growing in every region of the world by 2030

Breakthrough sector	Country co-leads	Breakthrough sector goal
Buildings	France and Morocco	Near-zero emission and resilient buildings are the new normal in all regions by 2030
Agriculture	Egypt and the United Kingdom	Climate-resilient, sustainable agriculture is the most attractive and widely adopted option for farmers everywhere by 2030

Under the IEA’s NZE Scenario, the six sectors covered in this Report contribute to around three-quarters of cumulative emissions reductions by mid-century. International collaboration will be vital in helping achieve these emission reductions, alongside strong national actions.

Figure 1.3 Greenhouse gas emissions by sector, 2019



IEA. CC BY 4.0

Note: Emissions from hydrogen cut across several sectors.
 Source: IPCC (2022), [Climate Change 2022: Mitigation of Climate Change](#).

APPROACH TO THIS REPORT

In this Report we assess the current state of international collaboration across the six sectors, identify the most significant and urgent areas where this could be strengthened, and recommend steps to be taken to realise those opportunities. Our assessment, which spans from September 2023 to August 2024 and is the third such annual report, looks at progress made against our recommendations last year. It was informed by dialogues with

countries, businesses and organisations active in international collaboration in each sector. We considered any progress made through international efforts involving countries, companies and civil society stakeholders, and drew on expertise throughout the community to identify areas where greater and sustained collaboration is needed. We conducted interviews with a wide range of stakeholders to inform this assessment, including government officials, industry representatives, initiative secretariats, academic experts and civil society organisations, and considered the following factors:

- **Membership:** How has the membership of key organisations changed and is there adequate representation (geographic, market share, member type)?
- **Participation:** To what extent do members actively participate in these collaborations?
- **Focus:** Is joint activity focused on problems of the transition where there are the greatest potential gains from international collaboration?
- **Resources:** Are these collaborative activities adequately staffed and funded?
- **Ambition:** Does the stated ambition align with a 1.5 °C trajectory and are there outcome-oriented timelines to support this aim?
- **Progress:** What is the degree of progress made against both the aims of the collaboration, as well as the recommendations made in the previous Breakthrough Agenda Report?
- **Roles:** Are there clearly defined roles in the sectoral landscape to help reduce overlap and duplication?

Considering all these elements allows us to provide a holistic assessment of the progress being made against our recommendations from last year’s Report. The following assessment colours have been assigned to describe progress made towards each recommendation:

Assessment	Description
Minimal progress	Little to no progress has been made against the recommendation that was made last year, requiring urgent action from governments to increase their activity.
Moderate progress	Some progress has been made against the recommendation made last year, potentially including a limited set of governments or stakeholders, requiring greater focus in the coming years.
Good progress	Solid progress against the recommendation made last year, with broad inclusion of key countries delivering on action at a high level of ambition. Further efforts needed to get the sector on track globally.
Strong progress	The sector is now on track to deliver against this recommendation, with global action on track to meet the Breakthrough goal.

The Breakthrough Agenda Report assesses progress in international collaboration in relation to our judgement of what is needed to meet the internationally agreed Breakthrough goals. In many areas, countries, initiatives and businesses have agreed on “priority actions” to take together. While these are considered in the Report, the focus of the assessment remains on progress compared to our judgement of what is necessary, as summarised in the recommendations of the previous year’s Report. As such, the assessments of progress do not represent assessments of the performance or effectiveness of the initiatives *themselves*, but rather our aim is to provide a critical assessment of progress as related to last year’s recommendations, and not to report on routine activities that may be more or less directly related to the issue being assessed.

Whether international collaboration happens at all, and whether it is of sufficient quality, quantity and strength, depends primarily on the decisions of national governments – and where relevant, those of subnational governments and businesses. The onus for achieving effective collaboration is therefore on them, and not primarily on the initiatives themselves. Our assessment aims to make clear the extent to which those who need to collaborate are doing so, not to pass judgement on those who work to support them.

It is important to recognise that the Breakthrough goals themselves are highly ambitious, just as the goal of limiting global temperature increase to below 1.5°C is extremely challenging to meet. As such, our assessment of progress and recommendations in each sector point to areas of action that can contribute to meeting these highly ambitious goals. Since this is our benchmark for assessment, the progress rating can sometimes be low even when valuable steps forward have been taken in other ways.

The strongest co-ordination gains – faster innovation, stronger incentives for investment, greater economies of scale, level playing-fields – lie in the ability to scale up new clean technologies and solutions. It is for this reason that the Breakthrough goals are focused on technologies and solutions that would lead to a step-change in emissions reductions. Technologies for incremental emissions reductions continue to be important in national policy for reducing cumulative emissions, and can be appropriate as a focus for international co-operation, but the priority focus for international collaboration in the context of the Breakthrough Agenda is on the former.

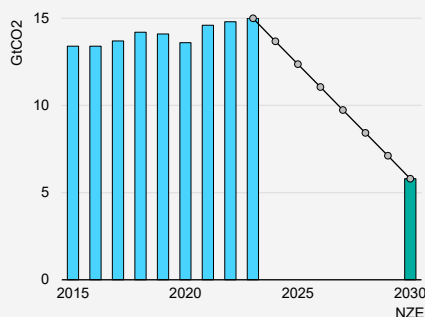
It should not be overlooked that progress in some areas can directly support progress in others, both within and between sectors. For example, the establishment of standards and definitions for ‘near-zero’ or ‘low-emissions’ (such as in steel, cement and buildings) directly supports the ability to create sufficient market demand and mobilise finance, and spills over into other sectors (such as hydrogen). These interdependencies underscore the importance of accelerating international collaboration across all areas in each sector.

CHAPTER 2. POWER

STATE OF THE TRANSITION

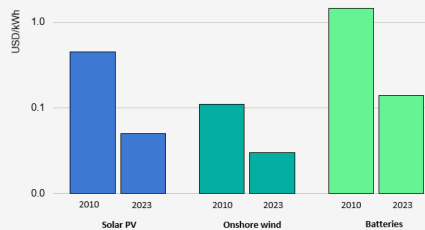
Among all clean energy technologies, those associated with power generation have seen the most progress since the Breakthrough Agenda was agreed: more solar PV was installed in 2023 than all other generation technologies combined. Power sector emissions have broadly plateaued as a result, but emissions reduction trajectories still show significant regional disparities. At COP 28, 200 countries made a landmark pledge to triple renewable energy capacity globally and double the global average annual rate of energy efficiency improvements by 2030, as well as accelerating efforts to phase down unabated coal power.

Emissions



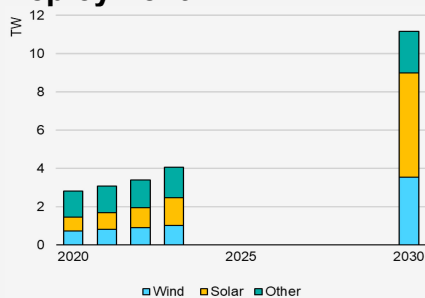
- Total power sector emissions reached 14.8 Gt CO₂ in 2023, despite record renewable power capacity. Emissions need to more than halve by 2030 to align with the IEA Net Zero Emissions by 2050 Scenario (NZE Scenario).
- The carbon intensity of electricity has decreased 1% since 2022 to 460 g CO₂/kWh, around a third of the annual rate of reduction in the IEA NZE Scenario.

Cost¹



- The average cost per unit of electricity for new projects has fallen by 88% for solar PV and 60% for wind since 2010. Prices for solar PV modules in 2023 declined by almost 50% from the previous year.
- Costs of storage have fallen nearly [90% since 2010](#), but there are significant differences between regions.

Deployment²



- [50%](#) more renewable capacity was added in 2023 than in 2022. Investment in nuclear increased to a 6-year high, and investment in storage reached all-time records – though less than 1% reached emerging markets and developing economies (EMDEs) outside China.
- Deployment is on track to meet just over half of what is needed by 2030 in the NZE Scenario. If solar and wind maintain their current growth trajectory, they will reach 5.4 TW installed capacity by 2030. Further action is therefore needed to reach the goal of tripling capacity to at least 11 TW by 2030.

¹ Source: IEA (2024), [Batteries and Secure Energy Transitions](#).

² IEA (2024), [IEA Renewables 2023](#).

STATE OF INTERNATIONAL COLLABORATION

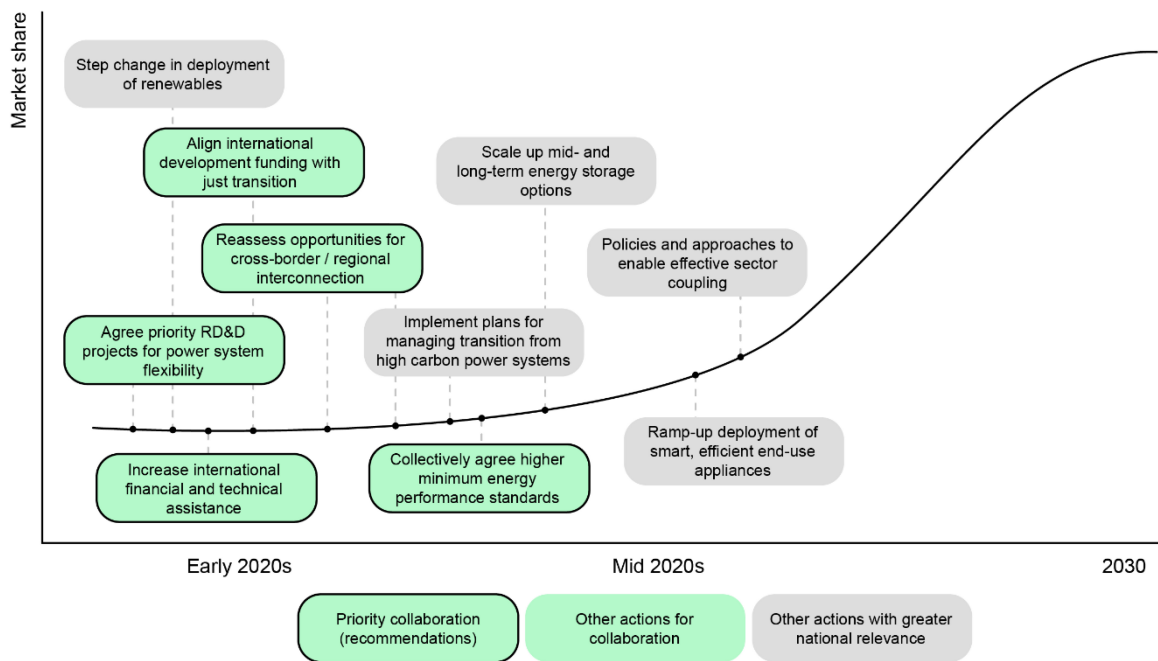
The landmark agreement at COP 28 to triple renewable energy capacity globally and double the global average annual rate of energy efficiency improvements by 2030, as well as to accelerate efforts towards the phase-down of unabated coal power, has given further global impetus to transition in the power sector, but more action will be needed to meet these goals. The COP 28 agreement stressed the need to enhance international collaboration initiatives to achieve the targets in the pledge, explicitly those outlined in the Power Breakthrough Agenda. In this chapter, we assess progress in international collaboration in the power sector over the past year against key recommendations from the [Breakthrough Agenda Report 2023](#). Our assessment focuses on the areas of finance, social engagement, research and innovation, infrastructure and demand management, all of which have been identified as having urgent needs for international collaboration in the power sector – and potential opportunities to create impactful change. Our assessment is summarised in the table below, and the following sections address each area of international collaboration in turn.

Area	What key progress has been made?	What more needs to be done?	2024
P1. Finance and investment	<ul style="list-style-type: none"> Global clean electricity investment rose to over USD 900 billion in 2023, far outstripping fossil fuels, but almost all the recent growth has been in advanced economies and China. Enough investment has been made in existing and projected supply chain infrastructure for solar PV panels and batteries – but not yet for wind – to put manufacturing on track to satisfy needs under the NZE Scenario by 2030. The pace of divestment away from coal power remains far off track, with coal consumption for power generation growing worldwide in the first 6 months of 2024. 	<ul style="list-style-type: none"> Technical assistance efforts need to be strengthened and immediately focused on financing and de-risking clean power value chain development in EMDEs, and understanding the systemic implications of the energy transition for finance, beyond deployment. International collaboration efforts should also target regional disparities in the cost of capital. The cost of capital needs to be reduced where it is currently high, including countries in Africa, Latin America and Asia where solar energy resources are abundant and the need for energy is growing. 	Minimal (↓)
P2. Social engagement	<ul style="list-style-type: none"> Several initiatives advanced their remits, including the Energy Transition Accelerator and the JETPs. A smattering of local dialogues and engagements throughout 2023. The number of people without access to electricity in sub-Saharan Africa is not decreasing fast enough: it is currently stagnant, after rising for 3 consecutive years. 	<ul style="list-style-type: none"> Further clarity on just transition best practices for fossil fuel-dependent countries (e.g. through JETP), including better alignment with bilateral initiatives. Develop strategies to strengthen local value chains, using local expertise and international best practice, and creating value for local communities. Enhance knowledge-sharing and collaboration towards financing the phase-out of fossil power generation and economic diversification. 	Minimal (=)

Area	What key progress has been made?	What more needs to be done?	2024
P3. Research and innovation	<ul style="list-style-type: none"> • Good progress from key stakeholders in advancing region-specific research and innovation in power, including in ASEAN, India and Brazil. • Increased participation from countries in key multilateral initiatives. 	<ul style="list-style-type: none"> • Demonstrate fully-fledged, highly decarbonised systems at scale and in different national contexts. Most focus is on individual technologies or assets, but very few transferable demonstrations of advanced electricity systems exist today, and almost none in EMDEs. • Develop and demonstrate technologies and processes for managing renewable-based systems that have largely phased out fossil fuel/thermal generation. • Demonstrate long-term/seasonal storage and balancing at scale, and prove value of different options to manage seasonal balancing in different national conditions/environments. 	Moderate (=)
P4. Infrastructure	<ul style="list-style-type: none"> • Moderate increase in engagement in regional bi- and multilateral initiatives. • Improved knowledge-sharing between TSOs, DSOs and regulators across borders. 	<ul style="list-style-type: none"> • Beyond interconnection, there is an immediate need for countries to enhance efforts in co-ordinated energy planning across borders, including renewable scale-ups, electrification plans, and grid planning. Very few economies today score highly in joint grid and low-carbon generation planning. • Enhance efforts in developing power pools and power pool integration and include longer-term grid resilience and adaptation in infrastructure planning. • Empower regional regulatory institutions to achieve the full benefits of cross-border power trading. 	Moderate (=)
P5. Demand management and creation	<ul style="list-style-type: none"> • Increased membership and advanced remit of multilateral standards and efficiency initiatives. 	<ul style="list-style-type: none"> • Most claimed progress is in MEPS for technologies that deliver marginal gains today (LEDs, even electric motors). Further efforts are needed to extend the range of products covered by MEPS. • Extend standards to cover a larger share of the global market, particularly for energy-intensive loads. Even where best available technologies (BAT) and MEPS instruments are adequate, they only impact a small share of the market. • Beyond adopting MEPS, international co-operation effort is needed to create an enabling environment for efficient appliances, which includes international standards for technology neutral metrics, labels, and eventually MEPS, as well as for interoperability and digital rules and standards. 	Moderate (↑)

Notes: The arrows indicate relative progress compared to last year's assessment in the Breakthrough Agenda Report 2023. "↑" indicates an improved assessment; "↓" indicates a downward assessment; "=" indicates the same assessment.

Figure 2.1 Critical path to 2030 for the power sector



IEA. CC BY 4.0

Source: [Breakthrough Agenda 2023](#)

IMPROVE THE EFFECTIVENESS OF TECHNICAL AND FINANCIAL ASSISTANCE FOR THE POWER SECTOR TRANSITION

OVERVIEW

Last year, we recommended that donor governments, working with key institutions and funds, should ensure that international support is available at better terms, including lower interest rates for loans, concessional finance, or grants at early stages of project development and investment for EMDEs in particular. That includes creating de-risking mechanisms, tailored to the countries’ respective contexts, in order to help mobilise private sector investments. Overall provision of resources should be increased, particularly for technologies that have not achieved commercial maturity.

WHAT PROGRESS HAS BEEN MADE?

Global clean electricity investment rose to over USD 900 billion in 2023, but almost all the recent growth has been in advanced economies and in China: other EMDEs account for less than 20% of power investment. While electricity demand soared in 2023, growing at the [highest annual rate](#) since 2007, investments aimed at enhancing grid infrastructure in EMDEs other than China have remained stagnant. Surging electricity demand in these countries is preventing a fall in coal demand in power generation, and this is [expected to continue](#) into 2025. These trends highlight a significant disparity in the energy transition between advanced economies and those in which energy systems are still being developed.

An important step towards greater international financial co-operation was the establishment at COP 28 of a [task force of experts](#) convened by governments to explore innovative sources of finance for clean energy, which is considering a range of taxes and levies to redirect funding towards clean energy technologies, including those in power.

Among key activities from Multilateral Development Banks (MDBs), the Asian Development Bank (ADB), Global Energy Alliance for People and Planet (GEAPP), and the Monetary Authority of Singapore announced their intent to establish a [blended finance partnership to accelerate energy transition at scale in Asia](#), aiming to raise USD 20 billion in concessional and commercial finance. The International Finance Corporation (IFC), in partnership with Social Investment Managers and Advisors LLC and other financiers, have reached the first close of a USD 150 million solar green bond, which will finance solar projects that power productive economic uses throughout Africa. GEAPP and IFC [will make](#) first investments in the solar green bond under a new partnership, while the Japan Bank for International Cooperation and Australia's Clean Energy Finance Corporation [signed a Memorandum of Understanding \(MoU\)](#) to promote co-operation on renewable energy and electricity grids, among other priorities.

Significant activities by other funders included Breakthrough Energy Catalyst [announcing](#) EUR 240 million of funding commitments to accelerate high-impact climate solutions in Europe, which to date include long-term power storage and zero-carbon power and steam facilities. The Climate Investment Funds (CIF) [approved USD 85 million](#) to launch the North Macedonia coal phase-out and [endorsed](#) Kenya's USD 70 million plan for 100% clean energy.

WHAT MORE NEEDS TO BE DONE?

Immediate efforts are needed in financing and de-risking renewable energy deployment in EMDEs, tailoring finance delivery vehicles better to real needs, and understanding the implications of the energy transition for finance. The concept of de-risking dominated many of the international discussions on finance and investment in 2023.

The gap in finance needed to meet the objective of tripling renewable capacity varies greatly by country and technology. For solar PV, annual capacity additions need to increase 35% by 2030, while for wind they would need to double. For hydropower and other renewables, annual additions need to triple. Further efforts are especially needed on technologies that are further behind.

Today, 90% of renewable capacity is in Group of Twenty (G20) countries, which typically have more robust financing and existing platforms for international collaboration. Moreover, renewable energy expansion in 2023 was heavily concentrated in just ten countries that are responsible for 80% of global annual additions. A much faster rate of deployment is needed, particularly in EMDEs with fast growing electricity demand, those that rely heavily on coal, and in lower-income EMDEs that today rely on hydropower, which – given its limited potential for growth – need to compensate by investing in other renewable technologies. There is a growing need to broaden the clean energy generation portfolio beyond wind and solar support to include other technologies like geothermal systems or nuclear power. Nuclear power investments are generally not included in the mechanisms mentioned above. The International Atomic Energy Agency is collaborating with around 30 “embarking” countries, many of which are EMDEs, particularly in Africa, as they progress through various stages of programme implementation. These countries lack access to climate finance or MDB loans, despite the COP 28 Global Stocktake recognising nuclear power as one of the low-carbon technologies that require accelerated deployment.

There is a pressing need for the international finance community to scale up finance flows from all sources into EMDEs, including through increasing public commitments channelled through direct investments, blended finance, and other instruments such as grants and subsidies to help reduce the cost of capital in developing economies. Given the need to scale up finance across the board, exploring and developing more innovative sources of finance should be a key priority for international collaboration. For instance, environmental, social and governance (ESG)-related investment funds today have over USD 2.5 trillion under management, but only a negligible amount flows to EMDEs. Vehicles like [cross-border guarantees](#) may be able to mobilise 6-25 times more finance than traditional loans, and could have a large impact in EMDEs, given their less stable and favourable financial conditions. More [empirical evidence](#) is needed, however, to fully validate their promise as a tool to mobilise private capital. Green bonds, sustainability-linked loans, project aggregation platforms, and voluntary carbon markets, are other under-utilised tools to draw international investment capital at scale in support of credible and robust transition plans.

Clarity is a key requirement for investors: Achieving deployment targets for the power sector will require clarity on the size and means of investment and the investment vehicles available, as well as on any interconnection delays and transmission infrastructure upgrades. To increase finance flows into EMDEs in particular, much greater volumes of concessional finance need to be made available through MDBs, multilateral finance initiatives and donor countries to mitigate country and project risks, enhance credit quality, and improve financing terms, thereby attracting private investors to clean power projects. International assistance with regulatory reforms to improve capital markets and financial systems in EMDEs will be vital to scale up domestic private investment in clean energy.

Nevertheless, more capital under more attractive conditions will not be sufficient, and further efforts are needed to enhance the clarity, level of long-term commitment and stability of transition policy, regulatory and planning frameworks. Private sector organisations continue to emphasise the need for strong nationally determined contributions (NDCs) as investment signals, and stable policy environments to reduce the risks associated with their investment decisions, including effective power planning, clear targets, capacity-building, and operational capabilities. International efforts can be an enormous help to increase target transparency and collective ambition. For instance, the Renewables in Latin America and the Caribbean (RELAC) initiative involves 16 countries that aim to achieve a collective target of 70% renewable energy in their electricity mix by 2030.

Given the growing range of initiatives, there is a pressing need to map out best practice principles and opportunities for scaling up investment through development finance institutions, multilateral initiatives and MDB programmes. Rationalising and simplifying the breadth of options available to stakeholders in the power sector would go a long way towards drawing in finance flows.

RECOMMENDATION P1 HAS BEEN UPDATED AS FOLLOWS:

Donor governments, working with key institutions and funds, should ensure that international support is available at better terms, including grants at early investment stages for higher-risk projects. That includes creating de-risking mechanisms, tailored to the country's respective contexts – particularly for EMDEs – and technical assistance for finance and regulatory reforms across all clean energy technologies. This should focus on avoiding lock-in to high-carbon power generation, and instead aim to streamline its phase-out, all of which can help to mobilise private sector investments. Overall provision of resources should be significantly increased, particularly for technologies that have not achieved commercial maturity. International finance institutions should provide technical

guidance to countries that explains and simplifies the breadth of financing streams available to stakeholders.

IMPROVE TARGETED SUPPORT FOR LOCAL JOBS, SKILLS AND INVESTMENT IN FOSSIL FUEL-DEPENDENT COMMUNITIES

OVERVIEW

Last year, we recommended that donor governments and MDBs should work together to align development funding more strongly with targeted support for local jobs, skills and investment, towards the aims of repurposing of fossil fuel assets and achieving economic diversification and environmental restoration in fossil fuel-dependent regions and communities. We also stressed the need for civil society, governments and industry to scale up their contributions towards creating international centres of expertise on the just transition within existing institutions.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been minimal progress made against our recommendation of last year. While some existing initiatives continue to expand their activities, there has been little increase in targeted support for local jobs and skills.

Little progress has been made to date to align and co-ordinate just transition finance and activities between country platforms, multilateral initiatives, bilateral efforts and official development assistance (ODA). Progress has also been poor in increasing transparency and data availability on concrete activities, and some key initiatives have not yet reached adequate scale and momentum.

Strong and growing interest in country-level platforms has been seen in the past year, as well as increased scrutiny of existing multilateral initiatives and [frameworks](#). The Just Energy Transition Partnerships (JETPs) were set up to provide international support in tackling the social impacts of the energy transition, including through enhancing training and job opportunities for affected workers, promoting economic diversification and fostering innovation. Notable steps forward include Indonesia's JETP launching its Comprehensive Investment and Policy Plan in November 2023, which charts a course for the country's power sector, and includes a range of ambitious milestones including achieving net zero emissions in power generation by 2050. However, out of the USD 9.7 billion earmarked to finance the initiative, 0.2% (USD 200 million) is destined to finance just transition initiatives such as capacity-building, scoping studies or pilots. Meanwhile, in the same month, South Africa's cabinet approved its JETP implementation plan, while Viet Nam launched its Resource Mobilisation Plan, the first milestone towards JETP implementation.

At present, there has been little progress in concrete commitments and disclosure to be confident that enough finance is flowing into JETPs towards supporting economic diversification beyond coal. Finance that is truly [additional](#), including concessional finance, has yet to materialise, and there is insufficient access to in-country capacities. Beyond JETPs, there has been little progress in supporting economic diversification in coal-dependent communities from multilateral banks and other initiatives, which we highlighted as a key priority in our 2023 report.

As the IEA has highlighted, there is more than [USD 1 trillion of capital](#) yet to be recovered from today's coal plants, and the need for co-ordinated technical assistance and capacity-

building in transitioning away from coal became increasingly prominent in 2023. In particular, a number of forums have stressed the need to co-ordinate just transition assistance by donors, development agencies and public development banks with multilateral initiatives like the JETPs, emerging country platforms, and the myriad bilateral initiatives in place. In particular, the mechanisms for aligning wider bilateral development co-operation and bilateral ODA expenditures with JETP mechanisms and targets remain unclear – particularly given these are far from streamlined. Viet Nam’s JETP support, for instance, has 11 International Partners Group (IPG) countries,³ as well as the ADB and the CIF contributing through more than 40 financing facilities. Indonesia’s JETP involves 10 IPG countries, CIF, the World Bank and the ADB, spread across more than 50 funding packages.

WHAT MORE NEEDS TO BE DONE?

To ensure a just transition in the power sector, it will be crucial to accelerate learning from successful projects and to use this knowledge to better target resources towards a greater number of fossil fuel-dependent regions. In particular, there is enormous potential to expand activity into coal-intensive regions. To date, 43 countries have pledged to phase out coal and set a date for achieving this aim. However, they cover only 16% of the global coal fleet. Countries accounting for around 70% of coal consumption in power do not have specific commitments to decrease coal use, despite having net zero pledges.

International collaboration has a central role to play in accelerating the transition from fossil-fuelled power in a just manner. Mainstreaming strategies for the creation of jobs and economic diversification activities into financial development assistance can greatly increase acceptability and create momentum to accelerate the transition. While there are a growing number of activities addressing the socio-economic impacts of the energy transition, these efforts are still in their early stages. Consequently, large-scale, impactful successes in terms of regional transitions have not yet been observed. International assistance is also needed to mainstream just transition across national plans, as only 38% of NDCs today explicitly reference just transition principles.

Social dialogues are [critical](#) for a just transition in energy, and should increasingly be viewed as a policy area in their own right, as they promote mechanisms for inclusion of key stakeholders, including workers and employer’s organisations at all levels. Last year saw a slowdown in just transition dialogues, though there were some notable exceptions. The first of the United Arab Emirates Just Transition Work Programme’s planned biannual dialogues took place in Bonn in June 2024, stressing the need for whole-of-society approaches to the energy transition. The European Committee on Regions also organised a [Multi-level Dialogue on Just Transition](#). Many more similar dialogues are needed in other regions, particularly those with emissions-intensive power sectors.

Multilateral just transition initiatives like JETPs would greatly benefit from applying lessons emerging from their initial activities. Further clarity is needed on roles and responsibilities that are well adapted to the country’s local context. Independent monitoring and evaluation would be beneficial to cement credibility and accountability and gain momentum for JETP activities. Most importantly, the provision of finance will need to be scaled up and financing conditions improved for JETPs to deliver at scale. For instance, [the Climate Policy Initiative \(CPI\)](#) highlights that Indonesia has no readily accessible guarantee facility, and the Government of Indonesia faces risks due to the high cost of meeting specific provisions across the number of intermediaries, as well as foreign exchange risk. Moreover, the size

³ The JETP IPG consists of Canada, Denmark, the European Union, France, Germany, Italy, Japan, Norway, the United Kingdom and the United States.

of sovereign guarantees required may place a high burden on its fiscal balance, and procurement limitations might preclude financing smaller projects, which could leave out many (typically smaller) activities encouraging a just transition.

While the more active discussion and engagement of just transition issues at the international level is positive, local regulatory and technical expertise needs to be strengthened to channel and absorb the knowledge-sharing and capacities being developed. The latter remains a blind spot across JETPs: building and strengthening local institutions, supporting value chains, and activities aimed at ensuring a just transition, are not yet adequately financed.

RECOMMENDATION P2 HAS BEEN UPDATED AS FOLLOWS:

Donor governments and MDBs should work together to more strongly align development funding with targeted support for local jobs, skills and investment, for the repurposing of fossil fuel assets, economic diversification, and for environmental restoration, in fossil fuel-dependent regions and communities. Efforts should be made to ensure consistency with regional priorities and needs, and to ensure new clean energy infrastructure benefits and creates value for local communities. Clearer, more transparent, and fully independent monitoring, including progress reporting on social outcomes, should be incorporated within Just Energy Transition Partnerships, to build mutual confidence in implementation. Institutional capacities should be reinforced to be able to absorb the social components of clean energy finance programmes. Civil society, governments and industry should contribute to creating international centres of expertise on the just transition, within existing institutions.

ACCELERATE THE DEPLOYMENT OF PRIORITY PROJECTS SHOWCASING NOVEL TECHNOLOGIES AND SOLUTIONS ACROSS MULTIPLE REGIONS

OVERVIEW

Last year, we recommended that governments should work through relevant initiatives to accelerate the identification and implementation of suitable demonstration projects, resource them appropriately, and ensure high-quality knowledge-sharing structures are put in place. We also emphasised that to facilitate knowledge-sharing among a wider set of countries and stakeholders, close collaboration with regional research and innovation networks will be required.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress against the recommendation made last year. The power sector has arguably made the most progress in terms of demonstrating and deploying clean energy technologies at scale, which our assessment takes into account. A number of countries have made efforts to demonstrate net zero power systems within their jurisdictions. However, most of the know-how and demonstrations of highly decarbonised power systems at scale remain confined to advanced economies, where conditions and learning are not easily transferable to other contexts. Moreover, most national pledges for net zero include the power sector achieving near-zero emissions well before other sectors, which sets a higher bar for efforts in the space. The overall result is that further effort is required, particularly to increase the number and scale of transferable

demonstrations of net zero power systems, develop long-term balancing solutions for high penetration of variable renewables, and develop technology innovation roadmaps and system planning adapted to the regional needs of EMDEs.

The European Investment Bank Group partnered with Mission Innovation (MI) to launch an initiative to share its expertise on financial instruments that can support early-stage innovations. Within MI initiatives, the Green Powered Future Mission (GPFM) launched a monitoring exercise for innovative national pilot projects through three continental Task Forces, and its first report compiled 80 pilot projects that are fully aligned with the mission's objectives. GPFM also released a demo version of a knowledge-sharing platform ("GPFM Toolbox"), designed as a regularly updated online resource to promote sharing best practice, outcomes of demonstration projects and translatable results. GPFM also progressed with its "five pilot demonstrations in five continents" initiative – all demos are planned to be launched by the end of 2024, and a series of [webinars](#) is underway to share their emerging findings. MI also launched the "Sunlight to X" Initiative to promote efficient and scalable solar fuel production pathways. Solar fuels, while still at the early prototype stage according to the IEA [Clean Energy Technology Guide](#), may play a role in producing synthetic fuels and industrial products.

Membership of other key power sector collaborative initiatives also grew – Brazil joined the International Smart Grid Action Network (ISGAN), an IEA Technology Collaboration Programme, thereby expanding ISGAN to 28 members across 6 continents. ISGAN also launched its first Lighthouse Project, "Electricity Network Planning and Implementation under Uncertainty for the Clean Energy Transition", focused on assessing the critical role of distribution grids in the energy transition. Breakthrough Energy Fellows, an initiative of Breakthrough Energy aimed at providing direct funding and hands-on support to researchers, launched a Regional Hub in Southeast Asia. A new multinational innovation centre, "Electric Power Innovation for a Carbon-free Society", was launched by the Global Power Systems Transformation Consortium (G-PST). Led by Johns Hopkins University, the centre comprises 26 leading research groups across 8 universities in 3 countries to advance computing, engineering and policy methods towards 100% renewable, net zero power grids. G-PST also held a "Community of Practice" event series and expanded technical assistance activities globally. The African School of Regulation (ASR), which aims to become a centre for excellence in research and training on energy regulation in the continent, was officially launched during an event at the Africa Climate Summit in Nairobi. A few weeks later, the ASR was formally recognised by the African Union and was included in the Zanzibar Declaration, which calls on pan-African energy organisations to support the ASR.

WHAT MORE NEEDS TO BE DONE?

The focus of the majority of late-stage innovation, demonstrations and scale-ups remains on individual technologies or assets. Beyond selected initiatives like GPFM, and a smattering of multilateral demonstration projects, very few full-scale, transferable demonstrations of highly advanced electricity systems exist today – and almost none in EMDEs.

System-level innovation should be a higher priority within international initiatives for power sector research and demonstration. As the penetration of wind and solar increases, so does the complexity of balancing the system over longer periods of time, from several hours to several days. This includes ensuring that generation is adequate during periods of high demand and low generation from wind and solar, but also improving key grid quality determinants like frequency and voltage stability. Long-term or seasonal storage and balancing need to be demonstrated at scale, and there is also a need to prove the value of

different options to manage seasonal balancing in different national conditions and environments, particularly in countries with weaker grids and in EMDEs. At the other end of the spectrum, system-level innovation is needed to develop technologies and solutions that support the management and operation of systems with low levels of system inertia. Inertia is a key property of grid stability in conventional grids and is abundant in systems with thermal power plants, but wind and solar only contribute marginally to it.

Beyond demonstrating and piloting new clean energy technologies, additional research is essential to assess the viability of repurposing coal and gas-fired plants to provide services to decarbonised systems, such as supporting system inertia and stability. This could potentially reduce the cost of integrating wind and solar, while remaining compatible with a net zero trajectory. Retrofitting existing coal plants to convert them to geothermal, nuclear or bioenergy, are key options that require further research and assessment, and that would benefit from knowledge-sharing and experience gained through collaborations – particularly in EMDEs. Continued efforts are needed from the international community to demonstrate and share knowledge in emerging renewable generation technologies beyond solar and wind – particularly in enhanced geothermal systems, tidal and wave power.

RECOMMENDATION P3 HAS BEEN UPDATED AS FOLLOWS:

Governments should work through relevant initiatives to accelerate the identification and implementation of suitable demonstration projects across a broad range of power systems contexts, with a greater focus on deeply decarbonised systems that require long-term energy storage and balancing. Governments should resource these demonstrations appropriately and ensure high-quality knowledge-sharing structures are put in place. To facilitate knowledge-sharing among a wider set of countries and stakeholders, close collaboration with regional research and innovation networks will be required.

REASSESS OPPORTUNITIES FOR CROSS-BORDER ELECTRICITY TRADE, ACCELERATED BY ENHANCED TECHNICAL SUPPORT

OVERVIEW

Last year, we recommended that governments should work together to reassess the opportunities for cross-border and regional power interconnection and smart grids to support the transition to clean power systems. This should include opportunities that have been previously considered but not taken forward, given that technology is improving, costs are falling, and there is an increasing need for system flexibility. We also emphasised that countries and investors should support international efforts to identify top regional priorities for interconnection, and to replicate successful approaches to technical agreements.

WHAT PROGRESS HAS BEEN MADE?

We assess that countries have made moderate progress towards the achievement of this objective. Minimal progress has been made in physical interconnection capacity – totalling around 6 GW of new high-voltage DC capacity worldwide, only a small proportion of which is across borders. The vast majority of cross-border projects are in Europe: two European projects accounted for two-thirds of total investment. Progress was also made in developing training and capacity-building initiatives. However, outside of these projects,

more substantive, meaningful progress towards more co-ordinated cross-border infrastructure and trade has not been made.

Electricity trade across borders is a key enabler of the net zero transition. Interconnected grids can improve overall grid stability, increase energy security and enhance flexibility to both host a higher share of variable renewables, and electrify a higher share of final energy demand – both cornerstones of the NZE Scenario. Better interconnections allow countries and regions with excess clean energy to transfer it to areas with higher demand or less available capacity. Electricity trade can also lead to overall cost savings and revenue generation across the interconnected region, helping finance in-country deployments and reducing the cost of achieving net zero objectives.

To develop successful cross-border electricity trade, countries must establish and harmonise frameworks for regulating and disclosing technical and economic parameters related to national power markets and physical assets. Addressing these aspects from the outset can expedite trade agreement negotiations. Beyond the synchronous interconnected grid of continental Europe – the largest example of a cross-border system in the world – there are several models in place around the world at various degrees of advancement. The Central American Electrical Interconnection System (SIEPAC) connects 50 million consumers in six Central American countries. The SINEA initiative to further interconnection in Andean countries achieved a milestone last year with the approval of an interconnection between [Ecuador and Peru](#). Africa has 5 regional power pools, connecting a total of 40 countries, albeit with more limited capacities. The latest West African Power Pool annual report puts the interconnected system at 24 GW installed capacity, with 11% of all energy generated exchanged across borders in 2022.

Interconnections delivered on time and within a market framework are few and far between. For instance, a Bay of Biscay interconnector between France and Spain announced in 2017 and planned for 2025 is now expected for 2028, with an expected 63% increase in project costs. An interconnection line between Canada and the United States (Avangrid) was interrupted for 2 years following local opposition, while the interconnection between South Africa and the Democratic Republic of the Congo has not yet started construction a decade after the signing of the bilateral agreement between the countries.

Marginal progress against our recommendation was seen last year, mainly concentrated in the initiatives named above. Progress has centred on increased international engagement, with the launch of new best practice guides and training courses, but there has been little progress on new negotiations, deals or electricity trade arrangements across borders. A notable exception was under the Support for the Regional Energy Integration of the Southern Cone (SIESUR) initiative in South America, where the eight participating countries delivered a roadmap to achieve interconnection. At COP 28, the Green Grids Initiative (GGI) launched its [Principles for Interconnectors](#). Designed around the full life cycle of an interconnector, they focus on best practices from the initial infrastructure concept, through to its development, operation and decommissioning. GGI also held in-person regional training courses in Latin America and Asia Pacific on the [Electricity Transition Playbook](#), a tool for developing holistic electricity network transformation strategies that are aligned with the COP 28 pledges. The Regulatory Energy Transition Accelerator published [Institutional Architecture for Regional Power System Integration](#), led by the IEA in collaboration with the International Renewable Energy Agency (IRENA) and the World Bank.

The Utilities for Net Zero Alliance was also launched at COP 28, bringing together 32 utilities serving 350 million customers. Their [roadmap](#) to 2030, launched during the 14th IRENA Assembly, is aimed at mobilising capital and de-risking grid cross-border

investment, and building capabilities and talent. The UN's Council of Engineers for the Energy Transition launched its [Best Practices](#) for Variable Renewable Energy Integration. This includes a list of replicable examples covering several dimensions, including regional grid interconnection, proactive energy planning, and integration measures like forecasting and energy storage technology. Among the few areas of progress towards enhancing cross-border trade, Singapore and Indonesia signed a MoU last year to strengthen cross-border electricity trade, aimed at developing enabling regulation and facilitating commercial projects. Similarly, the second phase of the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP) kicked off in June 2024, with plans for multilateral cross-border power trade of up to 200 MW via existing infrastructure.

Resilience in grid infrastructure rose to the forefront in 2023, with blackouts capturing headlines in Argentina, Bangladesh, Brazil, Nigeria, Kenya, Pakistan and South Africa – yet there are few international partnerships focused on strengthening institutional capacities to develop, enforce and monitor regulatory frameworks [related to grid resilience](#). A step in this direction in 2023 was the Sharm el-Sheikh Adaptation Agenda's launch of [2030 adaptation outcomes for infrastructure](#). This lists a series of objectives for infrastructure development that incorporate adaptation concerns, such as better incorporation of grid resilience to extreme events and varying patterns of demand, and a call for increasing grid and battery investment by 2030.

WHAT MORE NEEDS TO BE DONE?

In order to fully realise the opportunities of greater international connectivity between electricity grids, efforts need to go beyond resolving technical issues around interconnectors. Political engagement needs to take place at a high level between countries, providing a strong mandate to officials to advance technical negotiations and agree plans for implementation. Successfully interconnecting regions requires a much broader range of stakeholders to be engaged in these dialogues beyond grid utilities, including impacted local and regional governments, merchant investors, renewable energy developers and civil society. While agreements on principles and best practice guidelines are an important foundation, an increased focus on deal-making is needed to bring progress in this area in line with the Power Breakthrough goal.

Beyond deploying interconnectors, in order to maximise gains from electricity trade, there is a need to enhance co-ordination efforts across borders between grid owners and operators, utilities, regulators and other key stakeholders, across several dimensions. First, to co-ordinate cross-border infrastructure development and regulatory and market frameworks for electricity trade; second, to co-ordinate renewable generation and grid expansion on both sides of shared borders; and third, to plan for grid expansions and expansion of other low-carbon energy infrastructure, particularly for hydrogen.

Integrating the deployment of interconnectors in larger national grid-planning processes is essential: interconnectors can only be successful if national grids on both sides have enough capacity to manage and transport the electricity to where it is needed. Many jurisdictions where interconnections can deliver high benefits, such as EU member states, sub-Saharan African countries, Central American countries and Association of Southeast Asian Nations (ASEAN) countries, have already developed institutional capacities to co-ordinate and expand cross-border interconnections capacity, or platforms to facilitate electricity exchange. The European Transmission Network Operators Organisation for Electricity (ENTSO-E), for instance, has a long-standing Ten-Year Network Development Plan, which identifies priority projects across borders based on cost-benefit analyses across the European system. In 2022 for instance, 88 GW of potentially beneficial capacity

increases across 65 borders were identified. Phase II of the ASEAN Plan for Energy Cooperation (APAEC) is underway, and includes a feasibility study of bilateral and multilateral power trading platforms for the region, as well as assessing the need for and feasibility of new regional institutions for implementing multilateral power trade, and developing a system for settling disputes. Elsewhere, however, such exercises are in short supply.

Cross-border co-operation around electricity trade is also needed. While some power pools, like those in Europe, are highly integrated, cross-border trade is very uneven elsewhere. Among African power pools, the Southern Africa Power Pool trades 20% of electricity consumption across borders, the West Africa Power Pool 11%, and the East Africa Power Pool around 2%.

Planning interconnections together with expansion of renewable and other clean electricity generation is also emerging as a key priority for international collaboration. A number of regions have seen a significant mismatch between supply and demand and difficulty in co-ordinating procurement across regions and forming partnerships at scale. Sourcing equipment can be a barrier: grid equipment supply chains are tight, and they require reserving equipment and capacity well in advance. Lead times for new overhead transmission lines in Europe and the United States today average around 10 years, and this lead time can double when the interconnection straddles a border. Given that new renewable generation can come online in around 3 to 5 years, in the case of solar PV and onshore wind, rapid growth of renewables in one country can create transmission bottlenecks for its neighbours. This can delay cross-border electricity trade negotiations, and increase the costs and risks associated with transforming power systems. Enhanced co-ordination between neighbouring countries is therefore needed to reduce lead times. The ASEAN Power Grid initiative under APAEC, for instance, responds to this challenge by incorporating measures to enhance joint grid and renewables planning in the region; while the [African Continental Master Plan](#) aims to bring together over 100 stakeholders to co-ordinate generation and transmission planning. All in all, however, very few economies today score highly in joint grid and low-carbon generation planning.

International engagement is also needed to mainstream longer-term grid resilience and climate adaptation in infrastructure development. The knowledge and infrastructure gap between EMDEs and advanced economies with regards to grid resilience is enormous: For instance, high wind speeds are between 6 and 11 times more likely to cause an outage in Bangladesh, than they are in the United States. This need is consistent across transmission system operators (TSOs), distribution system operators (DSOs), utilities, government agencies and MDBs. While most MDBs have advanced programmes for direct support for projects that are focused on adaptation (e.g. weather-proofing climate-vulnerable power equipment), MDBs do not often value adaptation benefits when the increase in resilience comes from standard investments (e.g. investing in power equipment that is more climate resilient), often trading resilience off against mitigation benefits rather than valuing those that deliver combined 'win-win' measures.

RECOMMENDATION P4 HAS BEEN RESTATED AS FOLLOWS:

Governments should work together to reassess the opportunities for cross-border and regional power interconnection, increase their engagement with international efforts to identify top regional priorities, and focus on reaching new agreements to realise these opportunities. Countries should engage a much broader, whole-of-society coalition of public and private stakeholders to successfully appraise these opportunities and develop regional interconnections. Countries should also work together on the joint planning of grid infrastructure, supported by improved permitting processes, and speed up

discussions on the alignment of regulation and markets for electricity and system services, including power pool integration.

COLLECTIVELY AGREE HIGHER MINIMUM ENERGY PERFORMANCE STANDARDS FOR MAJOR ELECTRICITY CONSUMING APPLIANCES

OVERVIEW

Last year, we recommended that countries, in consultation with industry, should collectively agree to higher minimum energy performance standards (MEPS) for high energy-consuming appliances, supported by awareness campaigns and incentives, such as energy efficiency retrofit programmes. We also emphasised that improved technical assistance should facilitate the implementation of effective standards in developing countries.

IEA analysis consistently shows the importance of appliance efficiency in its NZE Scenario. By 2035, industrial electric motor technologies need to average today's highest standard of efficiency; all household appliances sold would need to be as efficient as today's best in class; and the average efficiency of air conditioners around the world needs to increase by more than half.

Appliance standards are a fundamental component of a clean energy transition, and co-ordination on standards by a large number of countries could provide a clear signal to manufacturers and raise the standard of appliances throughout global markets. The average energy efficiency of new major appliances in countries with energy efficiency standards and labelling programmes can increase two to three times faster than the underlying rate of technology improvement, based on global evidence, and lead to average energy use reductions of 10-30% over 15 to 20 years.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress made against our recommendation for countries to agree on higher MEPS. Most activities have been limited to sharing best practice, and countries have not advanced on meaningful co-ordination on standards in the past year. A notable exception is through the Global Cooling Pledge, which is examined in detail in the Buildings Chapter of this report.

As of 2023, more than 110 countries around the globe, including all major energy consumers, have implemented MEPS, but the stringency and coverage of these labels varies greatly by country and technology. Regional coverage differs even more starkly, which underscores the opportunity for international co-operation in this area. Regions such as Europe, North America, and Asia Pacific are at the forefront of coverage for key end uses, while Africa, Eurasia and the Middle East demonstrate significant potential for broader policy implementation. Regional alignment of MEPS and labels in areas with very different levels of economic development would yield significant advantages, including a need for fewer testing methods and conformity assessment processes, reduced compliance costs for industries, and lower government expenditures on compliance testing, in addition to the primary benefit of shifting the market towards more efficient products.

Collaborative activity on standards for energy efficiency plateaued in 2023, with some exceptions. Progress was primarily seen through the development of new resources and capacity-building rather than co-ordination to strengthen standards. The Super-Efficient

Equipment and Appliance Deployment (SEAD) Initiative, a collaboration of more than 20 governments and international organisation partners, made strong progress in expanding its portfolio of analysis and training activities. The United States re-joined SEAD, and a new analysis of crowdsourced market data showed that energy-efficient appliances cost less than less-efficient counterparts in most major economies in sub-Saharan Africa and Latin America. SEAD also started several bilateral and multilateral exchanges on best practices and road mapping to meet the goal agreed to at COP 28 to double the global average annual rate of energy efficiency improvements by 2030. SEAD also delivered training, including to policy makers and their support networks in Africa. Elsewhere, SE4ALL [held](#) the Kenya Energy Efficiency and Sustainable Cooling Marketplace Workshop.

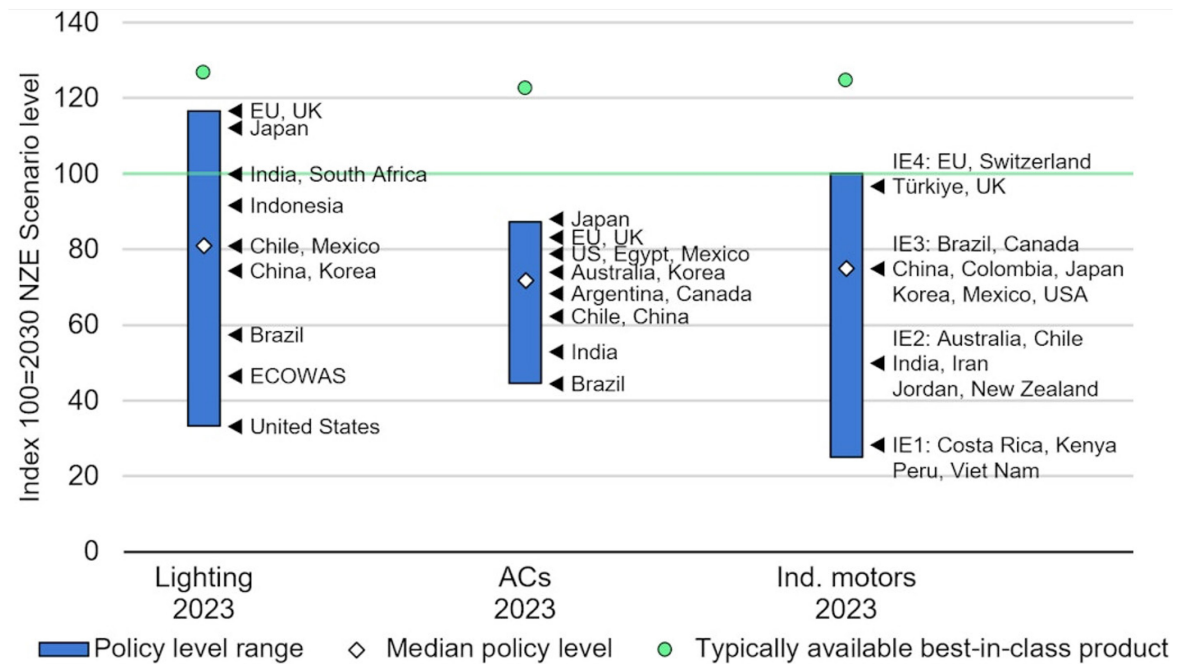
The IEA's Digital Demand-Driven Electricity Networks ([3DEN](#)) Initiative and the [Energy Efficiency Hub](#) launched a Government and Industry Exchange on Data Centres and Energy Efficiency. In 2023 the International Electrotechnical Commission (IEC) produced guidance on how to incorporate energy efficiency aspects for all its committees developing technical standards. Through the guide, the IEC provides a structured, systems approach to mainstreaming energy efficiency across all electrical standards.

WHAT MORE NEEDS TO BE DONE?

Countries should work together to both extend standards to cover more of the market and to increase the stringency of existing standards, in a co-ordinated way. This should go beyond knowledge-sharing, and include political dialogue on how to align standards to a level consistent with the pledge to double the global average annual rate of energy efficiency improvements by 2030.

Last year the IEA launched the "Efficiency Policy Level Index" [to assess progress](#) on MEPS. The analysis revealed that some leading nations and regions have already adopted energy performance standards that are in line with the NZE Scenario for 2030. In fact, products available in the market for various end-use technologies often surpass the minimum policy levels outlined in the NZE Scenario. Outside of market leaders, however, the stringency and coverage of standards varies greatly. A global tracker of [MEPS progress](#) was launched by CLASP in 2023. This found a significant gap in key appliance categories, particularly for those with heavier loads like heat pumps and air conditioners. For example, only 45 countries have implemented mandatory standards to ensure minimum performance levels of heat pumps. Countries should work together to collectively raise standards in each of these categories, enabling widespread savings in costs and emissions.

Figure 2.2 Minimum Energy Performance Standards and IEA Efficiency Policy Level Index



IEA. CC. BY. 4.0

Notes: AC = air conditioning; Ind. Motors = industrial motors; ECOWAS = Economic Community of West African States; EU = European Union; NZE = Net Zero Emissions by 2050 Scenario; UK = United Kingdom; US = United States.

Source: IEA (2023), [Energy Efficiency 2023](#)

Sharing best practice on policies, standards and international rules remains important in some areas, and could help close out loopholes in regulations and create an enabling environment for efficient appliances. For energy-intensive appliances in particular, such international engagement should encourage national policy makers to widen the scope of MEPS regulations, both in terms of different configurations, and to incorporate broader policies for integrated products including equipment systems. Heat pumps, with or without heat storage and AC equipment, in particular, would benefit from a broad approach to standards development. For instance, mandating heat pump/AC reversibility in cold countries can reduce overall heating, ventilation and air conditioning (HVAC) costs and displace fossil fuel use during the high load season.

Furthermore, as energy systems around the world electrify, there is a need to internationally harmonise appliance standards for digitalisation and interoperability. Household appliances and higher capacity electrical devices like electric vehicles, or rooftop PV solar systems, can operate independently of each other, often shielded by proprietary hardware or software interfaces on the consumer end. When deployed in large quantities, these devices could potentially disrupt electricity grid stability if left unmanaged.

Interoperability will be key to ensuring seamless integration of electrified end uses. Many smart appliances are traded internationally, manufactured by companies that sell to multiple countries. International co-ordination is therefore required to ensure large numbers of smart appliances can operate seamlessly with each other. When fully interoperable, such appliances can become an asset for managing supply and demand and hosting a higher share of variable renewables. A more comprehensive, collaborative approach to standard-setting therefore not only enhances energy efficiency but also accelerates the

transition to a lower-carbon power supply. Initiatives in this respect are still at an early stage: in Europe, a [Code of Conduct](#) for appliance manufacturers that incorporates interoperability requirements for white goods and HVAC equipment is currently under development.

RECOMMENDATION P5 HAS BEEN RESTATED AS FOLLOWS:

Countries, in consultation with industry, should collectively agree to more ambitious MEPS for energy-consuming appliances, including appliances for heating and cooling. Countries should also agree on interoperability and digital standards, which could be supported by awareness campaigns, improved labelling, or appliance retrofit programmes at the national level. Improved technical assistance should facilitate the implementation of effective standards in developing economies.

RECOMMENDED REPORTS

We recommend the following reports for more detailed descriptions of the technologies for power sector decarbonisation and of the actions that countries and businesses can take individually.

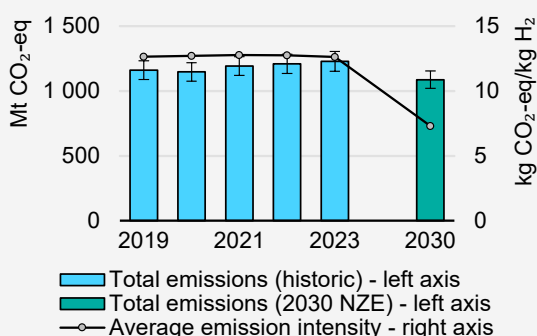
- IEA (2024), [Renewables 2023](#)
- IEA (2023), [Batteries and Secure Energy Transitions](#)
- IEA (2024), [Accelerating Just Transitions for the Coal Sector](#)
- IEA (2024), [World Energy Investment 2024](#)
- IEA (2023), [What does doubling global progress on energy efficiency entail?](#)
- IRENA (2023), [Innovation landscape for smart electrification](#)
- Rockefeller Foundation (2024), [Scaling the JETP model](#)
- 21st Century Power Partnership (2023): [Action plans for power sector decarbonisation](#)
- GGI (2024), [Principles for interconnectors \(phase 2\)](#)

CHAPTER 3. HYDROGEN

STATE OF THE TRANSITION

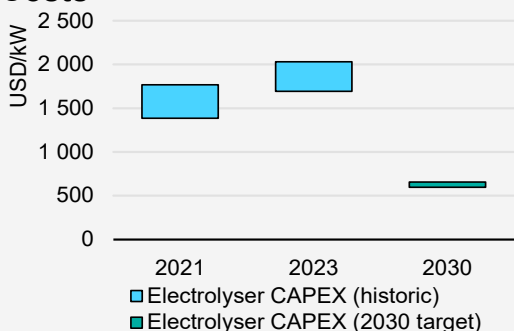
The deployment of renewable and low-carbon hydrogen⁴ and reduction in the production and use of hydrogen from unabated fossil fuels is significantly behind where it needs to be to get on track with the IEA Net Zero Emissions by 2050 Scenario (NZE Scenario), despite significant progress achieved in the last few years in this nascent sector.

Emissions⁵



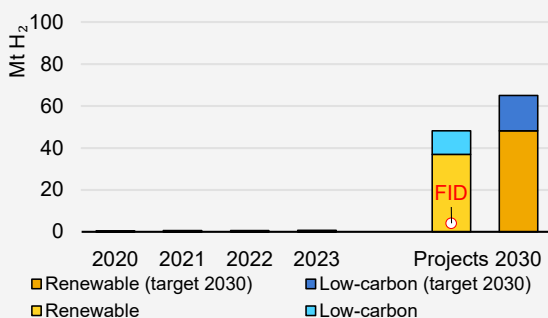
- Hydrogen production today is associated with more than 1 200 Mt CO₂-eq, including upstream emissions of fossil fuel supply, and there has been no progress in reducing them.
- The emissions intensity of hydrogen production needs to fall by 40% by 2030 for a 10% reduction in total emissions.

Costs⁶



- Renewable and low-carbon hydrogen remains more expensive than hydrogen from unabated fossil fuels.
- The cost gap has increased recently due to inflation and the fall in fossil fuel prices.
- Electrolyser capital cost is expected to decrease through accelerated innovation, improved manufacturing and scale-up, depending on how quickly deployment can be ramped up.

Deployment



- Total global hydrogen production reached 97 Mt in 2023, but renewable and low-carbon hydrogen deployment remained below 1 Mt – less than 1% of global production.
- Renewable and low-carbon hydrogen production must reach 65 Mt a year by 2030.
- If all announced projects for renewable and low-carbon hydrogen were realised, they could meet three-quarters of the needs in the NZE Scenario.

⁴ This report does not define a specific carbon intensity limit for renewable and low-carbon hydrogen. All of the production routes encompassed by this term will need to achieve verifiable low-carbon intensities that trend towards near zero by 2030. For example, this implies that fossil-based hydrogen production must operate with high carbon capture rates applied to all streams containing CO₂, and that the captured carbon must be permanently stored underground to prevent its release into the atmosphere. Additionally, it is critical that methane leakage is reduced to near zero, if not completely avoided. Rigorous measurement, reporting and verification of emissions will be necessary.

⁵ Included upstream emissions of fossil fuel supply. Error bars reflect the variability of emissions depending on the allocation method for the production of hydrogen as a by-product in the petrochemical industry.

⁶ Electrolyser capital costs, [IEA](#). The 2030 target refers to the project cost in the NZE Scenario.

STATE OF INTERNATIONAL COLLABORATION

The cost of producing renewable and low-carbon hydrogen remains the most important barrier to its adoption, and closing the cost gap with unabated fossil-based production will require government action in the form of support schemes. However, there are other areas in which international co-operation can make a big contribution to overcoming further barriers, which can in turn help to reduce the cost gap by de-risking project development. The Hydrogen Breakthrough community identified four key areas for international collaboration back in 2022: standards and certification, demand creation, technology demonstration and finance. In this Chapter we assess the progress that the hydrogen sector has achieved in these areas since the [Breakthrough Agenda Report 2023](#).

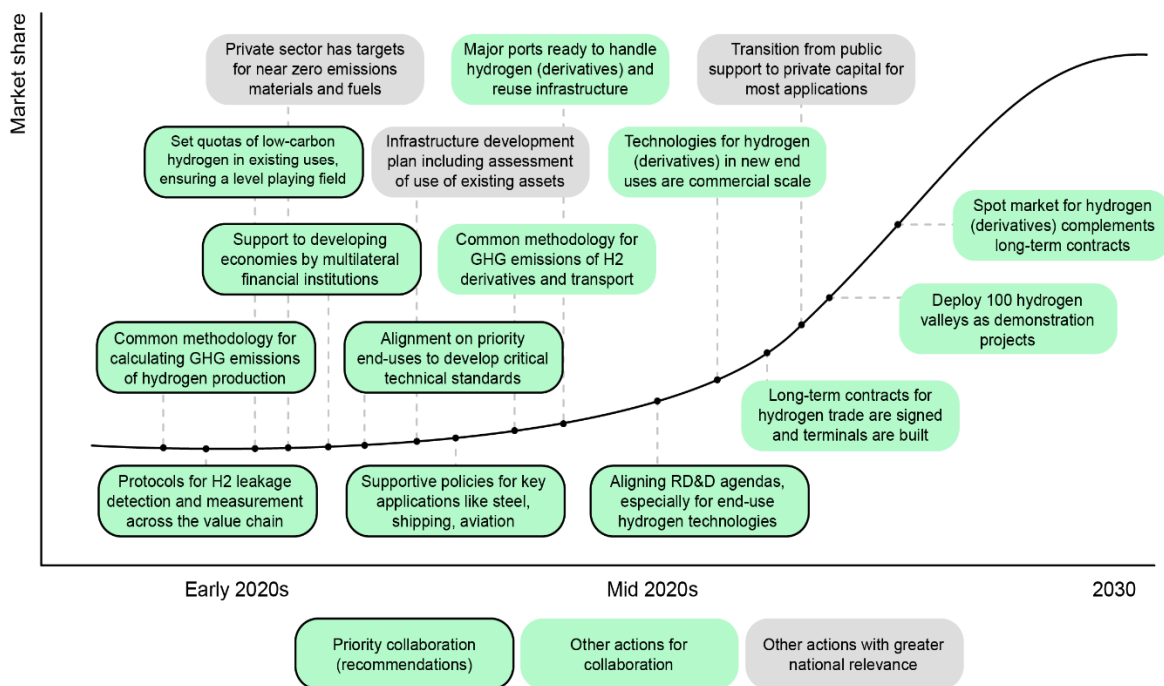
Significant progress has been made on standards and certification, with the International Organization for Standardization (ISO) issuing a specification for GHG emissions associated with hydrogen, and 37 governments signing a [Declaration of Intent](#) for mutual recognition of certification schemes at COP 28. Progress has also been made on finance and investment, with multiple new international initiatives to scale up support for hydrogen projects having emerged since COP 28.

Area	What key progress has been made?	What more needs to be done?	2024
H1. Standards and certification	<ul style="list-style-type: none"> ISO published a Technical Specification to determine well-to-gate GHG emissions associated with hydrogen supply chains. 37 governments signed a Declaration of Intent for mutual recognition of certification schemes for renewable and low-carbon hydrogen and hydrogen derivatives. The Hydrogen TCP “Task” for Certification of Hydrogen and Derivatives advanced the development of the technical mutual recognition framework for certification schemes. 	<ul style="list-style-type: none"> Prepare a well-articulated plan to identify the resources required to develop a comprehensive portfolio of standards. Provide the resources for developing and agreeing a portfolio of safety and operational standards. Governments to refer to and/or seek consistency with the ISO Methodology in their regulations and certification schemes to facilitate mutual recognition. Build domestic technical capacities needed in EMDEs to verify compliance with international standards. 	Good (↑)
H2. Demand creation	<ul style="list-style-type: none"> Creation of a working group of international initiatives under the umbrella of the Hydrogen Breakthrough. Extensive analysis provided by international organisations, providing recommendations to facilitate demand creation. Some countries began to implement regulations and 	<ul style="list-style-type: none"> Governments to commit to implement policies and market mechanisms that stimulate demand in priority sectors and to share lessons learnt in existing international forums. Governments to co-ordinate efforts to create a level playing-field for 	Minimal (=)

Area	What key progress has been made?	What more needs to be done?	2024
	support schemes to stimulate demand. <ul style="list-style-type: none"> RMI launched a Sustainable Steels Buyers Platform, piloted a Maritime Book and Claim chain of custody system, and launched a Sustainable Aviation Fuels Registry. 	applications in which hydrogen is used for the production of globally traded commodities. <ul style="list-style-type: none"> Industry to move beyond announcements and MoUs to binding contractual agreements. 	
H3. Research and innovation	<ul style="list-style-type: none"> CHM identified nearly 100 hydrogen valleys. CHM and H2 TCP announced the development of a global research and innovation agenda. 	<ul style="list-style-type: none"> Provide the necessary resources for CHM to move beyond identification of valleys and become an implementation platform. Extend the reach of demonstration efforts to involve EMDEs. Focus efforts on priority applications including heavy industry, shipping, aviation, seasonal electricity storage, and segments of heavy-duty trucking. Develop a co-operation framework to define and agree minimum reporting principles and to guide knowledge-sharing. 	Minimal (=)
H4. Finance and investment	<ul style="list-style-type: none"> The Scaling Hydrogen Financing for Development report was published in early 2024 by the World Bank, ESMAP, OECD, G20 GIF, and the Hydrogen Council. 10 GW Lighthouse Initiative is currently being established - including Governments, MDBs and DFIs. The ITA was launched at COP 28 to support project delivery and policy design and implementation in selected countries. Mapping efforts are underway to identify hydrogen projects. 	<ul style="list-style-type: none"> Build on progress regarding information and knowledge dimensions to design and deliver financial de-risking mechanisms. Focus on implementation of individual projects, including but not limited to those identified for the Lighthouse Initiative. Ensure additionality in the delivery of support and assistance programmes, with a focus on EMDEs. 	Good (↑)

Notes: The arrows indicate relative progress compared to last year's assessment in the Breakthrough Agenda Report 2023. "↑" indicates an improved assessment; "↓" indicates a downward assessment; "=" indicates the same assessment.

Figure 3.1 Critical path to 2030 for hydrogen



IEA. CC BY 4.0

Source: [Breakthrough Agenda Report 2023](#)

ACCELERATING THE DEVELOPMENT OF COMMON STANDARDS FOR HYDROGEN SUPPLY CHAIN EMISSIONS, SAFETY AND OPERATIONS WITH INCREASED GOVERNMENT SUPPORT

OVERVIEW

Last year, we recommended that governments and businesses should provide financial and human resources for the development and implementation of a comprehensive portfolio of national and international standards, based on a well-articulated plan that defines resource needs. Governments should also work towards the adoption of a common methodology to calculate the carbon footprint of the hydrogen value chain in order to facilitate mutual recognition and interoperability of certification systems. Additionally, governments should anticipate building technical capacity within their national systems to verify compliance with international hydrogen standards.

This workstream has been co-ordinated by the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) since COP 27, with support from the [Hydrogen Council](#), the [IEA's Hydrogen Technology Collaboration Programme](#) (H2 TCP), [the International Renewable Energy Agency \(IRENA\)](#)'s [Collaborative Framework on Green Hydrogen](#), the [United Nations Economic Commission for Europe \(UNECE\)](#) and the [United Nations Industrial Development Organization \(UNIDO\)](#). At COP 28, it was agreed that these organisations will work to implement an agreed multi-year global programme to develop and secure agreement to international standards, certification and related processes, including emissions accounting, safety, operational issues and mutual and cross-border recognition of certification schemes.

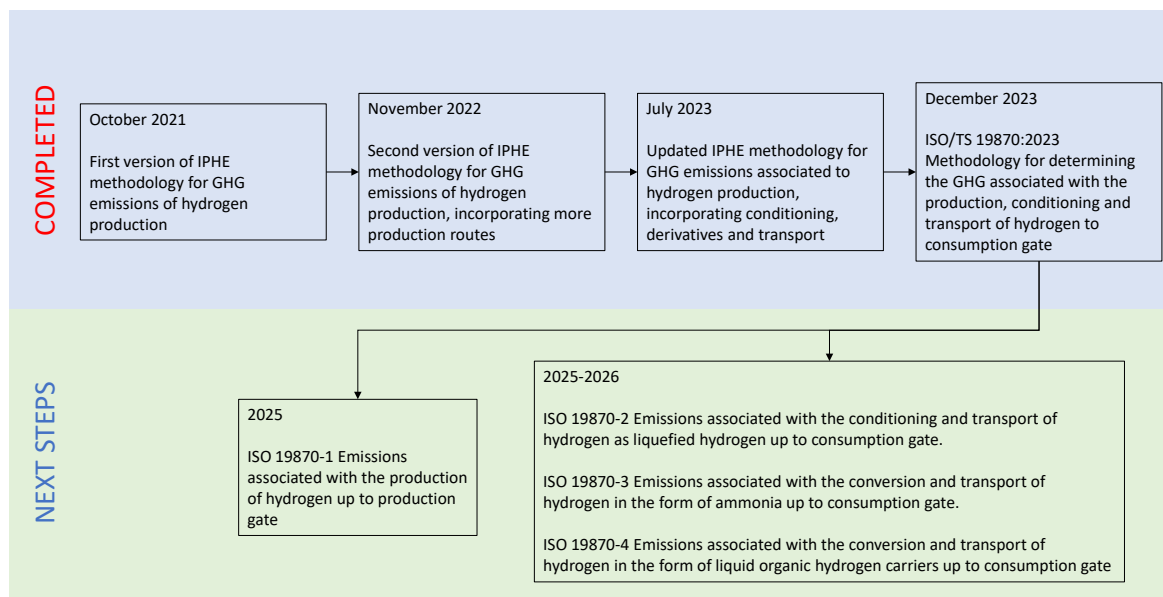
Establishing and implementing robust and globally harmonised standards will be essential to increasing the use of hydrogen and hydrogen-based fuels⁷ in order to support decarbonisation. These standards should cover emissions intensity alongside other aspects of sustainability, such as water and land use, as well as safety and operations for emerging applications and technologies not yet integrated into the energy system. International co-operation will be crucial to the adoption of these standards, thereby enabling the safe use and effective cross-border trade of hydrogen and its derivatives while limiting the administrative burden for companies.

WHAT PROGRESS HAS BEEN MADE?

We assess that good progress has been made against our recommendation on standards and certification in the past year.

In November 2023, at COP 28, the ISO presented [Technical Specification ISO/TS 19870:2023](#), which provides a methodology for determining the GHG emissions associated with the production, conditioning and transport of hydrogen, from the raw materials used as inputs to the consumption gate. This Technical Specification offers a trusted international methodology for assessing the GHG emissions of hydrogen on a life-cycle analysis basis. It will form the basis for a series of four international standards to account for GHG emissions across the hydrogen and hydrogen-based fuel supply chain, to be released between 2025 and 2026 (Figure 3.2).

Figure 3.2 Progress on the development of an international standard to determine the well-to-gate greenhouse gas emissions associated with hydrogen



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Notes: IPHE = International Partnership for Hydrogen and Fuel Cells in the Economy; ISO: International Organization for Standardization; TS = Technical Specification.

Another step forward in terms of certification was seen at COP 28, where 37 governments signed a [Declaration of Intent](#) for mutual recognition of certification schemes for renewable and low-carbon hydrogen and hydrogen derivatives. This is a positive development given that a growing number of countries are now adopting regulatory frameworks for the

⁷ In this report, hydrogen also includes hydrogen-based fuels such as ammonia and synthetic hydrocarbons.

certification of hydrogen for producers seeking support through government programmes. These frameworks currently present [significant divergences](#) in terms of scope, system boundaries and eligibility criteria, which can lead to market fragmentation and pose a risk to the development of global trade. In addition, in November 2023, 14 countries in Latin America, with the support of the Interamerican Development Bank and the Latin American Energy Organisation, [launched a regional certification scheme](#) (CertHiLAC), which Mexico later joined at COP 28.

To support mutual recognition efforts, the IPHE, the H2 TCP, and the Hydrogen Council have launched several activities. In August 2023, the three organisations jointly published [Hydrogen Certification 101](#), which aims to provide clarity on terminology and concepts used in hydrogen certification and to set out the concept of mutual recognition of certificates. This paper will be updated in Q3 2024 to include additional terms and provide more information on what would be needed to implement the mutual recognition of certificates.

The three organisations have also started a “Task”, or collaborative research project, ([Task 47: Certification of Hydrogen and Derivatives](#)) for the Certification of Hydrogen and Derivatives within the H2 TCP. This task has been designed to lay out a technical framework for mutual recognition between certification schemes, and run case studies and pilot projects between countries to test the framework and ensure its technical robustness. More than 50 experts are now participating in this initiative, which has already completed 15 workshops on existing and future mutual recognition frameworks, structures and their development, and is also engaging with the signatories of the Declaration of Intent from COP 28. In 2025, ISO will initiate a standardisation project based on the findings and recommendations from the above H2 TCP Task.

However, the GHG emissions from hydrogen production, conversion and transport is not the only area where standards are needed to accelerate the uptake of renewable and low-carbon hydrogen. New operational and safety standards are required across the value chain. To date, ISO has published 21 standards, and 26 more are under development, but the development of standards takes time and progress is slow. In the past year, the ISO published two [new standards](#) on the topic of fuelling vehicles. In addition, the Emerging Fuels Institute (established by the Pipeline Research Council International) started a collaboration with European and Australian counterparts to develop a technical supplement so that an existing ASME B31.8 standard for gas transmission pipelines can be used for hydrogen pipelines. Beyond this, the only significant step towards the development of operational and safety standards for hydrogen resulting from international collaboration came from the IPHE, which published a [Review and Gap Assessment of Bulk Hydrogen Storage](#). This assesses gaps for regulations, codes and standards for large-scale hydrogen storage in order to identify critical areas for technical research and regulatory changes that could enable the bulk storage of hydrogen. In addition, Japan and the European Commission agreed to co-operate on hydrogen technology standards under their [High-Level Hydrogen Business Forum](#). Finally, later this year Canada will complete a [Codes and Standards roadmap](#), identifying gaps and prioritising codes and standards based on how critical they are to developing the hydrogen sector.

There is wide agreement among stakeholders involved in this priority action on the need for a clear, transparent and well-articulated plan to identify the resources required to develop a comprehensive portfolio of safety, operational and environmental standards. However, there is still no plan in place, despite earlier expectations that one would be presented at COP 28. As a first step towards getting a global picture of overall resource needs, the IPHE and the US Department of Energy (DoE) initiated a process to survey IPHE member countries for information about the resources (financing and staff) they

currently have devoted to standards development, and their estimates of the resources needed to develop such standards in a timely manner.

The IPHE has also opened participation in its task force on standards to non-IPHE members, with the aim of involving as many countries as possible in the process, which should help to broaden awareness and expertise.

Building expertise will be particularly important for emerging markets and developing economies (EMDEs), where the capabilities for assessing conformity with standards and implementing certification schemes are limited. In November 2023, UNIDO organised the [ISO Hydrogen Technologies Plenary Week](#), which convened over 150 global experts representing 62 countries, including 34 developing economies. Following this plenary, UNIDO is now supporting the development of a framework for quality infrastructure along the renewable hydrogen supply chain, which will include a guide (developed jointly with ISO) to simplify the ISO Methodology for the use of industry and government stakeholders. This guide will be used for capacity-building activities expected to start in the second half of 2024. IRENA is also working on a roadmap for quality infrastructure, with a case study on Tunisia.

WHAT MORE NEEDS TO BE DONE?

The priority action on standards and certification is by far the most advanced of all the Hydrogen Breakthrough actions, but progress is still insufficient to align with a net zero pathway.

The critical path to 2030 (Figure 3.1) defined in the [Breakthrough Agenda Report 2022](#), set out three milestones that were expected to be reached in the first half of this decade. Two of these were related to the development of a methodology for calculating the GHG emissions of hydrogen production, conversion into derivatives, and transport. These have now been achieved thanks to the excellent work carried out by the IPHE in recent years, which resulted in the publication of the ISO Technical Specification and will lead to the ISO standards in the next 2 years. However, the development of this methodology is just the first step: the standards alone cannot (and are not intended to) ensure that hydrogen production is based on low-emissions technologies. It will then fall to governments to implement regulations that set thresholds for acceptable levels of emissions for hydrogen producers and users to be eligible for support schemes. Governments also need to ensure that robust data is available to perform adequate assessments of upstream emissions of fossil fuel supply, which is still an area of uncertainty. In addition, governments need to refer to the ISO Methodology (and the standards, once they are ready) in their regulations and certification schemes, or at least ensure that they are consistent with this methodology, in order to facilitate mutual recognition of certificates and enable a certain level of market interoperability. The COP 28 Declaration of Intent is a good first step, but must be translated into real action. The work being undertaken on certification and mutual recognition (by the IPHE, the H2 TCP, the Hydrogen Council and IRENA) is primarily analytical, and although it could pave the way for implementation – as yet – there are no tangible steps towards that outcome. The work that the IPHE and the H2 TCP are currently undertaking needs to be transformed into an implementation plan with concrete deliverables that can inform decision-making, and can turn the political commitment to mutual recognition of certification schemes into action among first-mover countries. In addition, better communication of the work being developed, and the timeline to complete different tasks, will facilitate dissemination and engagement of a wider group of stakeholders to enable faster deployment and scale-up.

GHG emissions in fossil fuels supply: an unresolved challenge

In 2023, more than 80% of global hydrogen demand was met by hydrogen produced from fossil fuels and another 16% with hydrogen produced as a by-product of processes that use fossil fuels as feedstock. Reducing the production of hydrogen from unabated fossil fuels is critical for decarbonisation, but the production of low-carbon hydrogen from fossil fuels coupled with carbon capture utilisation and storage (CCUS) is expected to play a role in the clean energy transition. Announced projects suggest that nearly one-quarter of the potential production of renewable and low-carbon hydrogen that could be achieved from these projects uses fossil fuels with CCUS, and this share raises to more than 40% when considering only those projects that have at least taken a final investment decision.

For low-carbon hydrogen from fossil fuels with CCUS to effectively contribute to decarbonisation efforts, there is a need to address GHG emissions from its supply chain, particularly methane emissions, which are [responsible for around 30% of the rise in global temperatures](#) since the Industrial Revolution.

The [ISO Technical Specification](#) includes guidelines based on a list of options to assess the upstream emissions of natural gas as follows:

Depending on the available data, calculation of the emission factor of the used gas (as energy or feedstock) (kgCO₂e / MWh) for the different pathways considered can be performed by:

- a) using a well-documented emission factor of the gas purchased based on independent, third party, public-funded scientific analysis;*
- b) individual gas suppliers can be given the possibility to prove that their facilities operate at a lower level of leakage than the default level. This can be achieved using Guaranties of Origin schemes;*
- c) using an emission factor provided by national authority, or data source which is generally used in the country or area where the well is located, or otherwise globally used LCA data base. The system boundary of the data should match that of the gas purchased. GHG emissions from gas transport to consumption gate and leakages from extraction gate to consumption gate shall be accounted for.*

The first two options in this list are robust alternatives to account for upstream emissions of natural gas in the assessment of GHG emissions associated with hydrogen supply chains, although the second one must be based on empirical data or methane measurements to be effective. The third option has raised some concerns. Some data from national authorities can be very reliable, as is the case of [Norway](#), which is often quoted as a reference for good practices in the field. In other cases, data available on national inventories [underestimates the real scale of these emissions](#), particularly methane leakage.

Awareness of the impact of methane leakage has been growing in recent years, and governments have taken steps with the objective of improving data robustness and availability. For example, in 2020 the United Nations Environment Programme (UNEP) launched the [Oil and Gas Methane Partnership 2.0](#) (its flagship oil and gas reporting and mitigation programme), which has developed very detailed [guidance](#) for methane measurement. In November 2023, the US DoE announced an [international working group](#) composed of 12 countries, the European Union and the East Mediterranean Gas Forum, to establish a [measurement, monitoring, reporting and verification \(MRV\) framework](#) for providing comparable and reliable information to natural gas market participants. Regulations introducing MRV practices and providing transparency are also coming forward. The [EU Methane Regulation](#), approved in May 2024, introduces mandatory MRV requirements on domestic production and establishes a transparency platform with country profiles (including non-EU member states exporting to the European Union).

Such efforts can lead to improved national data inventories, but building the necessary evidence, verifying it and making it available to market participants and the wider public will require some time. In the interim, governments can use other data sources that have been developed by public organisations and the private sector, using the best available technologies for measurement and estimation to provide more accurate emissions accounting than using current national inventories. Some examples from public organisations are the IEA's [Methane Tracker](#), UNEP's [International Methane Emissions Observatory](#) and the EU Joint Research Centre's [Emissions Database for Global Atmospheric Research](#). Private sector examples include the Environmental Defense Fund's [MethaneSAT](#) and tools developed by companies such as [Airmo](#), [GHGSat](#), [Kayros](#) and [Orbio Earth](#).

Further progress is also needed in developing and agreeing safety and operational standards. The survey work now being undertaken by the IPHE and the US DoE, as described above, is a key step towards development of a resourcing plan, allowing stakeholders to identify gaps in the resources already allocated and to commit to close those gaps. However, there is a need to transform the information collected into a well-articulated and evidenced plan as soon as possible. Governments and business should then commit to provide these resources. In addition, there is a need to expand this effort beyond IPHE members, particularly to involve EMDEs, to have full visibility on the resources that already exist.

Similarly, we recommended that governments should anticipate the need to build technical capacity within their national systems to verify compliance with international hydrogen standards. Despite the efforts of organisations like UNIDO, little progress can be made against this objective without greater clarity on the portfolio of standards itself.

Finally, the third milestone for the first half of this decade on the critical path to 2030, as defined in the Breakthrough Agenda Report 2022, referred to the development of protocols for hydrogen leakage detection and measurement across the value chain to make sure that its impact as an indirect GHG does not undermine hydrogen climate benefits. Almost no progress has been made towards this goal, with the exception of some R&D programmes

in the [United States](#) and the [European Union](#). There is a need for governments to address this gap more seriously, and to strengthen support for the development of detection and monitoring protocols. This should be complemented by the implementation of field studies and measurement campaigns to collect robust data and create emissions inventories that include emissions from hydrogen leakage, but also from other operational procedures (e.g. purging and venting). First efforts for the creation of inventories are also underway through [a project of the EU Clean Hydrogen Partnership](#) and research from the [University of Rhode Island](#), but a more global participation and data collection would be needed to build a robust evidence base.

RECOMMENDATION H1 HAS BEEN UPDATED AS FOLLOWS:

Governments working together through the international initiatives involved in the Hydrogen Breakthrough need to urgently present a well-articulated plan that defines resource needs for the development and implementation of a comprehensive portfolio of national and international standards for hydrogen and hydrogen-based fuels. Governments and businesses should provide financial and human resources in line with that plan to ensure the development of that portfolio. Governments should facilitate regulatory interoperability by committing to adopt, or ensuring consistency with, globally recognised international standards, such as the ones developed by the ISO Methodology, in their regulations, which is an important step to support the process of mutual recognition of certification schemes. Governments should anticipate building technical capacity of their national systems to verify compliance with international hydrogen standards.

CO-ORDINATING ACTION TO CREATE TARGETED DEMAND FOR LOW-CARBON AND RENEWABLE HYDROGEN, STARTING WITH EXISTING INDUSTRIAL APPLICATIONS

OVERVIEW

Last year, we recommended that governments and companies should co-ordinate internationally to increase commitments for the use of low-carbon and renewable hydrogen in sectors where hydrogen is already used (e.g. refining, chemical industry), supported by specific policies and purchase agreements, to collectively send a strong demand signal and mobilise investment in production. In addition, we recommended that in new priority application sectors, countries should share learning to accelerate early deployment. Any action taken to create demand should be done in a manner that ensures a level playing-field in international trade.

At COP 28, the [Clean Energy Ministerial Hydrogen Initiative](#) (H2I) and the [Rocky Mountain Institute](#) (RMI) agreed to jointly co-ordinate a working group that counts on the participation of a dozen organisations,⁸ which agreed to prepare a joint work plan to encourage coalitions of leading countries and companies to:

⁸ [Clean Hydrogen Mission](#) of [Mission Innovation](#), the [Green Hydrogen Catapult](#), the [Hydrogen Council](#), [H2Global Foundation](#), the [H2 TCP](#), the [UN Climate Change High-Level Champions](#), UNIDO (including the [Global Programme for Hydrogen in Industry](#)), the [World Bank](#) (including the [Hydrogen for Development Partnership](#), H4D), the [WBCSD](#), the [World Economic Forum](#) (including the [Accelerating Clean Hydrogen Initiative](#), the [First Movers Coalition](#) and the [Transitioning Industrial Clusters](#)).

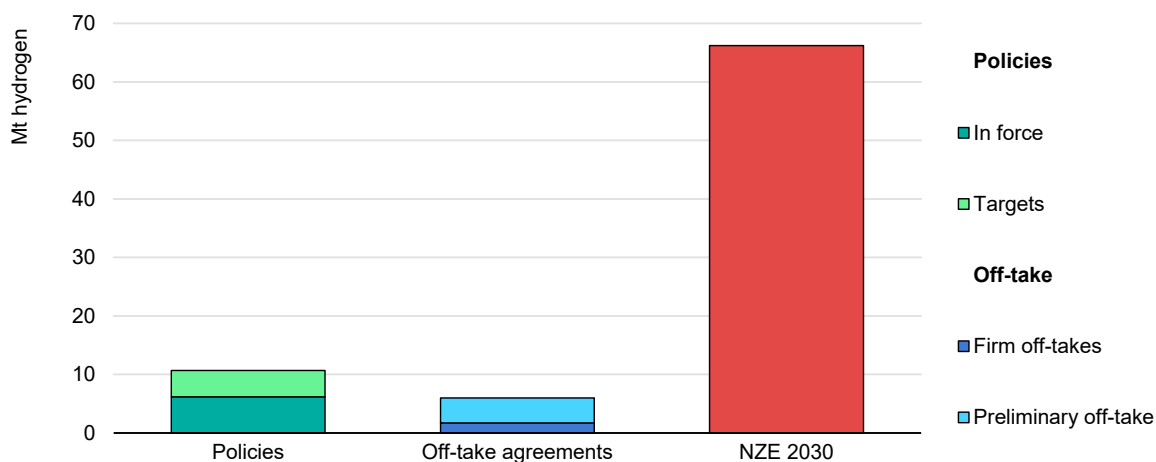
- make increased, firm commitments to use renewable and/or low-carbon hydrogen in key priority applications⁹
- to address key enabling conditions, including through mitigating financial risks and developing international standards and certification (utilising work under the other priority actions)
- to aggregate and communicate those commitments widely
- to address enabling conditions for connecting clean hydrogen supply and demand, including financing mechanisms and cross-border trade forums.

WHAT PROGRESS HAS BEEN MADE?

We assess that minimal progress has been made against our recommendation on demand creation from last year.

A number of publications from the past year – including the IEA’s [Global Hydrogen Review](#), a report from the World Business Council for Sustainable Development (WBCSD) on [sector-specific policy recommendations](#) and a [report](#) from UNIDO and IRENA on policy instruments for market creation – have provided robust analysis to inform the activities of international co-operation initiatives working towards this priority action. In addition, the H2Global Foundation aims to publish a report in Q3 2024 on the role of hydrogen hubs as demand anchors.

Figure 3.3 Potential demand for low-carbon and renewable hydrogen from announced policies and targets, private offtake agreements, commitments by international co-operation initiatives and the Net Zero Emissions by 2050 Scenario, 2030



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Notes: NZE = Net Zero Emissions by 2050 Scenario.

Source: IEA (2023), [Global Hydrogen Review 2023](#). IEA (Forthcoming), [Global Hydrogen Review 2024](#).

Some governments (including the [European Union](#), [Germany](#), [India](#), [Japan](#), the [Netherlands](#), [Korea](#) and the [United States](#)), have started to work on implementing

⁹ In the [Breakthrough Agenda Report 2022](#), priority applications were identified as applications in which emissions are hard to abate, and where there are limited viable clean energy alternatives, including heavy industry, maritime shipping, aviation, seasonal electricity storage, and segments of heavy-duty trucking

regulations and support schemes to stimulate demand for renewable and low-carbon hydrogen. However, these efforts are being developed by countries individually, and we are not aware of any attempts by groups of countries to agree on targets for the near-term deployment of low-carbon and renewable hydrogen. The member countries of the H2I have initiated conversations for the potential launch of a demand-creation campaign in which governments could work together to share best practices, information and lessons learnt on the development of demand-creation policies. However, this multilateral campaign has not yet been confirmed. UNIDO has developed and is currently implementing two funding schemes, the Green Climate Fund Readiness Programme and Global Environment Facility Global Clean Hydrogen Programme. These are expected to support the development of clean hydrogen clusters and to help countries with the process of developing enabling policies, improving technical readiness, knowledge management, building capabilities for standards and developing financial mechanisms for the successful uptake of clean hydrogen. However, the majority of activities will start only in 2025.

In the private sector, some progress in the past year came from activities that aim to aggregate demand for commodities that would require the use of low-carbon and renewable hydrogen. In September 2023, RMI, in co-operation with Microsoft, Nextracker, and Trammell Crow Company, launched the [Sustainable Steel Buyers Platform](#) to aggregate demand for low-emissions steel, and piloted, in collaboration with Mærsk McKinney Møller Center for Zero Carbon Shipping, a Maritime Book and Claim chain of custody system that is expected to be launched at the end of 2024. In addition, in December 2023, RMI and the Environmental Defense Fund launched a [Sustainable Aviation Fuels Registry](#) in collaboration with the [Sustainable Aviation Buyers Alliance](#) (with participation from more than 30 companies) and digital solutions developer Energy Web, to bring sustainable aviation fuel (SAF) suppliers together with end users and facilitate the procurement of these fuels through a system of SAF certificates. At COP 28 the Green Hydrogen Catapult partnered with the UN High-Level Climate Champions to co-ordinate a [Call to Action with Shipping Leaders](#), committing to increase maritime fuels derived from renewable hydrogen to nearly 11 million tonnes by 2030.

There are other initiatives developing industrial decarbonisation activities which can also trigger future demand for renewable and low-carbon hydrogen. These include the [Transitioning Industrial Clusters](#) of the World Economic Forum, which aims to foster co-operation among co-located industries to find opportunities for scale-up, sharing of risk and aggregating demand, and which today counts on more than 20 signatory industrial clusters around the world. In addition, the Industrial Transition Accelerator, launched in December 2023 at COP 28, has the objective to unlock investments in the next 3 years and accelerate the delivery of large-scale decarbonisation projects in heavy industry and transport. This proliferation of initiatives can lead to duplication of efforts and an inefficient use of resources, which underscores the need for greater co-ordination between countries and initiatives to minimise this risk.

[Hintco](#), the implementing body of H2Global mechanism announced in July 2024 the [results of its first pilot auction](#), with one bidder being awarded. H2Global Foundation is a non-profit organisation supported by various entities including corporations, philanthropists and governments. It proposes a double-auction mechanism, using Hintco as the market intermediary. The pilot auction was held to purchase renewable hydrogen derivatives (ammonia, methanol and e-SAF) from suppliers outside the European Union offering fixed price long-term contracts. A 7-year contract was awarded by Hintco to Fertiglobe for renewable ammonia. Hintco is planning to hold a separate auction to sell the renewable ammonia to buyers in Europe using 1-year contracts. The expected gap between what offtakers are willing to pay and the cost of the renewable ammonia will be covered by funds

provided by the German government. New tenders (with a budget of EUR 3.83 billion financed by the governments of Germany and the Netherlands) are set to start by Q4 2024 or Q1 2025. The implementation of this first pilot auction included the development of contractual arrangement for Hydrogen Purchase Agreements (HPAs) as well as Hydrogen Sale Agreements for the re-sale of the hydrogen derivatives to final users. The lack of an operating market for low-carbon and renewable hydrogen (and its derivatives) means that the HPAs are not a conventional type of contract. For this reason, in 2024 the WBCSD started a new activity in its work plan to address this issue and develop contracting solutions.

WHAT MORE NEEDS TO BE DONE?

The developments described above suggest that there has been some improvement on demand creation compared to last year, when practically no activity was identified and there was a complete lack of international co-ordination. However, in spite of this improvement, progress is far from being aligned with a net zero-compatible pathway. In the critical path to 2030 (Figure 3.1), the adoption of quotas for low-carbon and renewable hydrogen in existing uses, and the implementation of supportive policies in key new applications (steel, shipping and aviation) were proposed for the first half of the decade. At the time of writing – and as 2025 gets ever closer – almost no specific policies have been adopted, with the exception of some mandates in the European Union. Offtake agreements remain small-scale and insufficient, with most announcements representing preliminary agreements with non-binding conditions.

There is a need for governments to commit to implement policies and market mechanisms that stimulate demand in priority sectors, and to establish stable regulatory frameworks that create long-term certainty for the private sector. Governments have a wide variety of policy tools for this objective. There is no one-size-fits-all policy solution to stimulate demand for renewable and low-carbon hydrogen and governments will need to carefully assess which policy solutions are most suited to their own circumstances. However, individual action on this front carries the risk that first movers could be penalised, leading to industry relocation which, in turn, can result in carbon leakage, particularly in the case that renewable and low-carbon hydrogen are used to produce commodities that are globally traded today (ammonia, fertilisers, methanol and steel). To minimise this risk, governments should co-ordinate action to enable a level playing-field to a certain extent. The recently established Strategic Dialogues on spillovers from mitigation policies under the Climate Club, which address topics like carbon leakage in steel and cement industries, can serve as a guide to launch similar co-ordination activities within the hydrogen sector. Furthermore, existing government-led initiatives such as H2I and its International Hydrogen Trade Forum are available platforms to facilitate a co-ordinated dialogue, bringing together countries with different profiles, including potential exporters and importers of hydrogen and its derivatives, and advanced and emerging economies alike. Countries involved in these initiatives should now start conversations on how they can move forward together and implement policies in a co-ordinated manner. In addition, it is of primary importance that emerging economies are involved in such discussions from the beginning to facilitate the development of an equal playing-field for future bilateral and co-operation agreements between countries.

More policy action is clearly needed to stimulate efforts in the private sector, but industry also needs to take more decisive action. The initial commitments to adopt low-carbon and renewable hydrogen and its derivatives need to go beyond announcements and Memoranda of Understanding (MoUs) and lead to contractual agreements. Initiatives such as buyers' alliances can facilitate this step, but there is a need for these platforms to move

more quickly – for example, as of today, SAF buyers’ alliances have secured only two deals for the purchase of SAFs – and expand geographical reach.

RECOMMENDATION H2 HAS BEEN RESTATED AS FOLLOWS:

Governments and companies should co-ordinate internationally to increase commitments for the use of low-carbon and renewable hydrogen and hydrogen-based fuels, particularly in sectors where hydrogen is already used, supported by the implementation of specific policies and the signing of solid purchase agreements, to collectively send a strong demand signal and mobilise investment in production. In new priority application sectors, countries should share learnings to accelerate early deployment. This should be done in a manner that ensures a level playing-field in international trade.

DRIVING GLOBAL EXPANSION AND KNOWLEDGE-SHARING OF HYDROGEN DEMONSTRATION PROJECTS FOR DIVERSE HIGH-PRIORITY SECTORS

OVERVIEW

In the 2022 and 2023 Breakthrough Agenda Reports, we recommended that governments and companies should work together to dramatically increase the number and geographical distribution of hydrogen demonstration projects, and to ensure that these appropriately cover each of hydrogen’s high-value end-use sectors,¹⁰ namely: heavy industry, maritime shipping and seasonal electricity storage.¹¹ Governments and the private sector should agree on minimum reporting principles to guide deeper, faster knowledge-sharing, both among these demonstration projects and with the broader stakeholder community, including committing to share the lessons learnt from all publicly funded demonstration projects.

This workstream has been co-ordinated by the Mission Innovation [Clean Hydrogen Mission \(CHM\)](#) since COP 27, with support from the [H2 TCP](#). At COP 28, it was agreed that countries would work together through these initiatives towards the objective of delivering a wider portfolio of hydrogen valleys, supported by expanded R&D programmes and strengthened sharing of learning from those programmes.

Research, development, and demonstration play a crucial role in proving the viability of next-generation hydrogen technologies and supporting ongoing cost reductions. Production technologies have evolved substantially in recent years, with many methods already reaching commercial maturity. However, there are a number of different challenges on the demand side, especially in priority end-use applications. Accelerating the commercialisation of hydrogen technologies in these sectors is imperative, and could

¹⁰ The emphasis on demonstration projects over research in this section is driven by the large number of hydrogen technologies, particularly on the end-use side, that are at demonstration stage and could unlock large demands for hydrogen in priority sectors. Demonstration projects can enable real-world application and validation of hydrogen technologies, producing practical insights and instilling confidence among governments and companies to invest in and expand the use of hydrogen technologies on a larger scale.

¹¹ Aviation and heavy-duty trucking are also priority applications for the use of hydrogen and hydrogen-based fuels, but these sectors have not been included among the priority applications for demonstration since the use of hydrogen in heavy duty trucks has already been demonstrated (there are more than 10 000 FCEV trucks already in operation globally), as has the use of synthetic kerosene (blended with fossil-based kerosene) in aviation. However, both technologies would benefit and achieve further cost reduction from further innovation and demonstration efforts.

unlock significant levels of demand for renewable and low-carbon hydrogen, also contributing to progress towards the second priority action described above.

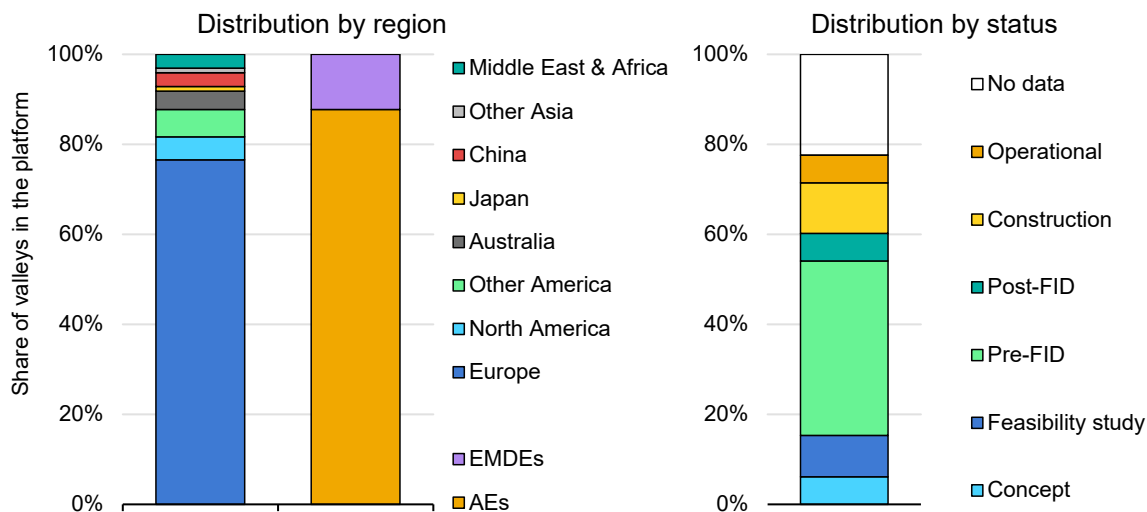
WHAT PROGRESS HAS BEEN MADE?

We assess that minimal progress has been made against our recommendation on technology demonstration from last year.

The CHM aims to identify at least 100 large-scale integrated low-carbon and renewable hydrogen valley projects worldwide by 2030. As of June 2024, the Mission Innovation Hydrogen Valley Platform showcases a total of 98 hydrogen valleys – 15 more than at the end of July 2023, indicating that the 100 valleys objective has nearly been achieved.

However, an analysis of the location, status and end uses of these valleys reveals that on these criteria, the network of projects falls short of meeting the recommendations in the Breakthrough Agenda Report 2023.

Figure 3.4 Distribution of hydrogen valleys identified in the Mission Innovation Hydrogen Valley Platform by region and status



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Notes: AEs = advanced economies; EMDEs = emerging and developing economies; FID = final investment decision. "Other America" includes Central and South America and the Caribbean. The category "No data" corresponds to the difference between the total number of valleys in the platform (98) and the valleys that reported a status (76).

Source: IEA analysis based on data from the [Mission Innovation Hydrogen Valley Platform](#).

A review of the end-use applications reported by the valleys indicates misalignment with the priority applications defined in the Breakthrough Agenda Report 2022. Less than one-quarter of the valleys have reached a final investment decision (FID), and none of these valleys are targeting industrial or energy applications. Instead, all the valleys that have reached FID are focused on transport applications.

Around 80% of the valleys list transport among the end-uses for hydrogen, with a strong emphasis on road transportation. Conversely, applications in maritime shipping and aviation are significantly underrepresented, with only 23 and no more than 15 valleys, respectively, targeting demand in these sectors. On the industrial front, 60% of the valleys are targeting industrial applications. Specifically, 31 valleys aim to use renewable and low-carbon hydrogen in chemical production, 26 in steel production, and 25 in refineries.

Approximately three-quarters of the valleys showcased on the platform are based in Europe, a distribution that is unchanged from last year. Only slightly more than 10% are located in EMDEs. Governments involved in the CHM are using this platform as a way to share lessons learnt and facilitate knowledge exchange, including with EMDEs, but the activities are quite limited. Last year, the CHM organised a series of workshops on topics like regulatory frameworks and certification, financing schemes, human capital and technologies, with participants from countries in Latin America to facilitate the identification of valleys in the region. Despite receiving positive feedback from participants, this initiative has yet to yield tangible results. There are currently only four valleys identified in Latin America, some of which were already included on the platform last year. As a follow-up, this year the CHM plans to conduct a similar activity focused on Africa, where there are currently no valleys featured on the platform.

UNIDO launched the [Accelerate-to-Demonstrate \(A2D\) Facility](#) in May 2023 to accelerate the commercialisation of innovative solutions in low-carbon and renewable hydrogen, industrial decarbonisation, critical minerals and smart energy through lighthouse pilot demonstration projects in EMDEs. The Facility has initial funding of GBP 65 million (~USD 80 million) and currently runs from April 2023 to March 2029. The A2D Facility is being delivered through funding calls, and the programme undertook a large-scale market assessment on low-carbon and renewable hydrogen in developing countries in 2024 (to be released in Q3 2024) to enhance the evidence base for the development of upcoming calls for pilot demonstration projects under the programme.

To the best of our knowledge, there has been no co-operation among countries to establish minimum reporting principles for publicly funded demonstration projects, as we previously recommended. The importance of this activity should not be underestimated, as it can support the replication of successful experiences, facilitate a faster diffusion of novel technologies, and avoid repetition of failed experiences, thus leading to a more efficient use of public resources. The lack of knowledge-sharing is likely to result in slower technology deployment. However, other collaborative efforts on innovation have recently started, with the objective of enhancing co-ordination of global innovation efforts in hydrogen technologies. The H2 TCP and the CHM have announced the development of a global research and innovation agenda, which will aim to inform governments about priority areas for promoting research and innovation in hydrogen technologies. This initiative could significantly advance the alignment of R&D agendas, particularly for end-use hydrogen technologies, a key milestone identified for mid-decade in the Breakthrough Agenda Report 2022.

Furthermore, the H2 TCP has established a Hydrogen Co-ordination Group to map and align all hydrogen-related research activities across the IEA Technology Collaboration Programmes (TCPs). This development represents a critical step in fostering co-ordinated global efforts in hydrogen research and innovation.

WHAT MORE NEEDS TO BE DONE?

There is a strong need to move beyond the identification of valleys and start supporting project developers to get demonstration projects off the ground. According to the critical path to 2030 defined in the Breakthrough Agenda Report 2022 (Figure 3.1), there should be 100 hydrogen valleys deployed as demonstration projects in the second half of this decade. However, around 70% of developers of the hydrogen valleys identified in the Hydrogen Valley Platform said that more than 1 year (and up to 4) was required just for preparing and obtaining the construction permits. This means that more than half of the

valleys will not be able to begin construction until mid-2025, at least, and perhaps not even until 2028. This puts at risk the achievement of the milestones consistent with the critical path to 2030.

The governments involved in Mission Innovation will need to find ways to for the initiative to take a more proactive role to facilitate project implementation, if they want to achieve the goal of having 100 demonstration projects operating before the end of the decade. Governments should make use of the co-operation platform that the CHM offers to enhance knowledge- and experience-sharing, and translate this into improved national demonstration support programmes to dramatically increase the number of demonstration projects currently under development.

In addition, a much stronger focus is needed on key applications for hydrogen in heavy industry, marine transport and aviation. For some of these sectors – particularly heavy industry – 2050 is just one investment cycle away. This means that the timing of investments and the availability of clean energy solutions at the right time is of critical importance. Delaying the demonstration of the use of renewable and low-carbon hydrogen in these sectors, where other decarbonisation alternatives are limited or even non-existent, risks locking in emissions for many years and putting the objective of meeting net zero emissions by mid-century out of reach.

There is also an urgent need to extend the geographical coverage of the demonstrators beyond advanced economies and involve EMDEs. There has been almost no progress on this priority since last year and – considering the additional challenges that these countries face in terms of project implementation and financing – delaying action on this front could increase the gap between advanced economies and EMDEs. This could represent a significant missed opportunity for countries which have extraordinary potential to develop new clean industries, and to reap the many socio-economic benefits that they offer.

Finally, there is a need to develop a co-operation framework that can help to define and agree minimum reporting principles to guide deeper and faster knowledge-sharing. There has been virtually no progress towards this aim since it was proposed in the Breakthrough Agenda Report 2022. Maximising knowledge exchange between countries can accelerate technology development and commercial deployment, expand learning-by-doing and help reach economies of scale more quickly.

RECOMMENDATION H3 HAS BEEN RESTATED AS FOLLOWS:

Governments and companies should work together to dramatically increase the number and geographical distribution of demonstration projects for hydrogen use and to ensure that these appropriately cover each of hydrogen's high-value end-use sectors, including maritime shipping, heavy industry and long-duration energy storage. Governments and the private sector should agree on minimum reporting principles to guide a deeper and more rapid sharing of knowledge among these demonstration projects and with the broader stakeholder community, including a commitment to share the lessons learnt from all publicly funded demonstration projects.

COLLABORATE FOR THE RAPID SCALE-UP OF PRIVATE INVESTMENT ALONGSIDE CONCESSIONAL FINANCE FOR LOW-

CARBON AND RENEWABLE HYDROGEN PROJECTS IN DEVELOPING ECONOMIES

OVERVIEW

Last year, we recommended that governments, MDBs and relevant technical partners should work to identify viable projects that are being delayed by high costs of capital and other obstacles to investment, then identify best practices to help unlock their progress. This should be supported by appropriate technical assistance programmes to assist governments with policy design for the further scale-up of projects.

This workstream has been co-ordinated by The World Bank and UNIDO since COP 27, with additional support from the Hydrogen for Development (H4D) Partnership, launched at COP 27.

At COP 28, it was agreed that these organisations would collaborate with relevant institutions to strengthen support for clean hydrogen projects, particularly in developing economies. The key objectives are to deliver a transition platform that co-ordinates, mobilises, and facilitates access to finance and related support, helping to connect emerging and developing economies with bespoke support mechanisms; and to identify a priority portfolio of the most viable “lighthouse” projects that are being delayed by obstacles to investment, developing methods of best practices to support targeted, co-ordinated and tailored assistance to overcome those obstacles.

The financial challenges associated with low-carbon and renewable hydrogen projects are substantial. High costs of capital and the perceived risks of investment continue to be significant barriers. Addressing these issues through co-ordinated efforts and targeted financial mechanisms is crucial. The adoption of de-risking mechanisms, the improvement of enabling conditions and the scale-up of concessional finance is critical to bridging the gap between current investments and the substantial capital required to realise the potential of low-carbon and renewable hydrogen in EMDEs.

However, to realise this potential, it is essential to develop a robust financial and policy framework that supports large-scale investments. This includes creating conducive policy environments, building technical capacity, and ensuring that financial instruments are co-ordinated, accessible and effective. Mobilising private sector financing, alongside and leveraged by international public finance is critical to achieving the necessary scale and impact.

WHAT PROGRESS HAS BEEN MADE?

We assess that good progress has been made towards our recommendations of last year, particularly in terms of the identification of viable projects being delayed by high costs of capital and other obstacles to investment, as well as the mapping of risks and barriers hindering progress. However, this has not yet been translated into financial resources to bring projects beyond FID stages.

Since September 2023, two reports on hydrogen financing have been released: [Financing cost impacts on cost competitiveness of green hydrogen in emerging and developing economies](#), published in November 2023; and [Scaling Hydrogen Financing for Development](#), in February 2024. These reports highlight the critical role of policy and financial risk mitigation mechanisms in reducing the funding gap and cost of hydrogen generation. The Scaling Hydrogen Financing for Development report was published by the

World Bank, ESMAP, OECD, G20 GIF, and the Hydrogen Council, including a mapping of risks, financial and technical assistance on low-carbon and renewable hydrogen in developing countries. The global review was finalised with 44 responses from international organisations, government agencies, and development financial institutions, and a brief on the outcomes of the global review was launched.

The report highlights that progress in actual deployment and investment varies significantly by region. The majority of low-carbon and renewable hydrogen projects that reached FID between 2022 and 2023 are in North America (USD 10 billion), Europe (USD 7 billion), China (USD 5 billion), and the Middle East and North Africa (USD 5 billion). Despite promising announcements, the conversion of these projects into actionable investments remains limited, reflecting a disconnect between ambition and financial commitment. The situation is particularly challenging in EMDEs excluding China, with only a small amount of large-scale (>10 MW) renewable hydrogen projects in the pipeline having reached later stages of development.

UNIDO has been taking steps to advance low-carbon and renewable hydrogen projects in developing economies through two of its programmes. The GEF-8 [Global Clean Hydrogen Programme](#) is a country-specific mapping effort of stakeholders, needs and priorities of developing economies for low-carbon and renewable hydrogen projects. Participating countries include Algeria, Ecuador, Egypt, Malaysia, Namibia, Nigeria, the Philippines, and South Africa, with further co-operation foreseen with Brazil through the UK-Brazil Hydrogen Hub. The expected outputs of the programme include specific finance-oriented outcomes, including capacity-building for clean hydrogen financing, the development of risk mitigation strategies for clean hydrogen projects, and innovative financing options, as well as country assistance for improving financial mechanisms. UNIDO is identifying global partners to support the programme and provide tailored technical and financial assistance. In addition, UNIDO's A2D Facility (as detailed earlier in this Chapter), launched in 2023, will offer grants to support innovative pilot projects in developing countries, aiming to close the gap between early-stage projects and commercial-scale projects.

A 10 GW Lighthouse Initiative is currently being established by the World Bank Group, involving governments, MDBs, and development finance institutions (DFIs), designed to boost the low-carbon and renewable hydrogen industry in EMDEs by getting more projects to the FID stage by 2030 through concessional finance and grants, including the promotion of tools for prioritising and assessing projects, initially drawing from the existing pipeline of projects, and comprehensive guidelines covering critical aspects of the supply chain necessary for low-carbon and renewable hydrogen project development. This initiative aims to promote mid- to large-size lighthouse projects (100 MW to 1 GW) with a total electrolyser capacity of 10 GW or more in EMDEs, excluding China.

The Industrial Transition Accelerator (ITA) was launched at COP 28 to support project delivery and policy design and implementation in selected countries. This initiative focuses on two pillars: supporting project development and enabling conditions for investment. The objective is to progress a portfolio of deep decarbonisation projects towards FID over the next 2 to 3 years in three or four specific geographies, prioritising EMDEs. Sectors covered by the ITA include aluminium and cement, as well as sectors using or with the potential to use hydrogen derivatives, such as chemicals, steel, aviation and shipping.

ITA is currently establishing partnerships with national governments to mobilise domestic and international industry, energy, demand and finance actors in support of a pipeline of projects in each geography. Additionally, the ITA aims to strengthen the investment case for projects globally by growing global uptake of key policy, value chain and finance solutions, facilitating a broader cohort of projects than those directly supported. In July 2024

Brazil was announced as the [first country partnership](#), including a call for Expressions of Interest to invite private sector organisations to participate, in co-ordination with the Brazil-UK Industrial Decarbonisation Hub.

The European Union [has committed](#) a total of EUR 53.9 million (EUR 59.9 million) in funding for “green” hydrogen and renewable energy projects across Africa, with EUR 36.9 million specifically allocated for investments in Namibia.

As part of this initiative, the European Union has also pledged EUR 50 million to hydrogen-focused funds in Namibia and South Africa, including EUR 25 million for the SDG Namibia One fund, a key supporter of the 3GW Hyphen Hydrogen Energy project. The allocation of the remaining EUR 25 million is yet to be determined.

WHAT MORE NEEDS TO BE DONE?

Despite the good progress made towards last year’s recommendations, critical areas still need to be addressed to unlock the potential of low-carbon and renewable hydrogen, particularly in EMDEs, and to translate advances in knowledge into investment and facilitate the deployment of finance at scale.

Collaboration between governments, international financial institutions, and the private sector can contribute to overcome the existing barriers to investment. The establishment of platforms that facilitate access to finance, coupled with the identification and support of high-impact projects, will be instrumental in driving this priority action forward.

Building on the progress made in information and knowledge dimensions, it is crucial to design and deliver comprehensive financial and de-risking mechanisms to reduce the cost of capital, which are tailored to the unique challenges of hydrogen projects and diverse geographies. This involves leveraging a range of financial instruments, such as partial credit guarantees, political risk insurance, and local currency support, to mitigate risks and reduce the cost of capital for clean hydrogen initiatives (elements that have been embedded into the assistance programmes described above), as well as price guarantee mechanisms and support for infrastructure development through public-private investment mechanisms, among others. Enhancing the alignment of these instruments with existing and emerging climate finance initiatives and instruments, as well as the inclusion of a wider pool of stakeholders, can also contribute to achieving these objectives.

Focus now needs to shift towards delivery, especially with regards to investment in and de-risking of individual projects, particularly, but not limited to, those identified under the 10 GW Lighthouse Initiative and through the global surveys led by The World Bank and UNIDO.

To ensure the success of these projects, resource mobilisation needs to be prioritised by engaging partner financing organisations and fostering dialogue with the private sector, including supporting country-specific project pipelines and providing appropriate, tailored, and co-ordinated support, including through the full funding and implementation of ongoing assistance programmes.

Ensuring additionality and inclusion in the delivery of support and assistance programmes is critical, by addressing more diverse beneficiary geographies and projects, beyond traditional target countries.

Efforts should also be directed towards enhancing knowledge-sharing, including building capacity within national systems. This includes promoting training and capacity-building

initiatives to support the creation of enabling environments in EMDEs, including policy design, pre-investment financing, financing instruments and de-risking mechanisms.

RECOMMENDATION H4 HAS BEEN UPDATED AS FOLLOWS:

Governments, MDBs, DFIs and relevant technical partners should work to deliver and scale up support by financing instruments and de-risking mechanisms, particularly for viable projects that are being delayed by high costs of capital and other obstacles to investment. This should include appropriate and co-ordinated technical and financial assistance, particularly in developing countries, to assist governments with policy design.

RECOMMENDED REPORTS

We recommend the following reports for more detailed descriptions of the technologies for low-carbon and renewable hydrogen, and of the actions that countries and businesses can take individually:

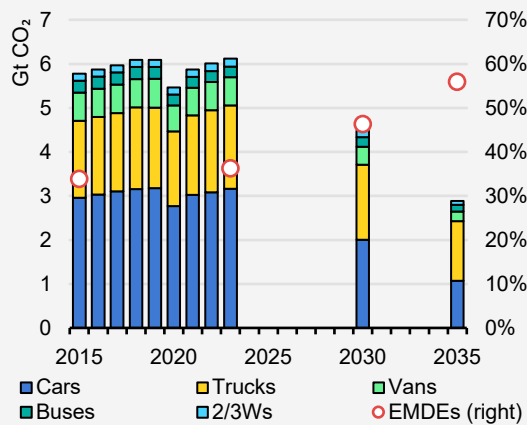
- IEA (2019), [The Future of Hydrogen](#)
- Energy Transitions Commission (2021), [Making the Hydrogen Economy Possible: Accelerating Clean Hydrogen in an Electrified Economy](#)
- IEA (2023), [Global Hydrogen Review 2023](#)
- IEA (forthcoming), [Global Hydrogen Review 2024](#)
- IPHE (2022), [International Trade Rules for Hydrogen and its Carriers: Information and Issues for Consideration](#)
- IRENA (2023), [Creating a global hydrogen market: Certification to enable trade](#)
- IEA (2023), [Towards hydrogen definitions based on their emissions intensity](#)
- IPHE, H2 TCP, Hydrogen Council (2023), [Hydrogen Certification 101](#)
- UNIDO, IRENA (2024), [Green hydrogen for sustainable industrial development: A policy toolkit for developing countries](#)
- OECD, World Bank (2024), [Scaling Hydrogen Financing for Development](#)
- IRENA (2024), [International Co-Operation To Accelerate Green Hydrogen Deployment](#)
- IRENA (2024), [Green hydrogen strategy - A guide to design](#)

CHAPTER 4. ROAD TRANSPORT

STATE OF THE TRANSITION

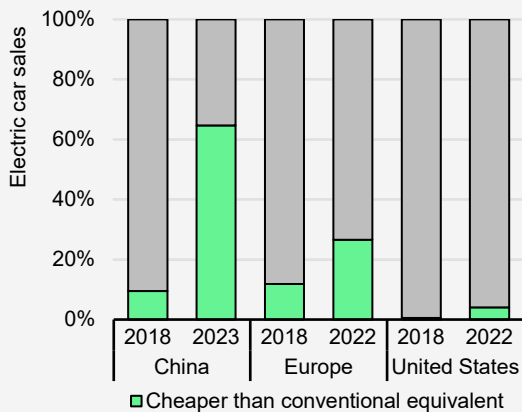
Sales of zero-emission vehicles (ZEVs) are making rapid progress: 18% of all cars and 13% of two- and three-wheelers (2/3Ws) sold in 2023 were [electric](#), even as overall light-duty vehicle (LDV) sales exceeded pre-pandemic levels. Sales of electric vans, buses and trucks are increasing, but far quicker uptake is needed to meet net zero ambitions.

Emissions



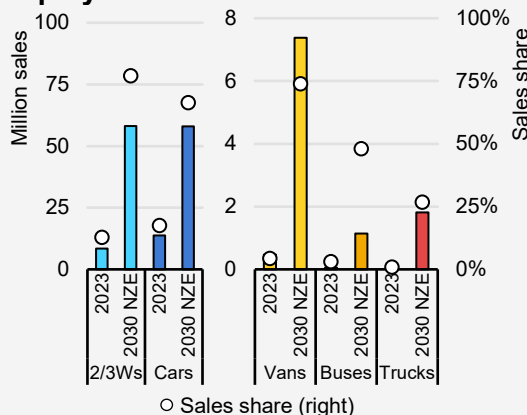
- Direct road CO₂ emissions from fossil fuel combustion have risen by 350 Mt CO₂ since 2015, reaching 6.1 Gt CO₂ globally, of which 35% is in emerging markets and developing economies (EMDEs).
- These emissions need to fall by 1.7 Gt CO₂ (30%) by 2030 and 3.2 Gt CO₂ (55%) by 2035 relative to 2023 to align with the IEA Net Zero Emissions by 2050 Scenario ([NZE Scenario](#)).

Price



- Affordability is key to faster uptake. Market competition, economies of scale, vehicle size, and battery prices all play a role in the price of electric vehicles (EVs).
- In China, [60%](#) of electric cars sold in 2023 were cheaper (based on purchase price, with no subsidy) than their conventional equivalents. Outside China, trends suggest that purchase price parity could be reached by 2030 for many models in major markets.

Deployment



- EV market shares are growing particularly in the car (18% of sales) and 2/3Ws (13%) segment.
- Electric vans, buses and trucks account for under 5% of sales today and need to be deployed far more quickly to get on a pathway compatible with net zero CO₂ emissions by 2050.

STATE OF INTERNATIONAL COLLABORATION

International collaboration on [road transport decarbonisation](#) has resulted in several high-level declarations or agreements over the past year, such as in communiqués by the Group of Seven (G7) or by the United Nations Economic Commission for Europe (UNECE). Combined with significant policy developments in major markets, this signals increased commitment to a long-term vision for electrification. EVs have emerged as the front-runner technology among ZEV options, which represents progress in the transition beyond earlier stages of market adoption. Accelerating ZEV deployment will require further action across more modes of transport – particularly medium and heavy-duty vehicles (M/HDVs) – and increased support for EMDEs, ramping up recent efforts.

In this chapter of the report, we assess progress on international collaboration on road transport against the recommendations made in the [Breakthrough Agenda Report 2023](#). This assessment draws on interviews with multilateral initiatives active in this space, as well as further research and analysis. A summary of this assessment is provided in the table below.

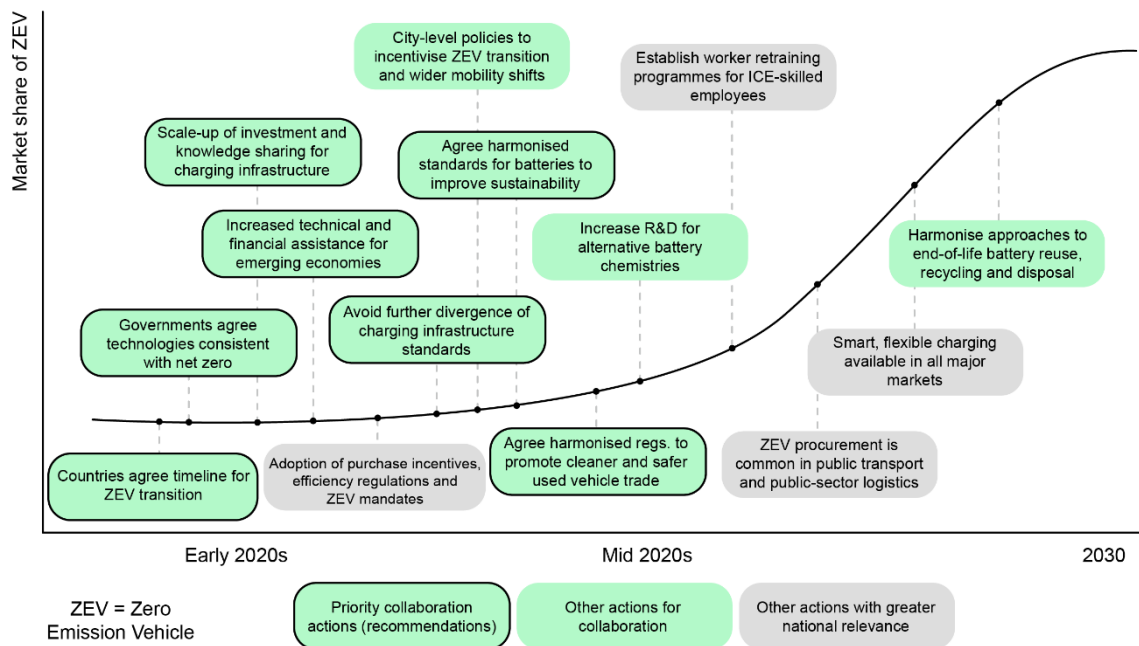
Area	What key progress has been made?	What more needs to be done?	2024
RT1. Long-term vision	<ul style="list-style-type: none"> National legislation in large markets, such as new CO₂ emissions standards for cars and trucks in the European Union and the United States, and ZEV regulation in Canada and the United Kingdom. Adoption of the UNECE global decarbonisation strategy for road transport (and other inland modes) by 2050 by a broad set of countries. 	<ul style="list-style-type: none"> Agree on a global decarbonisation pathway, with greater focus on trucks, buses and vans, learning from the successes for cars and 2/3Ws. Move towards implementation through policies that create demand, such as lower emissions standards and ZEV sales requirements. Expand global dialogue on industrial development, manufacturing, and trade of ZEVs, and their impact on the pace of the transition. Explore challenges associated with the increasing size of passenger vehicles. 	Moderate (=)

Area	What key progress has been made?	What more needs to be done?	2024
RT2. Finance and investment	<ul style="list-style-type: none"> ZEV pilots in EMDEs are starting operations and expanding to more countries (e.g. Senegal, India, Peru, Ghana, Brazil, Chile). Up to 20% of targeted funds have been raised under the Global Facility to Decarbonise Transport so far, with aims to leverage USD 1.2 billion in World Bank financing by mid-2025. 25 EMDEs are eligible for technical assistance under the ZEV Rapid Response Facility. A governance framework for delivering the ZEV Transition Council roadmap is expected at COP 29. 	<ul style="list-style-type: none"> Expand the scale of financial and technical assistance by leveraging private sector collaboration, demand aggregation and blended finance. Accelerate pilot projects aiming to increase low-cost financing in EMDEs, scale them up, and expand to more regions. Enhance awareness of available funding for EMDEs and build capacity to develop projects that are eligible for funding and respond to local priorities. Improve mechanisms to collect data on funds and information on ongoing pilots to track progress and share learnings publicly. 	Moderate (=)
RT3. Supply chains	<ul style="list-style-type: none"> High-level agreement and progress towards binding legislation relating to battery supply chains in major markets. Second wave of pilot projects for digital battery passports, with first learnings expected at COP 29. Increasing discussion of battery end-of-life strategies in EMDEs. 	<ul style="list-style-type: none"> Scale up battery passport pilots and work towards global harmonisation of standards. Set standards for battery recycling, ramp up recycling capacity and develop EV end-of-life strategies, especially in EMDEs, supported by financial and technical assistance. Assess and mitigate risks in battery supply chains to improve security and resilience. 	Good (↑)

Area	What key progress has been made?	What more needs to be done?	2024
RT4. Infrastructure	<ul style="list-style-type: none"> Shared vision on HDV charging technology and standards between the European Union and the United States. Increasing support for charging infrastructure in national legislation, such as in the European Union and the United States. Identification of pilot projects for ZEV freight corridors. 	<ul style="list-style-type: none"> Bring transport, power and finance stakeholders together around infrastructure projects at the interface between power, grids, and charging, leveraging data and shared learnings to optimise infrastructure planning. Accelerate pilots for HDV charging along freight corridors, especially those spanning borders, and expand them to more regions. Decide on global charging equipment standards and interoperability requirements. 	Moderate (=)
RT5. Trade conditions	<ul style="list-style-type: none"> Local regulatory progress on used LDV imports in more EMDEs. Moderate steps towards aggregation and publication of data on used LDV and HDV trade, although there are challenges relating to data scarcity. 	<ul style="list-style-type: none"> Further discussions between importing and exporting countries to find consensus on global standards for used vehicle exports in order to take polluting vehicles out of international trade, and on standards for ZEV refuelling and end of life. Set up harmonised mechanisms to assess and enforce compliance, with necessary support for developing technical capacity in EMDEs. 	Moderate (↓)

Notes: The arrows indicate relative progress compared to last year’s assessment in the 2023 Breakthrough Agenda Report. “↑” indicates an improved assessment; “↓” indicates a downward assessment; “=” indicates the same assessment.

Figure 4.1 Critical path to 2030 for the road transport sector



IEA. CC BY 4.0

Source: [Breakthrough Agenda 2023](#)

ALIGNING THE PACE OF THE TRANSITION INTERNATIONALLY TO SHIFT INVESTMENT AND ACCELERATE COST REDUCTION

OVERVIEW

Last year, we recommended that governments should agree on a time by which all new road vehicle sales should be ZEVs, noting that large vehicle markets and manufacturers were still absent from global initiatives. We also recommended that targets be supported by clear implementation plans including all vehicle types – not only LDVs but also M/HDVs and 2/3Ws.

At COP 27, countries nominated the [Accelerating to Zero Coalition](#) (A2Z) to co-ordinate action and track progress across the major initiatives featured in the table below, which aim to achieve close to a 100% ZEV share of new vehicle sales within the 2030-2040 period, in line with [recommendations](#) from the International Council on Clean Transportation ([ICCT](#)).

Table 4.1 Targets for zero-emission vehicles under major initiatives

Initiative	Scope	Target	Stakeholders
ZEV Declaration	LDVs	100% ZEV sales for cars and vans by 2035 in leading markets and by 2040 globally	National governments (43), subnational governments (80), and private or other (110)

Initiative	Scope	Target	Stakeholders
Clean Energy Ministerial Electric Vehicles Initiative (CEM-EVI)	LDVs & HDVs	100% ZEV civil government fleets by 2035 (Zero-Emission Government Fleet Declaration)	National governments (9 of 16 EVI members signed the government fleet declaration)
EV100	LDVs	100% electric (signatory owned and contracted) van and MDV fleet by 2030	Private (128)
EV100+	HDVs	100% ZEV MDV purchases by 2030 and 100% ZEV MDV operations by 2040 in leading markets (e.g. OECD, China, India)	Private (5)
Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles (Global MoU)	M/HDVs	30% ZEV M/HDV sales by 2030, 100% sales by 2040, to facilitate achievement of net zero CO ₂ emissions by 2050	Public (36); public subnational (9), and private (142)
First Movers Coalition's trucking commitment	HDVs	100% ZEV MDV and 30% ZEV HDV purchases and contracts by 2030, 100% by 2040	Private (16)

Notes: Signatory numbers as of mid-July 2024. This table covers initiatives under which signatory governments or companies set ZEV targets for themselves, but does not include other important initiatives providing research, analysis and advocacy to inform these targets and support implementation (e.g. Global Fuel Economy Initiative [[GFEI](#)]).

To put these commitments in context, electric car [sales](#) were up 35% in 2023 relative to 2022, to reach 18% of all cars sold, driven by market competition, policy and technology improvement. In more than 25 countries, electric cars now account for over 5% of all cars sold, an indicative potential tipping point of broader market uptake. In China, nearly 40% of cars sold in 2023 were electric, and around 60% of the electric cars sold in the same year were cheaper than their internal combustion engine (ICE) direct equivalents. In other regions – including Europe, the United States, and across EMDEs – electric cars remain more expensive in many cases, although continued policy support and competition are bringing down costs. Meanwhile, electric HDV sales are increasing, but remain behind in absolute terms; in EMDEs, 2/3Ws are the most electrified segment given their [prevalence](#) and affordability.

WHAT PROGRESS HAS BEEN MADE?

We assess that moderate progress has been made against our recommendation from last year.

In 2023-2024, there has been progress on two core fronts: firstly, policy developments seeking to accelerate the pace of the transition, supported by the work of multilateral initiatives and voluntary commitments; and secondly, high-level adoption of a global decarbonisation strategy for road transport by 2050 among a broader set of countries.

Significant new policies were implemented in large vehicle markets, indicating an important move from non-binding shared commitments to binding legislation. In the European Union, there were several developments in 2023-2024. In April 2023, new CO₂ emission performance standards were passed for new [cars and vans](#) in the internal market, targeting

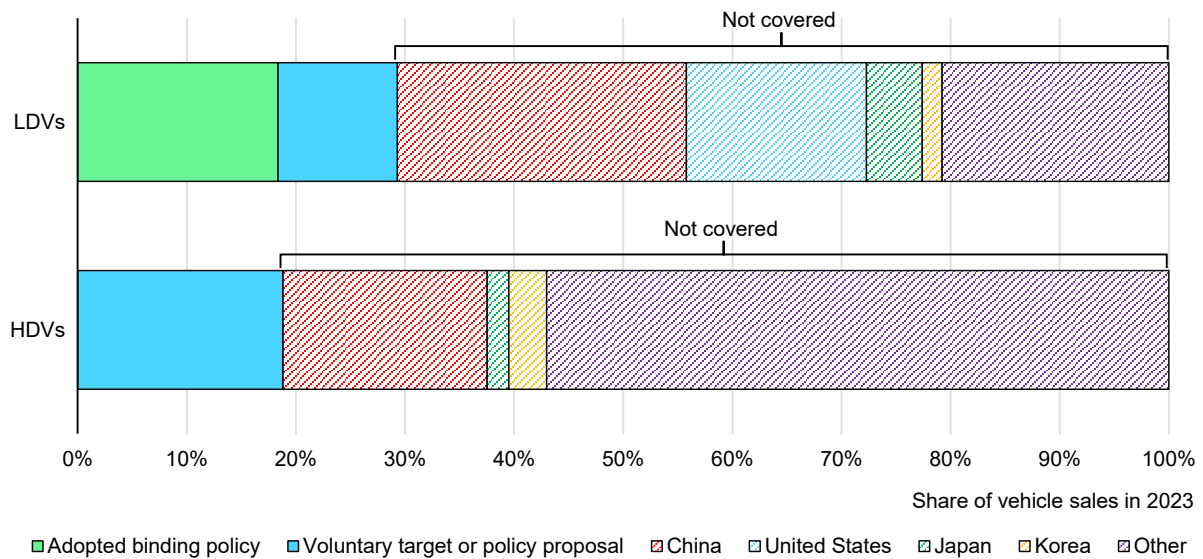
100% ZEV from 2035, and in May 2024, CO₂ emissions standards for [HDVs](#) were tightened as well, such as for urban buses, which should all be zero-emission from 2035. In April 2024, [Euro 7](#) regulations were also adopted, setting new pollutant emissions standards for cars, vans and trucks, as well as battery durability requirements. In March 2024, the United States announced new GHG emissions standards for [cars and trucks](#) for the 2027-2032 period, as well as multi-pollutant standards for [L/MDVs](#). Other important developments include [Canada's](#) Electric Vehicle Availability Standard targeting 100% ZEV LDV sales by 2035, and the [United Kingdom's](#) goal of 100% zero-emission car and van sales by 2035. Such supply-side measures (e.g. fuel economy, CO₂ standards, ZEV mandates, ICE bans) provide strong signals to industry by requiring compliance from manufacturers and efforts to bring more affordable models to market. These policy developments have benefited from years of collaborative work within multilateral initiatives, as well as knowledge-sharing and advocacy.

Emerging consensus on the pace of the transition is reflected in recent G7 communiqués. In 2024, G7 governments collectively [committed](#) to “accelerate vehicles fleet turnover in Paris-aligned trajectory through economic policy measures” and to support the commitment to “reduce global GHG emissions by around 43% by 2030 and 60% by 2035, relative to the 2019 level”. In the transport-specific communiqué of 2024, G7 Transport Ministers reaffirmed their “[commitment](#) to a highly decarbonized road sector by 2030”, following up on the 2023 communiqué, in which they noted “the [opportunity](#) to collectively reduce by at least 50%, CO₂ emissions from G7 vehicle stock by 2035 or earlier relative to the level in 2000 as a halfway point to achieving net zero”. However, the communiqués do not provide a time by which all vehicle sales should be zero-emission in G7 countries.

At COP 28, parties endorsed the outcome of the [Global Stocktake](#) and called for an acceleration of “the reduction of emissions from road transport on a range of pathways, including through development of infrastructure and rapid deployment of zero- and low-emission vehicles”. However, similarly to G7 communiqués, no timeline for ZEV deployment has been agreed. There is an opportunity for governments to set ZEV targets as part of their nationally determined contributions as they respond to the Global Stocktake.

Nevertheless, progress is uneven across segments. For zero-emission cars, electrification is expanding quickly and getting closer to a pathway compatible with net zero emissions by 2050. Shared commitments in this space have contributed to accelerating the pace of the transition. To put things in perspective, in 2017, the CEM-EVI [EV30@30 campaign](#) had set the target of reaching an EV sales share of 30% by 2030, with the [backing](#) of several key markets including China, India, Japan and Germany. In 2021, under the ZEV Declaration, governments agreed on a more ambitious timeline to reach a 100% sales share for cars and vans by 2035 in leading markets, and by 2040 globally. Shared commitments are still gaining momentum, especially among smaller countries, indicating a growing global consensus.

Figure 4.2 Share of global vehicle sales covered by zero-emission vehicle commitments, by country, 2023



IEA. CC BY 4.0

Notes: LDV = Light-duty vehicle; HDV = Heavy-duty vehicle. The methodology behind this figure has been improved since the last Breakthrough Agenda Report to better reflect country commitments. With the same methodology, the share of covered LDV sales in the last report would have been similar. “Adopted binding policy” refers to Paris-aligned ZEV legislation and can include countries beyond signatories of existing initiatives. “Voluntary target or policy proposal” refers to shared commitments such as the ZEV Declaration or the Global MoU, and other policy proposals that are not yet binding legislation. Only declarations at the national level are counted as “covered”; subnational government declarations are not. Other shared commitments and aspirational targets for road transport decarbonisation by 2050 that do not specifically set a timeline for ZEV sales are not counted, such as the recent [UNECE strategy](#) to reduce GHG emissions from inland transport.

Source: IEA analysis based on official country submissions, also see the IEA (2024) [Global EV Outlook 2024](#), and updates to the A2Z [COP 28 Progress Update](#).

Based on [reporting](#) by A2Z at COP 28 and developments as of mid-2024, we estimate that 29 countries, representing 18% of LDV sales in 2023, have adopted Paris-aligned binding policies for LDVs (including but not limited to signatories of the ZEV Declaration), and that an additional 25 countries have set voluntary political ZEV targets or proposed policies, covering another 11% of global LDV sales in 2023. These commitments combined aggregate to just under 30% of global LDV sales in 2023. This number has not increased much since 2022, but the distribution between binding versus proposed policy changed slightly, as a few countries passed legislation (e.g. Canada, the United Kingdom). Furthermore, Nigeria and Colombia [joined](#) the ZEV Declaration in May 2024, bringing the total to 18 EMDEs committed to reaching 100% zero-emission car and van sales by 2040. It is important to note, however, that some large car markets, especially in Asia, are not signatories.

In contrast, heavier segments of road transport – and especially trucks – are at an earlier stage of the transition. While many models of electric trucks are already [on the market](#) (e.g. over 150 models of battery-electric M/HDVs were available in China in 2023, and over 100 in North America), the sector lacks a wider commitment and supportive measures to transition at the required pace. At COP 28, A2Z and the Global MoU [reported](#) that 27 countries had set voluntary political ZEV targets for M/HDVs and buses, and 6 other countries (Cape Verde, Colombia, Ghana, Iceland, Israel, and Papua New Guinea) had [joined](#). Since then, 3 others have joined (Costa Rica, Tonga, and Seychelles), bringing the total to [36 nations](#) committed to reaching 100% zero-emission bus and truck sales in 2040. These trends indicate increasing appetite among EMDEs, which also get access to the

ZEV Rapid Response Facility (ZEV-RRF) for technical assistance to develop ZEV policies by signing the ZEV Declaration and the Global MoU. However, for the most part, the new signatories are small HDV markets and so the share of the global market covered by these commitments increased only marginally between 2022 and mid-2024 and remains at roughly 20%. Meanwhile, key HDV markets such as China, Germany, India (with the exception of the state of Goa, which [joined](#) in December 2023), Japan, Korea, Mexico, and other Southeast Asian economies are not yet signatories.

In February 2024, UNECE [adopted](#) a first-of-a-kind global decarbonisation strategy for road transport and other inland transport modes (such as rail and inland waterways) by 2050. While the roadmap sets an “[aspirational goal](#) of net zero GHG emissions from inland transport by 2050”, it falls short of setting a specific time by which all new road vehicle sales should be zero-emission. Nevertheless, it demonstrates a “raising of the bar” among a broader set of countries – 56 member states in Europe, North America, Oceania, Africa and Asia – and an encouraging step forward as countries seek to decarbonise, considering different national circumstances and approaches. The strategy includes a toolkit of over 60 legal instruments, an action plan with more than 50 milestones for implementation, and a dedicated section on partnerships and international collaboration.

WHAT MORE NEEDS TO BE DONE?

More remains to be done for governments to align behind the existing commitments for transitioning all new vehicle sales to zero-emission in order to get on track with the aim of the Paris Agreement – while considering national specificities and the range of possible pathways. This is particularly true for HDVs and the timelines set under the Global MoU. There are at least two areas where international collaborative efforts can make a difference: firstly, through shared commitments on the pace of the transition for zero-emission HDVs, particularly trucks, buses and vans; secondly, implementing these commitments through policies to create demand for zero-emission HDVs and to support their associated industrial development, manufacturing and trade.

More emphasis on trucks, buses and vans is needed to get on track with a pathway to net zero. In the NZE Scenario, electric trucks reach a sales share of over 25% in 2030, up from under 1% in 2023. Over the same period, electric buses reach over 50% from just 3%, and vans nearly 75% from under 5%. Despite this push, CO₂ emissions from trucks, buses and vans overtake those of cars by 2030 in the NZE Scenario, as the passenger car segment is increasingly decarbonised through the rapid uptake of electric cars. This calls for a potential priority shift from cars to heavier modes, strengthening existing initiatives such as the [Global MoU](#). The decarbonisation opportunity in medium and heavy segments is significant. In India, for example, M/HDVs accounted for under 2% of vehicle sales in 2023 but were responsible for over 30% of road transport CO₂ emissions – as well as generating air pollution in and around cities and logistics hubs.

Governments should work together on a global decarbonisation pathway and share learnings throughout implementation, building on existing initiatives. Shared commitments with clear targets and planning can help set the pace of the transition and accelerate the initial stages of market uptake, shifting and accelerating industrial investment in ZEV technologies through strategic public-private co-operation, achieving economies of scale, and bringing down costs more quickly. After this, global competition, industrial policy, and increasing affordability add momentum to the transition, as seen in the case of electric cars. Governments in large M/HDV markets should decide on a trajectory for the segment that is compatible with the NZE Scenario and implement it through strong national policy. In the

absence of policy, corporates should double down on supporting the transition with voluntary targets and investment along their logistics routes.

International collaboration can also help to foster sharing of knowledge and good practice throughout implementation, especially with regards to the types of policy instrument with proven records of increasing adoption, and those that could further accelerate change, such as ZEV mandates. In the case of M/HDVs, governments should also share learnings relating to power distribution and charging infrastructure so that grid development is undertaken along with ZEV deployment (e.g. to serve freight depots where loads are centralised). Looking at specific use cases of HDV electrification can help translate commitments into action, by developing compelling business models (e.g. at ports, along freight corridors, close to production facilities and distribution hubs) and learning from current pilot projects.

Governments should expand the global dialogue on industrial development, [manufacturing](#), and trade. In 2023-2024, the number of manufacturing and trade policies related to clean energy technologies – particularly for EVs and batteries – has significantly increased. Countries are seeking to position themselves in [growing global supply chains](#) and to develop their domestic industries, and are putting in place policies towards this end, such as incentives and subsidies for manufacturing, as well as trade policies such as tariffs, which may affect deployment of EVs in the near term. As they do so, governments should ensure that the trajectory in the transport sector remains Paris-aligned, and assess the potential impact of new industry, manufacturing and trade policy on ZEV deployment and the pace of the transition. As countries develop critical minerals supply chains, they should also agree on [core principles](#) such as those developed by the UN Secretary General's Panel on Critical Energy Transition Minerals.

In addition, governments should collectively explore the challenges associated with increasing demand for [larger cars and light trucks](#). In 2023, nearly 60% of battery-electric cars sold globally were large models, against just over 20% in 2018. Larger electric cars have a significant impact on battery supply chains and critical minerals, and they are far more expensive than smaller cars, hindering mass-market adoption. Co-ordinating regulation across countries (e.g. weight-based tax, vehicle or battery size or weight standards) can make compliance more efficient for manufacturers, and increase aggregated demand for smaller ZEVs, [making them more attractive](#), thereby accelerating global ZEV uptake while decreasing the impact on critical mineral demand. In Europe, several countries have initiated [legislation on car size](#), providing a good basis for knowledge-sharing, and setting a common trajectory within existing multilateral initiatives.

RECOMMENDATION RT1 HAS BEEN UPDATED AS FOLLOWS:

<p>Governments should commit to a Paris-aligned timeline by which all new road vehicle sales should be zero-emission, particularly for trucks, buses, and vans, backed by interim targets and clear implementation plans by 2030 and 2035. Governments should put effective laws, policies and programmes in place to implement these commitments, such as ZEV mandates, and share learning throughout implementation, particularly with emerging markets and developing economies.</p>

PROVIDING INTERNATIONAL ASSISTANCE TO EMERGING ECONOMIES

OVERVIEW

Last year, we recommended that governments and international organisations increase low-cost financing to accelerate ZEV adoption in EMDEs, focusing on ensuring that emerging economies are aware of and have ready access to technical assistance and financing offers, and ensuring the effectiveness of project delivery and policy development support.

Decarbonising road transport is capital intensive, which is challenging for EMDEs, given their exposure to [higher costs of capital](#) compared to advanced economies. Alongside access to finance, EMDEs can benefit from assistance to build capacity for policy design and implementation. These needs are clearly identified in the [Roadmap to 2030](#) published by the ZEV Transition Council ([ZEVTC](#)) International Assistance Taskforce (IAT) at COP 28, which will be updated at COP 29 with inputs from a broad range of countries and partner international organisations and a new governance framework to support implementation efforts.

WHAT PROGRESS HAS BEEN MADE?

We assess that moderate progress has been made against our recommendation from last year.

Much of the work in 2023-2024 has focused on designing and running pilot projects for international financial and technical assistance to EMDEs. Pilots are an important step before scaling up: they help identify what countries are really interested in, contribute to developing technical capacity locally, and provide useful learning about financing strategies and policy frameworks that can support ZEV uptake.

The Global Facility to Decarbonise Transport ([GFDT](#)), a multi-donor trust fund established at COP 26 to provide financial and technical assistance to EMDEs for transport decarbonisation through the World Bank, has been expanding its activities and list of [grantees](#). Since it was created, GFDT-funded activities have engaged 13 countries and 94 government entities via advisory services, technical support and capacity-building. In 2023, the GFDT [allocated](#) around USD 3 million in grants for seven activities promoting transport decarbonisation in EMDEs, after these were selected in late 2022. Some of these activities focus on ZEV deployment, but not all of them. GFDT expects to catalyse USD 480 million in World Bank lending operations across three of them: USD 200 million for bus electrification in Ghana, USD 150 million for electric mobility in India, and USD 130 million for promoting sustainable transport in Peru. Overall, GFDT aims to mobilise USD 1.2 billion in World Bank financing by mid-2025. In its [concept note](#) in 2021, the GFDT had targeted government grants worth USD 200 million by 2031 to fund its activities and leverage World Bank lending capacity. Estimates as of mid-2024 suggest up to 20% of these have been raised so far.

Beyond its role in the GFDT, the World Bank carries out financing operations in EMDEs as part of its historic transport practice, with an increasing number of electric mobility projects. Since 2016, the World Bank has [supported](#) 32 countries with lending and knowledge work in this area. One important achievement in 2023-2024 was the start of operations of a pilot project for an electric bus system in [Senegal](#), worth USD 430 million. Other ongoing projects include technical assistance on demand aggregation as India seeks to procure

50 000 domestically produced electric buses, with a [payment security mechanism](#) of USD 150 million from the US government and philanthropic partners, and another USD 240 million from the government of India; electrification of São Paulo's public transport in [Brazil](#), with USD 500 million committed over the 2025-2029 period; and support to [Chile](#) in purchasing nearly 1 000 electric buses, with around USD 300 million in loans. There are expectations of larger, regional projects from 2025 onwards, notably in Africa, to scale up from pilots to multi-country programmes that can pull resources together and aggregate demand to improve the business case.

At COP 27, governments, corporates, and financial institutions created the Collective for Clean Transport Finance (CCTF), hosted by the World Business Council for Sustainable Development ([WBCSD](#)), to spearhead pilot projects that help accelerate ZEV deployment in EMDEs. Several such pilots were [announced](#) at COP 28, such as on electric buses in India (see link above) as well as [electric trucks](#), and in sub-Saharan Africa through the GFDT. In 2024, CCTF also started designing a possible pilot project with Brazil on demand aggregation for electric buses, which could provide a framework to replicate in other countries.

The ZEV Emerging Markets Initiative ([ZEV-EMI](#)), which was created jointly by the WBCSD, the United States, the United Kingdom and other governments under the ZEVTC at COP 27, has also been contributing to important pilots, such as on [electric trucks](#) in India (also mentioned above), which in July 2023 signalled aggregate demand for 5 000 electric trucks by 2027 and 7 700 by 2030. ZEV-EMI is also introducing [good practice](#) approaches for financing and public-private collaboration aimed to increase private investment and put forward public policy supportive of ZEV deployment, with initial collaborative agreements in 2023 with India and Mexico, and ongoing discussions to expand these to two to three other EMDEs.

The ZEVTC has also been running several activities on international assistance over the past year. At COP 27, governments created the ZEV Rapid Response Facility (ZEV-RRF) under the ZEVTC to provide technical assistance quickly when needed by governments. At COP 28, USD 400 000 in additional funding was announced to scale the ZEV-RRF. As of mid-2024, 25 EMDEs were eligible for the ZEV-RRF, but we could not track how many have received technical assistance to date.

Through the Country Cluster Initiative, which is being tested until COP 29 with the view to scale-up in 2025, the ZEVTC seeks to convene countries with similar interests (e.g. developing capacity on supply-side regulation, end-of-life strategies) and provide grouped technical assistance. This is complementary to the more bilateral Country Partnerships, such as the one with India, which generated valuable [learning](#) in 2023-2024 on the EV financing landscape ahead of a possible scale-up into a multi-annual capacity-building programme.

WHAT MORE NEEDS TO BE DONE?

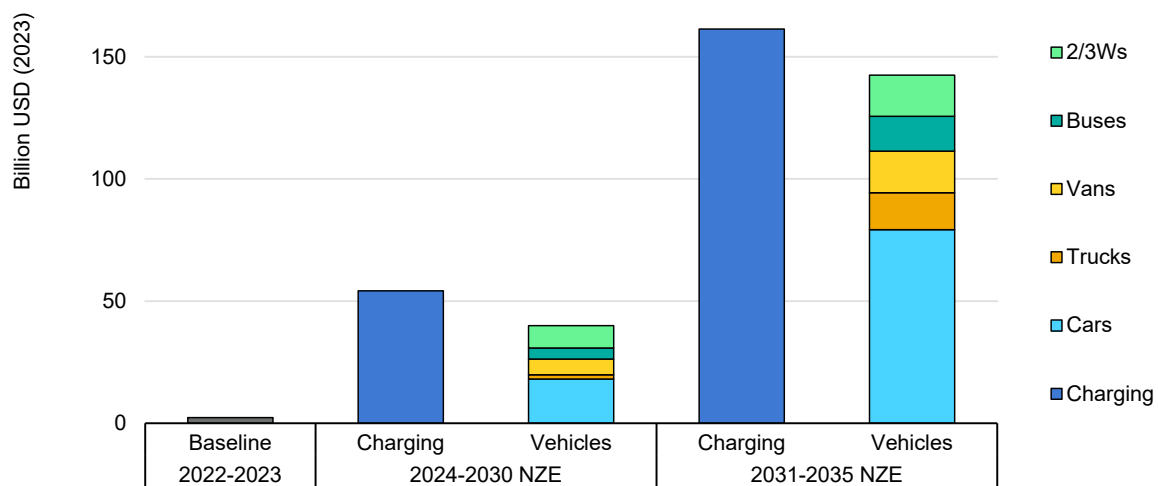
Priorities in this space are now well identified, especially with regards to lowering the cost of capital to [scale investments](#) and accelerate ZEV adoption in EMDEs, and important findings are being generated through pilot projects. The number of pilot projects is increasing, as is funding, but the scale of financial and technical assistance still needs to expand.

In 2022-2023, [investment spending](#) for road transport electrification (comprising both investments for charging infrastructure and spending on vehicles) in EMDEs stood around USD 2 billion. This is much lower than the global total across all countries, which stands at

USD 115 billion, indicating that investments for road transport electrification in EMDEs today are very low. The necessary investments for charging infrastructure in EMDEs ramp up very quickly in the NZE Scenario, exceeding expenditure on vehicles: over USD 50 billion per year on average over the 2024-2030 period, and USD 160 billion per year over the 2031-2035 period (Figure 4.3). When considering the capital required to ramp up other steps in the value chain, such as manufacturing, critical mineral supply, and end-of-life strategies, investment needs are even greater.

To give a broader context on funding gaps, advanced economies mobilised [over USD 115 billion](#) in climate finance for EMDEs in 2022. This is much more than the USD 60-90 billion range over the 2016-2021 period, thereby reaching the collective goal of mobilising over USD 100 billion for the first time. Within this total, an estimated USD 17 billion (15%) was allocated to transport, second only to the energy sector at an estimated USD 32 billion (30%). Much of this was public money: private finance mobilised around USD 22 billion in 2022, up from a USD 10-15 billion range over the 2016-2021 period. In terms of sectoral distribution, more private finance is typically allocated to energy (around 50% on average over 2016-2022) and less to transport (6%) compared to the total, suggesting that there are opportunities to further increase private finance supporting ZEV deployment in EMDEs.

Figure 4.3 Annual investment needs for charging and spending on electric vehicles in emerging markets and developing economies in a net zero pathway, 2024-2035



IEA. CC BY 4.0

Notes: 2/3Ws = two- and three-wheelers; NZE = Net Zero Emissions by 2050 Scenario. Charging includes both public and private charging points. Investment needs refer to investment spending over the 2020-2023 period, and to the overnight investment needs over the 2024-2035 period. For charging, this refers to investments in charging infrastructure; for vehicles, this refers to spending, shown here for comparison. The numbers in this figure are in addition to investment spending for improvements in energy efficiency.

Sources: IEA (2024), [Global EV Outlook 2024](#), IEA (2024), [World Energy Investment 2024](#).

Governments can help to bring transport and finance stakeholders closer together to bridge the investment gap between current levels and those needed in the NZE Scenario. Unlocking publicly backed concessional finance (with examples in [Latin America](#)) and aggregating demand to decrease the cost of capital (with examples in [India](#), and an ongoing World Bank project development in Africa), can help decrease risks until a good flow of deals is established and commercial finance comes in. Multilateral development banks (MDBs), in particular, are already used to supporting infrastructure projects in EMDEs

across many sectors of the economy, and they can similarly play an [important role](#) in climate finance. In the energy sector, parallel activities such as CEM's [21st Century Power Partnership](#) can also provide learnings. In addition, there are opportunities to work more closely with other climate finance institutions, such as the Green Climate Fund.

Many factors contribute to the currently limited flow of funding towards ZEV adoption in EMDEs – some of them are further detailed in the ZEVTC [mapping](#) of India's subnational EV financing landscape. These include a lack of awareness among EMDEs about available funding; a lack of quality projects in EMDEs ready to receive funding for implementation; a lack of experience among recipient countries and financial actors about ZEV adoption; a lack of specific policy frameworks enabling financial assistance to flow; and long lead times. Bundling funding with technical assistance is important to develop capacity and set up adequate regulatory frameworks. Policy tools associated with ZEV adoption (e.g. subsidies, supply-side measures, public procurement, compliance requirements) can be complex and are not always common practice in EMDEs. The implications of ZEV adoption are also wide-ranging (e.g. new infrastructure needs, systems integration challenges, foregone government revenue in fuel taxes) and need to be well understood.

To remain Paris-aligned, current pilots need to be completed and scaled up as quickly as possible. Running several pilots in parallel, and in many more countries, could help generate learning more rapidly. This learning should be shared broadly and publicly to benefit future projects and ensure transparency.

In terms of programme design, projects need to be designed in direct collaboration with partner organisations in the recipient country to identify local specificities and priorities. There is an opportunity to prioritise projects that have an industrial angle, such as for battery and vehicle manufacturing, critical mineral supply, recycling and end of life, and for electric trucks for freight transport, and to co-ordinate with projects in the power sector (e.g. new power capacity, batteries for energy storage). These could be especially attractive given the strong appetite to combine socio-economic development with meeting global energy and climate targets.

Consideration of the local context with regards to access to affordable transport options is also important. In 2024, car ownership remains low in EMDEs – under 10% on average, and only 3-5% in India, Indonesia and throughout Africa. In contrast, ownership of 2/3Ws, which are far more affordable to the average consumer, reached 17% in India and over 45% in Indonesia, averaging around 10% in EMDEs in 2024. In the NZE Scenario, electric 2/3Ws reach a sales share of nearly 80% in 2030, and full electrification can be achieved with further policy support. Programmes focusing on zero-emission buses and 2/3Ws are more likely to have impact in the near term at the same time as addressing equity considerations. In the medium-term, as car ownership rates increase, project scope could broaden and pair ZEV adoption with access to clean power.

RECOMMENDATION RT2 HAS BEEN UPDATED AS FOLLOWS:

Governments should work to accelerate the pace of pilot projects seeking to increase access to low-cost financing for zero-emission vehicle adoption in emerging markets and developing economies, and to scale up availability of low-cost financing to a wider set of countries, particularly for buses and trucks. Governments should work with public authorities, corporates and financial institutions, including multilateral and national development banks, to provide funding and technical assistance, mitigate risks, and rapidly create a larger pipeline of projects.

AGREEING ON STANDARDS FOR BATTERY SUPPLY CHAINS

OVERVIEW

Last year, we recommended that harmonised standards and metrics should be agreed for battery value chain sustainability, and for data governance and interoperability of digital product passports. We also recommended that governments consider strategies for battery recycling and end of life, and technical assistance for EMDEs.

While the CO₂ emissions associated with EVs on a lifecycle basis are [already lower](#) than ICE equivalents, on a global average, the carbon footprint of battery production must still be reduced further, especially for refining of raw materials and manufacturing of battery components. Growing demand for [critical minerals](#) used in batteries intensifies the need to develop secure, resilient, and [sustainable supply chains](#) that better encompass environmental, social and governance (ESG) standards.

WHAT PROGRESS HAS BEEN MADE?

We assess that good progress has been made against our recommendation from last year.

There are two main drivers behind this assessment: firstly, consensus at the highest level and the beginning of legislation relating to battery supply chains; and secondly, progress on pilot projects for digital battery passports, with results expected by COP 29.

As reflected in the G7 communiqués in [2023](#) and [2024](#), governments are increasingly committed to developing supply chains for batteries and critical minerals that are secure and sustainable, with explicit mentions of ESG standards and digital product passports. As mentioned above in the first priority action for road transport, the UN Secretary General's Panel on Critical Energy Transition Minerals is developing [core principles](#) on the topic. Some of these commitments are now being translated into policy.

In July 2023, the European Union [passed](#) regulation setting requirements in terms of sustainability, safety, labelling, marking and information for all batteries marketed in the Union. The legislation introduces a digital passport for batteries, to become effective in February 2027. Given the large share of EU countries in global EV markets – EU countries accounted for 17% of global battery-electric car sales in 2023, behind China but ahead of the United States – a battery passport could have ripple effects in jurisdictions where regulatory requirements are currently lower, as industry players improve their practice to enter the European market and anticipate more stringent regulation elsewhere. International discussions, such as through the Global Battery Alliance ([GBA](#)) and UNECE, played an important role in developing the concepts underpinning the EU battery passport regulation.

There have been other [important developments](#) in recent years, such in China with the “Interim Measures for the Management of Recycling and Utilization of New Energy Power Vehicle Battery”, which make battery and vehicle manufacturers [responsible](#) for EV battery recycling, and in the United States, with incentives for new recycling technologies. However, we are not aware of attempts by major markets to co-ordinate on these regulatory requirements, which creates a risk of different standards being set in different markets.

In June 2024, GBA corporate members launched a second wave of [battery passport pilots](#), after the [first wave](#) was launched in January 2023, with the view to establish globally harmonised, traceable and comparable performance metrics at the product level by 2030.

In this second wave, 11 pilots are running in parallel to test and generate learnings about standards related to battery carbon footprint, human rights, child labour, forced labour, indigenous peoples' rights, biodiversity and circular design. The world's main battery manufacturing companies are involved, together accounting for over 80% of global EV battery markets, suggesting the pilots hold potential to deliver real-world impact upon completion. Indeed, there appears to be growing appetite among large corporates – especially in Asia, where most battery manufacturers are headquartered today – to work internationally to set global battery supply chain standards to ensure compliance, market access and competitiveness.

Some progress has also been seen on the topic of battery end-of-life management and strategies. In 2024, UNEP started a new programme to support EMDEs to develop battery end-of-life strategies. This follows a related [report](#) published in 2023, which estimated that second-hand EV flows could exceed 2 million by 2035, up from under 75 000 in 2022, indicating a need to anticipate EV battery management. In April 2024, a first-of-its-kind [workshop](#) was organised with African countries to discuss standards and guidelines for the collection, preparation and transport of end-of-life EV batteries for local reuse, recycling and safe disposal of waste materials. These activities are encouraging, but they remain at an early stage and will need to scale up to translate into sizeable impact in EMDEs.

Improving battery lifespan is also an important aspect of battery circularity, and it benefits from collaborative efforts internationally. In particular, the European Union and the United States have transposed the [UNECE Global Technical Regulations No. 22](#) on “In-vehicle Battery Durability for Electrified Vehicles” in their respective legislation (i.e. Euro-7 and post-2027 GHG standards, respectively). Other countries that have adopted the technical regulation under the UNECE are also expected to follow with domestic policies to promote the deployment of batteries with a longer lifespan in EVs. UNECE is working on the development of a similar technical regulation for HDV battery durability.

WHAT MORE NEEDS TO BE DONE?

While we have assessed good progress against our recommendation from last year, much remains to be done to develop secure, resilient and sustainable battery supply chains by 2030. International collaboration could focus on three areas in particular: 1) scaling up ongoing battery passport pilots and ensuring sustainability standards are adopted globally; 2) anticipating needs for battery end-of-life management, especially in EMDEs; and 3) improving critical mineral supply chain security and resilience.

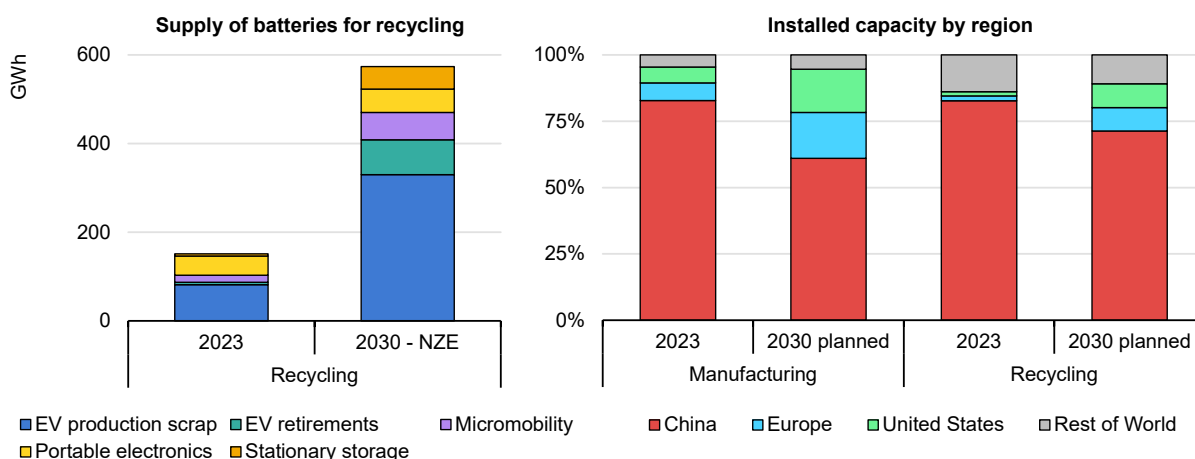
In June 2024, the GBA released a [communiqué](#), drafted in collaboration with stakeholders and governments around the world, focusing on the opportunities for further harmonisation of standards for sustainable battery value chains. The GBA is actively engaging with decision makers to spark a dialogue at COP 29 on actioning its recommendations. The communiqué calls attention to a “co-operation gap” if countries advance battery strategies in a fragmented way, from critical minerals extraction to battery manufacturing and recycling. It argues that siloed action risks increasing costs along the value chain and impeding sustainable scale-up of the battery industry. Today, many conversations are taking place bilaterally, for example between importer and exporter countries, but without globally harmonised standards, there is a risk that different regions of the world develop standards at different levels of stringency. The fact that the recent EU legislation is not coordinated across other major markets, or that governments are not as involved as corporates in GBA pilots, illustrates this “co-operation gap”. The communiqué issues four policy recommendations: 1) improve transparency through harmonised approaches to ESG performance; 2) create a global regulatory framework and/or amend existing ones;

3) channel financing to sustainable solutions; and 4) make ESG considerations core principles for battery and critical mineral projects and build capacity among decision makers.

In line with the GBA’s call for action, we agree that there is a need for governments to agree on internationally harmonised standards, methodology and data governance for tracking battery supply chains, learning from ongoing pilots. The topic of data governance and interoperability of digital passports is key because these are only as effective as data are transparently available and regulated, at the international scale. Financial institutions should also be part of the discussion, given that digital passports can help create a marketplace that allows for product differentiation (e.g. cleaner and better batteries) to attract investment in a race to the top, with market access requirements tightening over time. Beyond batteries, setting harmonised standards for the lifecycle analysis of entire vehicles could be the next step. Existing initiatives and frameworks should be used to set up these standards when possible. For example, the International Organization for Standardization set up a [framework for implementing ESG principles](#) in 2024, which could be relevant to actors in critical mineral and battery supply chains.

There is also a need for international collaboration to further address the topic of EV battery end of life, which has seen less activity than that of standards and digital passports since last year. As battery markets continue to expand rapidly, with greater EV penetration and the expansion of stationary power, [battery recycling needs](#) are set to become significant in the 2030s (Figure 4.4). In 2023, the supply of batteries for recycling stood at around 150 GWh, and this number increases to nearly 600 GWh in 2030 in the NZE Scenario, primarily from EV production scrap, and to a lesser extent from EV retirements. Beyond 2035, the potential for recycling increases much further, contributing to a considerable decrease in raw critical mineral demand.

Figure 4.4 Battery recycling needs (left) and installed capacity for battery manufacturing and recycling (right), 2023-2030



IEA. CC BY 4.0

Notes: EV = Electric vehicle. NZE = Net Zero Emissions by 2050 Scenario. Recycling capacity refers to material recovery. A maximum factor of 85% and an average cell energy density of 180 Wh/kg are assumed. A battery manufacturing scrappage rate ranging from 10% (2023) to 6% (2030) is used. “Planned” refers to current announcements. “Micromobility” refers to batteries contained in electric bikes or small electric scooters. “Stationary storage” includes uninterruptible power supply batteries, which are assumed to have a shorter life than EV batteries.

Sources: IEA (2024) [Global EV Outlook 2024](#); IEA (2024), [Advancing Clean Technology Manufacturing](#).

Industry players are already positioning themselves to capture a share of this market, with many announcements for [new recycling capacity](#) by 2030. However, most of these

announcements are concentrated in China – nearly 75% of the planned global capacity in 2030 – and advanced markets, with very few in EMDEs. This means that there is a pressing need to develop battery end-of-life strategies, which could call for either building recycling capacity in EMDEs, where significant imports of second-hand EVs are expected in the coming decade, or for sending end-of-life vehicles back to recycling centres, such as to the battery or vehicle manufacturer. Providing financial and technical assistance to EMDEs needs to be part of these discussions as well.

Battery recycling remains largely [under-regulated](#) today, with increasing reports of malpractice. This calls for greater focus on standards and harmonisation, and linkages with digital passports to ensure recyclers comply with recycling standards, in collaboration with manufacturers, recyclers and financial actors. There are opportunities to leverage learning from China, such as to develop whitelists (i.e. a regulated list of authorised recyclers that meet specific requirements) for battery recyclers and mechanisms for cross-border enforcement, the implementation of which can be supported by existing multilateral initiatives. Battery passports should be linked to whitelists, so that governments and regulatory bodies can more effectively enforce compliance with the accepted recycling standards.

Finally, there is an opportunity for countries to work together to improve battery [supply chain security and resilience](#). From critical minerals extraction and refining to battery manufacturing, today's supply chains are geographically concentrated. Increasing dependency creates supply risks in case of disruption, increases costs along the whole value chain due to lower competition, hinders value addition in mineral rich economies, and potentially undermines the ability for importing countries to address ESG issues in exporting countries. Governments can further work together to understand and address these risks and explore supply chain diversification. In the case of critical mineral supply, for example, opportunities for further collaboration between the [G7 and African nations](#) have already been identified to ensure effective regulation and ESG safeguards as mining operations ramp up.

RECOMMENDATION RT3 HAS BEEN UPDATED AS FOLLOWS:

Governments should agree on environmental, social and governance standards and metrics that are harmonised across regions, including battery carbon footprint and responsible sourcing, with the view to support international markets for more sustainable products. Governments should work towards enabling global interoperability, transparency, and harmonised data governance of digital battery passports (e.g. data collection, management, exchange, assurance, and verification standards). Further, governments should jointly address priority areas for secure, resilient, and sustainable value chains, and circularity-based product design and processing, including bottlenecks for battery materials, longer battery lifespan, recycling standards at the end of life, and technical assistance for emerging markets and developing economies on EV battery end-of-life management.

DEVELOPING CHARGING INFRASTRUCTURE

OVERVIEW

Last year, we recommended that governments should further increase technical and financial assistance to support charging infrastructure, and that governments and

companies should work to foster the sharing of best practice, knowledge and technology, with a view to supporting implementation at national and regional levels.

WHAT PROGRESS HAS BEEN MADE?

We assess that moderate progress has been made against our recommendation from last year.

International discussions and knowledge-sharing on technology standardisation are accelerating. In May 2023, the European Union and the United States published a [shared vision](#) on HDV charging with a view to standardise equipment and share technical guidance. At around the same time, the Society of Automotive Engineers started [standardising charging](#) in North America. The multiplying number and increased ambition of such discussions – often at the regional level – are encouraging indications of change.

Since mid-2022, there has also been important progress in terms of national legislation to support charging infrastructure, as highlighted in the online [policy summary](#) by ZEVTC.

In April 2024, the new [Alternative Fuels Infrastructure Regulation](#) came into force in the European Union. The regulation aims to ensure minimum infrastructure support across all modes of transport, full technical interoperability, and comprehensive user information and payment methods. Important targets are being set, such as fast charging every 60 km along core EU transport corridors from 2025 onwards for cars and vans, and from 2030 for HDVs. The regulation is supported by funding of over [USD 450 million](#). Other important developments in 2023-2024 took place in Canada, France, Germany, the United Kingdom, and the United States (e.g. [USD 950 million](#) in new investments for charging announced, and the publication of a [National Zero-Emission Freight Corridor Strategy](#)). On the corporate side, in 2024, companies representing roughly 70% of all new M/HDV sales in the United States formed [PACT](#) to share good practice and co-ordinate implementation. As of Q1 2024, the 128 corporate members of [EVI100](#) had installed over 35 000 charging points and committed to another 6 700.

New activities have been launched within existing collaborative initiatives. In May 2024, the ZEVWISE coalition¹² launched the [Ten Green Corridors Initiative](#), aiming to complete ten zero-emission freight corridor pilots by 2026 on road corridors with high traffic volumes across different countries to generate learnings and set a blueprint for future corridor planning (Figure 4.5). This can help to ensure that zero-emission HDVs can operate effectively on international routes. The success of these freight corridors hinges on successful regional collaboration between governments and corporates. We could not assess whether governments in all countries along these corridors have been involved to date. In 2024, a workshop organised by WBCSD recommended three priority corridors to focus on: in India (#4 on the map); between Mexico and the United States (#2); and the East Africa corridor from Mombasa Harbour through Nairobi (not featured on the map).

¹² The ZEVWISE partners are CALSTART/Drive to Zero, Electric Vehicles Initiative, ICCT, ITF, the Netherlands, Smart Freight Centre, UK Department for Energy Security & Net Zero, US Department of Energy, The World Bank, and WBCSD.

Figure 4.5 First eight of the Ten Green Corridors Initiative, as of mid-2024

Notes: This map does not imply that governments or authorities in relevant countries have expressed support for the target corridors. #1: U.S.: FIFA 2026 Corridor (Canada-USA-Mexico). #2: WBCSD: USA-Mexico border corridors (California – Baja California, Texas – Nuevo Leon, Arizona – Sonora). #3: UNEP (ZEVWISE Focal Point): Southern Africa Container Corridor (Port of Durban, including South Africa, Lesotho, Eswatini, Zimbabwe, Botswana, and Zambia). #4: WBCSD: India Corridor I (Mumbai-Delhi and Delhi-Jaipur). #5: ICCT: India Corridor II (NH48: Delhi – Mumbai – Chennai). #6: AVERE Ukraine / EVConsult: European Corridor to Zero (Netherlands, Germany, Poland, and Ukraine). #7: UNEP (ZEVWISE Focal Point): Trans-Caspian International Transport Route (TITR) Corridor (China, through Kazakhstan, Azerbaijan, Georgia, and Turkey to Europe). #8: CALSTART: USA I-95 Corridor (Georgia – New Jersey). Two more corridors to be included later in 2024.

Source: [Ten Zero-Emission Freight Corridors around the World](#) (2024)

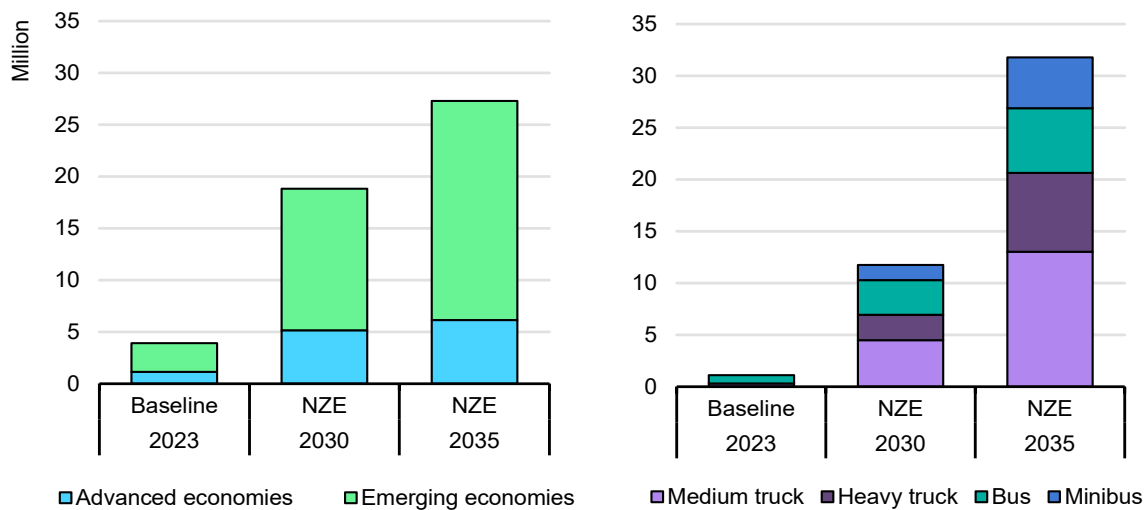
In May 2024, the UNECE Working Party on Transport Trends and Economics organised the first session of the [informal task force on e-mobility](#), after the initiative received positive consideration from the UNECE Inland Transport Committee at its [86th annual session](#). The task force, running until at least 2026, aims to identify good practice and support global harmonisation relating to EV charging (e.g. interaction with power grids, smart charging solutions, charging accessibility and affordability, pricing strategies and tax systems, data protection). In 2024, CALSTART, ICCT and WBCSD have been working on a framework for collaboration on charging availability across all modes, clean power availability to meet demand, and user experience. In October 2023, WBCSD published a report on [financing charging infrastructure](#), outlining business models and financing mechanisms available to companies and policy makers investing in charging infrastructure. WBCSD also [identified digital solutions](#) that could help optimise planning, increase capital efficiency gains, and reduce emissions, and is currently working on a proof of concept to demonstrate their value in India.

WHAT MORE NEEDS TO BE DONE?

Despite encouraging policy developments and increasing activity among multilateral initiatives, global charging needs to 2030 and 2035 remain considerable, and technical and financial assistance to EMDEs remains limited.

In 2023, there were just under 4 million public charging points for electric LDVs installed globally, of which 70% were in China (Figure 4.6). In the NZE Scenario, the number increases to nearly 20 million in 2030 and more than 27 million in 2035, the majority of which are located in China.

Figure 4.6 Charging points for light-duty (left) and heavy-duty (right) vehicles in the Net Zero Emissions by 2050 Scenario, 2023-2035



IEA. CC BY 4.0.

Notes: LDV = Light-duty vehicle. HDV = Heavy-duty vehicle. NZE = Net Zero Emissions by 2050 Scenario.

Source: Updated from IEA (2024), [Global EV Outlook 2024](#).

There are opportunities for international collaboration to: 1) bring closer together transport, power and finance actors to support large-scale projects at the interface between power and charging infrastructure; 2) accelerate and scale up existing pilots for HDV charging; 3) increase financial and technical assistance in EMDEs, based on local needs and specificities; 4) develop good practice based on the learnings from advanced EV markets; and 5) leverage demand aggregation and digitalisation to facilitate planning and decrease investment risk.

Meeting high levels of growth in EMDEs, not only for charging infrastructure but also to develop low-emissions power capacity to meet this demand, calls for enhanced access to low-cost financing (as reported earlier in “Providing international assistance to emerging economies”). Given that most EMDEs currently have low rates of car ownership, financial assistance for charging infrastructure should also take in account and prioritise local needs and specificities, including, for example, the need to provide equitable access to charging for electric 2/3Ws, shared vans, and buses, as well as electric trucks for freight transport. In advanced economies and in EMDEs with large a population and well-developed car markets, public support should also be tailored to households without easy access to private charging.

The challenge for HDV charging is significant, with the number of charging points for buses and trucks jumping to nearly 12 million in 2030 and 32 million in 2035 in the NZE Scenario, from just 1.1 million in 2023. In this scenario, most HDV chargers in 2030 are depot chargers, but there is greater deployment and utilisation of opportunity chargers by 2035. Meeting such charging needs – especially those at depots with high and predictable loads – will require the addition of considerable power capacity and grid strengthening, which can be anticipated.

In the case of HDV charging along corridors that cross borders, governments and the private sector should work together to agree on infrastructure availability, interoperability, and affordability, as well as on power grid infrastructure planning and financing. This is particularly true when different utilities operate in different regions (which can also occur

within a single country if different utilities operate across different provinces). Current focus on long-distance international freight corridors should be strengthened as a result. Pilots such as Ten Green Corridors need to be accelerated, multiplied and rapidly scaled up, spreading from urban and logistical hubs. There are opportunities to promote collaboration between actors in the power and transport sectors, as well as with financial institutions such as MDBs, which have extensive experience in large power and transportation projects, and can support HDV charging infrastructure development and provide concessional finance to fleet operators lacking the capital to develop their own depot infrastructure and clean charging hubs.

International discussions on charging technology, equipment and standards are important to enable medium-term ZEV deployment, particularly in cases where new or used ZEVs are exported to EMDEs. Adopting different charging standards in different regions of the world could slow down ZEV adoption in importing countries, whereas agreeing on interoperable equipment could foster faster deployment. Shared visions such as that between the European Union and the United States on HDV charging should be expanded to all vehicle segments and be inclusive of a broader set of countries, in collaboration with vehicle manufacturers.

RECOMMENDATION RT4 HAS BEEN UPDATED AS FOLLOWS:

Governments should co-operate to accelerate the roll-out of charging infrastructure along international freight corridors for zero-emission trucks. Governments should strengthen joint planning and co-ordinated investment across the transport and power sectors to anticipate greater demand for zero-emission power generation, transmission, and distribution for charging, as well as with financial institutions to increase funding allocated to large-scale infrastructure projects.

TAKING POLLUTING VEHICLES OUT OF INTERNATIONAL TRADE

OVERVIEW

The Breakthrough Agenda recommendation from 2023 was first for exporting and importing countries to agree on minimum standards for cross-border trade of used vehicles; and second, for countries to establish a publicly accessible database for tracking cross-border used vehicle trade. Third, we recommended that exporting countries establish strategies to enforce quality standards for used ICE vehicle trade at port of export, as defined and legislated by importing countries. Fourth, we recommended governments and companies commit to support the international trade of second-hand ZEVs, and to publish plans by COP 28.

WHAT PROGRESS HAS BEEN MADE?

We assess that moderate progress has been made against our recommendations from last year.

Firstly, limited progress has been seen in terms of exporting and importing countries agreeing to minimum cross-border used vehicle trade standards. UNECE, under the framework of the World Forum for Harmonization of Vehicle Regulations (WP.29), has made limited progress with the governments involved to agree on minimum performance requirements for the trade of safer and cleaner new used vehicles. Of course, there have been some national regulatory improvements, and some discussions are ongoing – such

as under the UNECE Working Party 29 on [Safer and Cleaner New and Used Vehicles](#), which is co-led by South Africa, the United States, the Netherlands, Kenya and Nigeria until December 2025 – but a global consensus has not yet been reached.

On the importing side, 24 additional countries had introduced “good” or “very good” policies for [used LDV imports](#) as of mid-2024 compared to 2021, to reach a total of 71 countries with such policies of 146 under review by UNEP. Notable examples of progress are listed across the Asia-Pacific region, in Africa (particularly East Africa), in Eastern Europe and in Central Asia. In many cases, neighbouring countries jointly adopt Euro 4, 5 or 6 standards, demonstrating the usefulness of cross-learnings and global harmonisation. [Ethiopia](#) banned ICE imports in January 2024 as part of its electric-only strategy. Regulation remains much weaker for [used HDV imports](#), with only 18 countries having complete bans, while 123 countries have minimal regulation based on vehicle age.

On the exporting side, the European Union’s new circular economy [legislation](#) concerning vehicle end of life has been moving forward, with the latest package proposed in July 2023. This aims to enhance critical mineral recovery and prevent the export of non-roadworthy vehicles at end of life. While there are expectations within the transport community that this policy could have a transformative impact on cross-border used vehicle trade, with important repercussions in EMDEs, it has not yet been adopted and there are a number of compliance and enforcement challenges ahead.

Existing multilateral organisations and initiatives, and especially UNEP, are actively seeking to convene governments and global stakeholders to enhance co-ordination. Prior to the April 2024 workshop mentioned above, a [workshop](#) in December 2023 gathered 16 Southern African Development Community members in Johannesburg to align low-sulphur fuel standards and safer vehicle imports.

Second, we tracked moderate progress towards the goal of establishing a publicly accessible database for tracking cross-border used vehicle trade. UNEP and the International Transport Forum (ITF), respectively, aggregate publicly available information and data as part of the [global overview](#) and the [used vehicles dashboard](#). However, limited sources, discrepancies, and the absence of disaggregated data (such as used ICE vehicles versus used EVs), as well as a lack of traceability of trade in used vehicles remain. The EU circular economy legislation embeds reporting requirements through an electronic platform and digital tracking of end-of-life vehicles, which could boost global efforts to put in place an accessible and transparent database for cross-border trade.

Third, we tracked no progress on the establishment of strategies by exporting countries to enforce quality standards for used ICE vehicles at the port of export, as defined and legislated by importing countries. EU exports of used LDVs (accounting for roughly 30% of global used LDV exports) could be covered by the forthcoming circular economy legislation. Japan (35%) has stringent local periodic technical inspections, but these are not controlled at export nor co-ordinated with importing countries. The United States (25%) lacks a uniform technical inspection system and quality control strategies at export.

Fourth, we observed limited progress on governments and companies committing to support the international trade of second-hand ZEVs. [Second-hand electric car markets are on the rise](#) as the EV stock ages in advanced markets, which could create opportunities for consumers in EMDEs. Trade in second-hand EVs can help accelerate the transition to decarbonised road transport in countries where fleets are primarily composed of used vehicle imports. In December 2023, ITF published a [report](#) on the possible impacts of EV adoption on used car flows. It responds to the call for published documentation by COP 28 by outlining plans to enhance used vehicle trade standards.

WHAT MORE NEEDS TO BE DONE?

Much remains to be done to effectively take the most polluting ICE vehicles out of cross-border trade, and to support trade of used ZEVs in a co-ordinated manner. While the improving regulatory environment around the world, including in EMDEs, is worth acknowledging, the pace of change needs to accelerate to get on track with net zero pathways by 2050. Co-ordination between importing and exporting countries needs to step up.

Firstly, further collaborative efforts are needed to decide and legislate on global standards for exporting used vehicles, both ICE and electric, and for both LDVs and HDVs. The landscape of used vehicle flows is evolving quickly, notably as a result of electrification in China. In just a few years, an increasingly large number of [used EVs could be exported](#) from China, as well as used ICE vehicles out of advanced car markets where EV sales shares are increasing. There is a need for countries to anticipate these developments and set standards for traded used vehicles to avoid dumping highly-polluting used ICE vehicles, or old EVs without adequate end-of-life strategies, in EMDEs. These measures will be most effective if they are decided on between exporting and importing countries and applied globally, not just through bilateral or subregional arrangements. The work initiated by UNECE Working Party 29 (as part of the group on Safer and Cleaner Used and New Vehicles) to develop technical requirements for minimum safety and environmental performance of used vehicles needs to reach actionable outcomes in a timely manner in order to provide a solid basis for countries' forthcoming used vehicle trade requirements.

Secondly, more efforts are needed on implementation. Setting up compliance and enforcement mechanisms (e.g. inspection, testing, verification) remains challenging and costly for importing EMDEs. Providing financial and technical assistance to develop local capacity can help, as well as proceeding with inspection at the port of export. There is also an opportunity to explore standards with lower compliance requirements. Countries should work together to harmonise technical inspections and tests required for exports, to increase the efficiency of implementation. For the trade of used EVs, more technical assistance is needed to develop end-of-life strategies in EMDEs and develop recycling capacity for EV batteries (as seen earlier in "Agreeing on standards for battery supply chains"). Over the medium-term, as imports of used EVs ramp up in EMDEs, it will be important to ensure they are simultaneously paired with a phase-out of old ICE vehicles, in order to cut CO₂ emissions. Agreement on technical standards for ZEV refuelling infrastructure is also needed to ensure imported ZEVs are compatible with local equipment and avoid different types of equipment depending on the region of export. Efforts to set up a database for cross-border trade also need to be expanded, especially if policy proposals such as those in the European Union are to be implemented effectively.

RECOMMENDATION RT5 HAS BEEN RESTATED AS FOLLOWS:

Governments in exporting and importing countries should agree on minimum quality, environmental and safety standards for cross-border trade of used vehicles across all segments. Governments should improve data traceability for tracking cross-border used vehicle trade, such as through a publicly accessible database. Governments and companies should develop strategies to promote and enforce standards at ports of export, support cross-border trade of used zero-emission vehicles, and manage vehicle end of life in importing countries.

RECOMMENDED REPORTS

We recommend the following reports for more detailed descriptions of the technologies for road transport sector decarbonisation, and of the actions that countries and businesses can take individually:

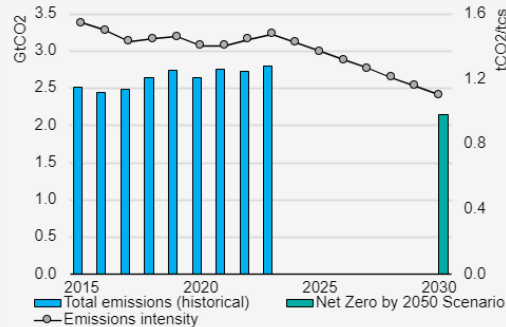
- IEA (2024), [Global EV Outlook 2024](#)
- IEA (2024), [Batteries and Secure Energy Transitions](#)
- IEA (2024), [Road Transport – Net Zero Emissions Guide](#)
- IRENA (2024), [Innovation landscape for smart electrification](#)
- ITF (2023), [New but Used: The Electric Vehicle Transition and the Global Second-hand Car Trade](#)
- UNECE (2024), [Report of the Inland Transport Committee on its eighty-sixth session](#)
- UNEP (2023), [Electric Vehicle Lithium-ion Batteries in Lower- and Middle-income Countries](#)
- WBCSD (2023), [Financing charging infrastructure](#)

CHAPTER 5. STEEL

STATE OF THE TRANSITION

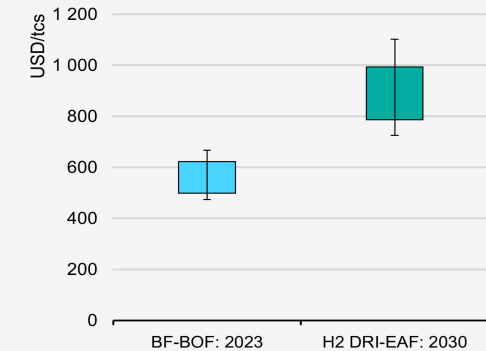
The steel sector is not on track to meet net zero by 2050: total emissions have continued to rise over the past decade. A large number of new high-emission blast furnaces are anticipated, with [approximately 65 Mt in planning or under construction](#) by the end of 2026.¹³ Announcements for new near-zero emission *capable* primary steel projects are increasing, but these require firmer timelines for transitioning to fully near-zero emission, and stronger policy support and demand signals to be converted to investments.

Emissions



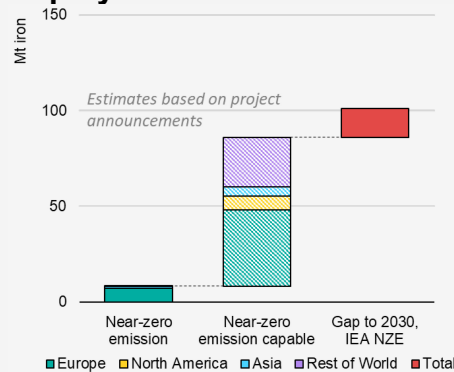
- Total CO₂ emissions from the steel sector have risen since 2015, reaching an all-time high in 2023.
- Direct CO₂ emissions intensity has not declined substantially since 2015.
- Both need to fall by around 25% by 2030, or about 4% each year, to get on track for net zero by 2050.

Cost



- The blast furnace-basic oxygen furnace (BF-BOF) route makes up about 70% of global steel production today, with typical costs of about USD 470-620/t in 2023.
- Hydrogen direct reduced iron electric arc furnace (H₂ DRI-EAF) is emerging as a preferred technology in announcements for low-emissions production in some regions.¹⁵ Cost estimates for 100% hydrogen blend for early commercial-scale plants in 2030 without policy support are estimated to be approximately 55% more on average than BF-BOF (range of about 30-75% depending on regional circumstances).

Deployment



- The project pipeline for primary near-zero emission plants by 2030 has not increased since last year, remaining at about 10 Mt.
- Primary near-zero emission capable¹⁶ plants have increased to 78 Mt, up from about 60 Mt last year. However, this capacity still lacks clear plans and timelines for full transition to near-zero.
- Over 100 Mt of primary near-zero emission steelmaking production is required by 2030 in the IEA Net Zero Emissions by 2050 Scenario (NZE Scenario) – a gap of about 15 Mt – assuming all capable projects accelerate to fully near-zero by 2030.

¹³ In the [Breakthrough Agenda Report 2023](#), we quoted an OECD estimate that 90 Mt of blast furnaces were planned or underway before 2025. The lower value of 65 Mt in this year's report is because 23 Mt were planned for 2023 itself; data is not currently available to confirm whether all of those plants were in fact built in 2023

¹⁴ Levelised cost of production (LCOP). Based on IEA analysis. Estimates are based on regional averages. Costs do not include any policy supports, e.g. carbon pricing or subsidies. The box represents the range of expected typical LCOP values, while the whiskers include the average LCOP in higher and lower cost regions. tcs = tonne of crude steel.

¹⁵ Over 90% of announced low and near-zero emission primary steel projects are set to use this technology.

¹⁶ 'Near-zero emission' refers to projects that, once operational, will be near-zero emission from the start, as defined in the IEA report [Achieving Net Zero Heavy Industry Sectors in G7 Members](#). Projects need to have achieved a final investment decision and provided clear details confirming near-zero emission production to be included here. 'Near-zero emission capable' refers to projects that will achieve substantial emissions reductions from the start – but fall short of near-zero emissions initially – with plans to continue reducing emissions over time such that they could later achieve near-zero emission production without substantial additional capital investments in core process equipment; project announcements that are still only at the concept stage are also included in this category due to the higher uncertainty surrounding their completion. Production from announced projects shown here excludes near-zero emission steel from scrap. Project announcements that have not achieved a final investment decision (FID) are also included in this category due to the higher uncertainty of their completion.

STATE OF INTERNATIONAL COLLABORATION

Since the [Breakthrough Agenda Report 2023](#), international collaboration on steel deep decarbonisation has continued to move forward, with several particularly noteworthy developments, including the launch of a number of country-specific partnerships to boost technical and financial assistance, the launch of the first call for proposals under the Accelerate-to-Demonstrate (A2D) Facility supporting R&D in emerging economies, and the start of strategic dialogues under the Climate Club on carbon leakage and other climate policy spillover effects. Still, many of the developments have yet to deliver tangible results – both an acceleration of activities and an expanded reach will be needed to get on track for the Steel Breakthrough’s ambitious objective of making near-zero emissions steel the preferred choice in global markets, with efficient use and production established and growing in every region by 2030. Strengthened leadership from governments is needed to increase policy ambition internationally and create the market conditions that enable investment and commercially viable production of near-zero emission primary steel. Resource gaps need to be filled to empower initiatives to move forward at the speed and scale needed.

In this chapter, we assess progress against priority actions in the areas of standards and certification, demand creation, research and innovation, trade and finance, and we make recommendations on the most urgent and high-impact opportunities in need of international collaboration in each of those areas. The assessment is measured against the ambitious goals of the Steel Breakthrough, focusing on the speed and scale of international collaboration needed to start deploying near-zero emission technologies and solutions. This does not imply that progress is not occurring on strategies to partially reduce emissions, nor that these strategies are not valuable components of the overall [steel sector pathway](#) to net zero emissions. It does, however, reflect that large-scale deployment of near-zero emission technologies will be required to fully decarbonise the sector, and also that the development, deployment and diffusion of near-zero emission technologies is where the greatest gains from co-ordinated international action are likely to be found.

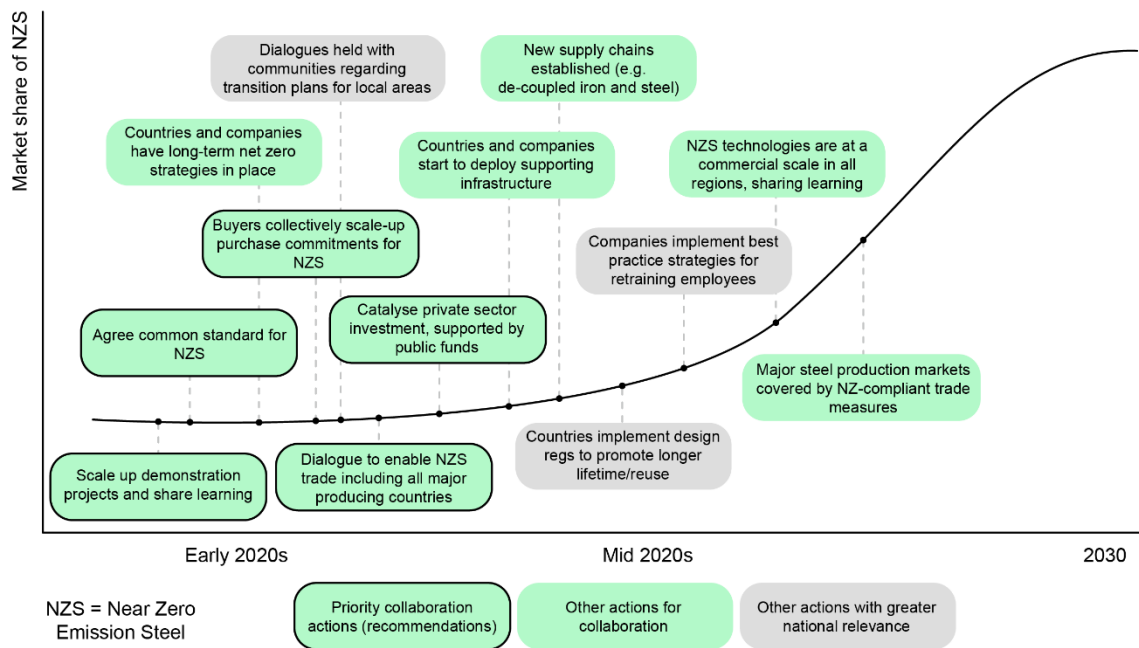
Our assessment and selected key developments are summarised in the table below, and the following sections address in more detail each area of international collaboration in turn. As there is considerable overlap between activities for the steel and cement sectors, given that both fall under industrial decarbonisation, the Cement Chapter that follows contains several references to this chapter on steel.

Area	What key progress has been made?	What more needs to be done?	2024
S1. Definitions and standards	<ul style="list-style-type: none"> Measurement methodologies: Steel Standards Principles launch and meetings, World Steel mapping exercise, IDDI PCR Harmonisation and priority accounting methods dialogues. Definitions: LESS launch, ResponsibleSteel version 2.1, strategic exchanges towards identifying common ground on definitions in Climate Club and WPID. Chain of custody: ResponsibleSteel consultation started. 	<ul style="list-style-type: none"> Measurement methodologies: leadership on identifying and taking forward priority revisions. Definitions: agreement on common principles for definitions and a process for determining equivalency of definitions. Chain of custody: clarity around innovative chain of custody models. 	Moderate (↓)

Area	What key progress has been made?	What more needs to be done?	2024
S2. Demand creation	<ul style="list-style-type: none"> Public sector: IDDI procurement pledges by four countries; exploration of regulatory policies to support scale-up by the European Union. Private sector: increased membership in FMC and SteelZero; RMI Steel Buyers Platform and FMC First Suppliers Hub launched. 	<ul style="list-style-type: none"> Public sector commitments to <i>near-zero</i> emission steel procurement; translation of pledges into firm policies; procurement by more countries; demand-creation policies beyond procurement (e.g. product standards/mandates). Increased private-sector commitments, particularly in sectors other than automotive. Commitments supporting demand in EMDEs. 	Minimal (↓)
S3. Research and innovation	<ul style="list-style-type: none"> Mission Innovation Net Zero Industries Mission Award and webinar programme. UNIDO A2D Facility launch. 	<ul style="list-style-type: none"> More and strengthened practical partnerships between countries on technology collaboration, including at different stages of TRL. Broad and high-quality knowledge-sharing and trust-building. Open dialogue on the role of intellectual property rights in accelerating technology collaboration. 	Moderate (=)
S4. Trade conditions	<ul style="list-style-type: none"> Strategic Dialogues initiated under the Climate Club on understanding international spillover effects of climate policy. Ongoing relevant discussions in WTO forums on trade (e.g. on CBAM, barriers to trade). 	<ul style="list-style-type: none"> Open dialogue on enabling near-zero emission steel and “green” iron trade. Active involvement of all major producers in carbon leakage dialogues, including the role of technical assistance to developing economies as an enabler. 	Moderate (=)
S5. Finance and investment	<ul style="list-style-type: none"> Key examples of direct country partnerships/platforms on industrial deep decarbonisation have been launched: UK-Brazil Industry Decarbonisation Hub (with UNIDO and LeadIT), Sweden-India Partnership (LeadIT) and Türkiye investment platform (EBRD). Global Matchmaking Platform is under development under the Climate Club. CEFIM continued work on enabling conditions for finance (Indonesia and South Africa). ITA launching national and regional project support programmes covering the steel sector. 	<ul style="list-style-type: none"> Financial sector alignment towards the net zero goals, in order to channel funding appropriately and avoid stranded assets. Robust enabling policy frameworks to underpin net zero-aligned finance. 	Moderate (=)

Notes: The arrows indicate relative progress compared to last year’s assessment in the Breakthrough Agenda Report 2023. “↑” indicates an improved assessment; “↓” indicates a downward assessment; “=” indicates the same assessment.

Figure 5.1. Critical path to 2030 for the steel sector



IEA. CC BY 4.0

Source: [Breakthrough Agenda 2023](#)

GREATER ALIGNMENT ON EMISSIONS ACCOUNTING METHODOLOGIES AND DEFINITIONS FOR NEAR-ZERO EMISSION STEEL

OVERVIEW

Last year, we recommended that countries should work through existing collaborative forums to align emissions accounting methodologies for steel by the end of 2024 and commit to adopting¹⁷ net zero-compatible mandatory standards from the mid-2020s. We also recommended that appropriate steps should be taken to clarify the compatibility of emerging definitions with net zero.

A further step towards achieving this recommendation was made at COP 28, where countries under the Steel Breakthrough agreed to accelerate the development of standards. This included working towards the interoperability of emissions measurement methodologies for steel, sharing knowledge to accelerate the adoption of emissions reporting and developing guidance to ensure definitions and related claims are compatible with net zero.

WHAT PROGRESS HAS BEEN MADE?

Overall, we assess that moderate progress has been made against our recommendation on the common understanding of definitions and standards. There have been positive steps forward on three key components of this work – emissions measurement methodologies,

¹⁷ Adoption refers to the requirement for companies to meet such standards in certain government policies, such as procurement, access to finance, subsidy, or regulations.

definitions/thresholds, and chain of custody. However, governments, in particular, have not yet reached clear agreements on these topics, which are fundamentally needed in the near-term in order to underpin other enabling mechanisms.

With regards to emissions measurement methodologies, the [Steel Standards Principles](#) signatories are working on identifying steps towards interoperability of methodologies. Initially launched at COP 28, as of September 2024 the principles have 55 endorsing organisations, consisting of steel companies and associations, standards organisations, non-governmental organisations, intergovernmental organisations and think tanks. While governments are not signatories of the principles, intergovernmental organisations provide a key conduit between discussions in this forum and discussions among governments. To feed into the discussions by the endorsing organisations, worldsteel is undertaking an exercise to map the methodologies of 30 priority steel standards, with the aim to develop potential recommendations for further alignment. Notably, worldsteel is also currently in the process of revising its own methodologies to be net zero compatible, such as expanding to cover GHG emissions, thus including upstream methane emission in addition to CO₂ emissions. The WTO Secretariat is co-ordinating the discussions of the Steel Standards Principles signatories, with discussions looking to identify tangible agreements for COP 29, such as a common emissions reporting point – crude steel – that would be additional to each standard’s current reporting point. It is yet to be seen, however, if the group will reach any concrete agreement, and then how those steps will be taken forward to implementation, including through engagement with intergovernmental forums. The International Standards Organization (ISO) could be a key player in taking such work forward – while individual standards are currently under revision, the revisions so far are not yet of the scale, scope and cross-cutting nature needed to make the various relevant standards interoperable and fully net zero-compatible.

Additionally, discussions continue among governments in the Industrial Deep Decarbonisation Initiative (IDDI) on routes towards increased alignment of emissions measurement methodologies. As a result of its discussions with members, the IDDI launched a set of [Product Category Rule \(PCR\) Harmonisation guidelines](#) in April 2024, focused on construction applications, although with principles potentially relevant to other applications. PCRs are standards defining how to calculate the environmental footprint, including the emissions intensity, of specific products and how to draft the corresponding Environmental Product Declaration (EPD), which are one of the most commonly used tools by industry to communicate emissions intensity. As such, PCRs are key emissions measurement methodologies. IDDI’s harmonisation guidelines make suggestions for how PCRs can be revised so that EPDs are more comparable and are clearer in the methodological choices and data used. It remains to be seen if the IDDI countries, the ISO and the European Committee for Standardization (CEN), will make progress this year towards taking these guidelines forward. Over the course of 2024, IDDI is also holding working group discussions in an effort to reach agreement on three identified key accounting issues: data quality, chain of custody, and carbon capture, utilisation and storage (CCUS).

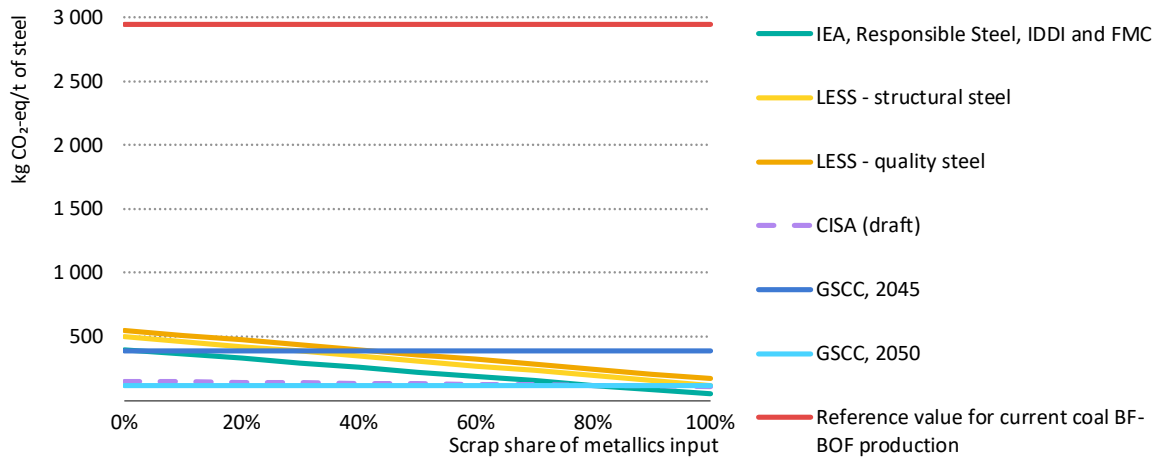
Another development in terms of data availability for emissions measurement is that the United Nations Environment Programme (UNEP)’s International Methane Emissions Observatory is set to launch a Steel Methane Programme at COP 29, focused on measurement and reduction of methane emissions from the sector, but few details are publicly available so far. This will be an important development given that upstream methane emissions from metallurgical coal make a considerable contribution to the lifecycle emissions of steel.

With regards to definitions and thresholds, there is ongoing work by several organisations to develop and expand use of standards for steel, largely led by the private sector, although also with some government and civil society involvement. A key development this year was the launch of the [Low Emission Steel Standard](#) (LESS), an initiative of the German Steel Association, implementing the [results of a broad stakeholder process](#) led by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), but with the intention to be usable globally. The classification system for steel and the label are based on the IEA's definitions and the label is expected to be fully ready for use before the end of 2024. Additionally, [ResponsibleSteel released version 2.1](#) of its standard, incorporating updates based on consultation with members. ResponsibleSteel continues to see increased membership, currently with over 150 members accounting for 132 Mt of steel production that has been certified through core site certification; the first certification of actual steel sold – which is separate from site certification – is expected before the end of 2024. The Chinese Iron and Steel Association is also developing a standard, with a final proposal expected to be released in Q3 2024.

The development of additional labelling schemes is positive in as far as they serve compatible and complementary purposes. For example, LESS focuses only on emissions, whereas ResponsibleSteel covers multiple environmental and social impacts, of which emissions is one component; these standards are therefore complementary as they could meet different certification needs and objectives. However, going forward, it may be preferable to coalesce efforts around the proposals already on the table, rather than the creation of several additional systems. Encouragingly, the proposals to date are converging around similar values for steel compatible with the net zero endpoint (Figure 5.2).

Work is also underway towards identifying common ground among governments on definitions. The IEA has laid out a set of principles for near-zero and low-emissions materials, including steel, and is consulting on these through a questionnaire, which received 15 responses from governments that are members or observer attendees of the IEA Working Party on Industrial Decarbonisation (WPID) and/or the Climate Club. In the Climate Club, work is ongoing to identify common ground on definitions. A statement by its members at COP 29 could indicate further progress on this question. Additionally, the IDDI is continuing discussions with its members towards developing positions on definitions for application in green public procurement.

Figure 5.2. Steel emission threshold proposals compatible with the net zero endpoint from selected initiatives and organisations



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Notes: IDDI = Industrial Deep Decarbonisation Initiative; FMC = First Movers Coalition; LESS = Low Emission Steel Standard; CISA = China Iron and Steel Association; GSCC = Global Steel Climate Council; BF-BOF = blast furnace-basic oxygen furnace. The boundaries/scopes have differences for some of the thresholds, which explains some of the differences in the thresholds themselves (for example, LESS has an enlarged emissions scope relative to the IEA definition). Most of the proposals are static thresholds, not tied to any particular point in time. The one exception is the GSCC, which changes over time; the threshold values for 2045 and 2050 are shown here, and are an average of the long and flat steel thresholds. The CISA threshold is based on a draft released for consultation; the final threshold is expected to be determined before the end of 2024. The “Reference value for current coal BF-BOF production” assumes hypothetical production with 0% scrap share of metallics input for all values shown for illustrative purposes, using the emissions boundaries of the IEA’s definitions proposals; note that typical BF-BOF production has about 25-30% scrap share of metallics input.

An increasingly relevant area of activity related to standards is on chain of custody, i.e. how emissions claims are passed along value chains. This covers emerging proposals that may aggregate emissions reductions from multiple different sources of production and selling emissions reduction certificates alongside sale of products, which is referred to by some in the steel sector as “mass balance” approaches, as well as proposals that would disconnect physical products from credits for using lower-emissions products, known as book-and-claim systems. The worldsteel association released in Q2 2024 a set of proposed [Chain of Custody Principles](#), which aim to align the basic conditions for use of GHG emission reduction certificates in the steel sector. ResponsibleSteel is developing a [Downstream Chain of Custody Standard](#), with consultations and pilot testing ongoing, and an aim for final publication by the end of 2024.

WHAT MORE NEEDS TO BE DONE?

While good progress has been made on several technical aspects of standards discussions, there is a need to move forward on taking political decisions and implementation. This is particularly critical given that standards underlie many enabling mechanisms, including demand-creation mechanisms (see S2) as well as aspects related to trade (see S4). To achieve the Steel Breakthrough’s objective for near-zero emission steel to be the preferred choice in global markets by 2030, clarity and mutual agreement on interoperable standards is an urgent need within the next year. Here, leadership from governments is critical in setting the direction and taking decisions, as private-sector voluntary actions can only get so far on their own.

Coming to agreement on definitions for near-zero and low-emission steel is perhaps the most pressing need. Agreement on common principles by the broadest possible set of

countries – including emerging markets and developing economies (EMDEs), many of which have been less involved in international discussion to date – would be an important step forward, and something that governments could aim to achieve by COP 29. Beyond that, steps are needed to provide clarity and oversight from governments on the threshold values themselves. Given that a handful of different certification and labelling systems have already emerged, it is likely not possible and perhaps also not necessary to agree to only one system internationally, but rather to promote coalescence around the existing systems and find ways for them to work together. Possible next steps forward may include: 1) governments who have not yet consulted with their domestic industries to do so, and bring findings back for discussion in international forums; 2) a collective statement from governments on the extent to which different systems are compatible with net zero and the agreed principles; 3) government support to develop a process for determining equivalency or mutual recognition of levels of different certification systems/definitions proposals, perhaps taken forward by the certification systems themselves (here, work by the International Partnership for Hydrogen and Fuel Cells in the Economy on mutual recognition of hydrogen standards may provide learnings – see the Hydrogen Chapter); and 4) governments take decisive action by adopting net zero compatible definitions in their own policies, ideally drawing from already-existing proposals. Adoption of comparable definitions by private-sector initiatives and actors would also be important.

With regards to emissions measurement methodologies, there remains a need to come together on a clear vision of required outcomes and well-defined priority next steps, and then to move forward on their implementation. Moving forward quickly to agree revisions and next steps in multi-stakeholder forums like the Steel Standards Principles should be pursued. Compromise and flexibility will likely be required to achieve outcomes, and in cases where multi-stakeholder forums do not reach mutually-agreed outcomes, political decision-making by governments via forums like IDDI, WPID and the Climate Club – and if possible, involving major steel producing and consuming EMDEs – may be required to help resolve outstanding questions (for example, on moving towards a common reporting boundary and on a common allocation method for slag). Standards bodies such as the ISO, will likely need to take a leadership role in taking forward the revisions. Such bodies may not have the resources to undertake all of the necessary technical activities required themselves, and better funding of technical inputs through support of governments, as well as inputs from other organisations, may be needed. One possibility could be for ISO to open a cross-cutting work programme (for example perhaps through what is known as a “workshop agreement” in ISO terminology) to address similar questions across multiple standards, with governments, industry and other stakeholders providing input via engagement with their National Standards Bodies. Such a work programme could be a route to take up and implement commonly agreed suggestions by stakeholders in other forums, such as through the Steel Standards Principles discussions or intergovernmental forums. Governments may also have a role to play in encouraging maximum use of primary data, and in facilitating common and publicly available data for key upstream emissions sources, including electricity grid factors and material inputs, which would assist in improving comparability of results across methodologies.

Collective government oversight and clarity is likely also needed on emerging alternative chain of custody models. Further technical discussions are likely needed, where possible building from ongoing work and analysis by organisations including IDDI, ResponsibleSteel and worldsteel, as well as in coherence with developments in other relevant industrial sectors, such as cement, for better consistency and clarity. Governments could perhaps work towards a collective statement or principles on suitability and use cases for different chain of custody models and verification procedures.

RECOMMENDATION S1 HAS BEEN UPDATED AS FOLLOWS:

Governments, industry and other relevant stakeholders should work through existing collaborative forums and with international standards bodies to identify by the end of 2024 and implement by the end of 2025 priority revisions for interoperability and net zero compatibility of steel GHG emissions accounting methodologies. Governments should collectively provide clarity on principles for near-zero and low-emission steel definitions, commit to adopting definitions within national policies by the end of 2025, select methods for determining equivalency of different certification schemes, and provide guidelines on chain of custody models.

FURTHER SCALE-UP OF HIGH-QUALITY DEMAND COMMITMENTS FOR NEAR-ZERO EMISSION STEEL

OVERVIEW

Last year, we recommended that governments and companies increase the scale of near-zero emission steel procurement commitments to cover a significant share of their future steel demand, joining relevant public and private-sector initiatives where these commitments are aggregated. These commitments should be high quality and should be supported by appropriate legal and implementation frameworks.

At COP 28, countries under the Steel Breakthrough agreed to rapidly expand demand commitments for low- and near-zero emissions steel, by working together to develop packages of co-ordinated, high-quality public and private procurement and purchase agreements by COP 29.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been minimal progress against our recommendation. Activities continue to lay the groundwork for potential future high-quality commitments, but there has been little increase in demand commitments for *near-zero emission* steel, which is essential for the decarbonisation of the sector. This is particularly the case in the public sector, which should be the most direct route for Steel Breakthrough countries to show leadership. There has been slightly more momentum on demand creation for *low-emission* steel, but this is still far from the scale and stringency needed to drive progress on near-zero emission *capable* technologies that could later transition to be fully near-zero emission.

On the public sector side, a number of countries have made pledges to procure low-emission construction materials including steel, and are developing emissions accounting systems to inform procurement decisions and report on the emissions embodied in construction materials. Under IDDI, at COP 28 four countries – Canada, Germany, the United Kingdom and the United States – [pledged to adopt timebound commitments](#) for procurement of low-emission materials, including steel, and to stimulate demand and commercialisation of near-zero emission materials. All of these governments already had in place some form of green public procurement policy (e.g. the US Federal Buy Clean Initiative, Canada's Greening Government Strategy, the UK Sustainable Procurement Strategy, and Germany's Programme of Measures), and work continues to further integrate targets for low-emission materials into these policies. For example, the US General Service Administration released in December 2023 its [Low Embodied Carbon Steel Requirements](#) and the United Kingdom is currently undertaking [public and technical consultations](#) related to embodied emissions reporting and product standards.

While groundwork is starting to be laid to create an aggregated demand signal for lower-emissions materials in public procurement, a greater ambition and number of pledges, and their rapid conversion into tangible policies – particularly targeting near-zero emission steel – is needed to achieve the goals of the Breakthrough Agenda and the decarbonisation of the sector. The green public procurement policies legislated so far are aiming for overall reductions in embodied carbon emissions or for “lower” emission materials – which are more in the order of incremental emissions reductions or best performers already in the market, rather than clear support for use of near-zero emission materials or investment in at least near-zero emission capable projects. (The latter includes projects that if not achieving near-zero emissions initially, have the ability to later transition to fully near-zero emission – for example direct reduced iron (DRI) plants that transition over time towards 100% hydrogen coming from fully decarbonised electricity, which is likely to be an important route for the steel sector). For example, the US steel requirements are based on current top 20%, top 40% or better than average performance, much of which could likely be met relatively easily with technologies already on the market today, including existing scrap-based production. Meanwhile, Canada’s commitment announced in 2022 to reduce embodied carbon in major construction projects by 30% starting from 2025, could also likely be met with technologies already on the market as well as material efficiency. Detailing in the near-term – within legislated policies – how such commitments will increase in stringency over time, and be complemented with specific measures to procure near-zero emission materials, would provide a much clearer and more ambitious demand signal to markets for deeper emissions reductions.

Certain governments are making some progress on targeted “first customer” programmes that demonstrate new technologies in public works. In July 2024 the United States announced a set of technologies selected under its [Green Proving Ground programme](#), which will use federal buildings to evaluate innovative building technologies, including those to reduce embodied emissions. While steel technologies have not been chosen for evaluation so far, cement technologies have. The programme could provide a model to provide direct support to technologies achieving deeper emissions reduction in steel products through use in government construction projects, in a way that may be more challenging for more general public procurement policies. Increased knowledge-sharing on and encouragement of novel programmes of this kind could be an important focus area for international collaboration.

There has been moderate progress in terms of other countries increasing their involvement in IDDI to aggregate demand signals. At COP 28, three other countries – Austria, Japan and the United Arab Emirates – [signed a statement of intent](#) to work towards key aspects of the IDDI Green Public Procurement Pledge. The membership of IDDI has not increased since COP 28, remaining at ten member countries covering around 22% of the global steel market. A larger number of governments joining the IDDI, actively engaging in its discussions, contributing to its joint announcements, and moving forward on ambitious green public procurement policies would help send a stronger collective demand signal to markets.

Development of policies beyond procurement that could directly support near-zero emission steel scale-up is also underway. For example, the European Union is conducting a [Preparatory Study on Iron and Steel Products](#), which will inform possible inclusion of steel in its Regulation on Ecodesign for Sustainable Products. Inclusion of considerations for low- and near-zero emission steel in this regulation would unlock a key route to supporting projects, and provide learnings for the international community.

On the private-sector side, some progress has been made in terms of offtake agreements for near-zero emission steel, but it also remains relatively moderate. There are now nearly

60 private-sector commitments in place, of which 39 are publicly announced offtake agreements and the remainder are letters of intent or memoranda of understanding. However, less than one-third of the offtake agreements disclose information on quantities or values of steel. Based on publicly available information, an estimated 1.2 Mt of near-zero emission steel¹⁸ for the year 2030 has been committed to through private-sector offtake agreements. This represents an increase of only 0.2 Mt over the past year. To put this in context, the IEA NZE Scenario requires about 100 Mt of near-zero emission primary steel in 2030. Only 20% of these agreements, constituting less than half of the volume of committed demand, are from companies who have joined at least one of the First Movers Coalition (FMC) and SteelZero, the two leading private-sector initiatives to aggregate demand. Of the commitments made, half are from the automotive sector or suppliers within the automotive supply chain.

Supporting activities to help spur private-sector demand scale-up are also underway, although the extent to which they may result in additional commitments is yet to be seen. The FMC is taking some important strides to expose near-zero emission steel supply and demand, and to connect the relevant actors from the supply and demand side. One of the means to this was the launch in early 2024 of the [First Suppliers Hub](#), a global repository of technologies and suppliers working to meet the FMC commitment thresholds. Alongside this, the FMC launched NearZERO Steel 2030 Challenge, consisting of three challenges focusing respectively on demand, supply and enabling technologies. The challenges concluded with results announced in Q2 2024, revealing [5 supply companies](#) and [17 enabling technology top innovators](#) that have been added to the First Suppliers Hub, as well as 21 submissions from companies interested in purchasing near-zero emission steel, all with diverse geographical coverage. Identifying potential supply and demand is an important step, but it is not yet a committed offtake agreement. FMC is also holding virtual dialogue webinars, and two workshops in 2024 in the United States and Japan (following two in 2023 in Brazil and India), to bring together members from both the supply and demand sides of the equation, as well as from the financial sector and governments, to try to secure offtake.

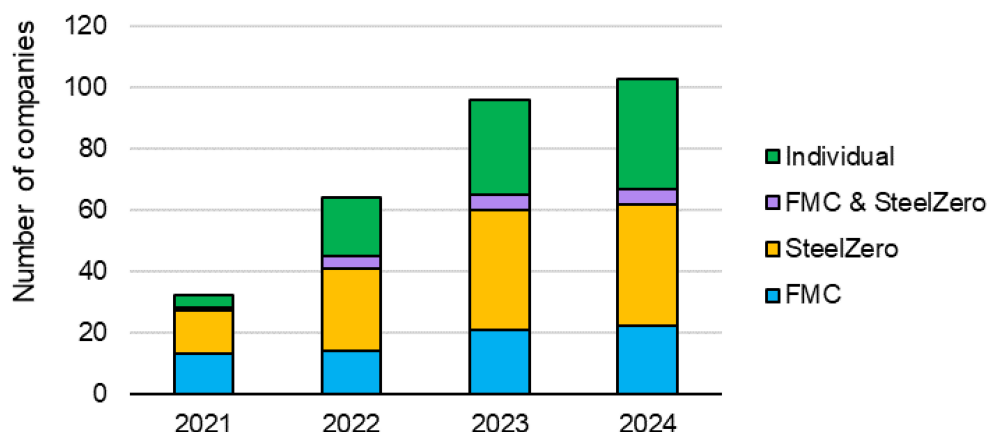
Other initiatives are also working along similar lines to the FMC to expose supply and demand towards securing offtake agreements. RMI has launched a Sustainable Steel Buyers Platform to aggregate demand for low-emissions steel in North America. A group of committed low-emission steel buyers has been brought together, and they have together launched a Request for Information (RFI) for potential suppliers. This RFI will close in December 2024, with a Request for Proposals to follow, with the aim to work toward offtake agreements. Meanwhile, SteelZero is working across Europe, North America, China, India and Korea with the objective to embed low-emission steel procurement across supply chains in all key consuming sectors (particularly property, infrastructure, automotive and shipping). SteelZero has developed a progress-reporting framework for steel procurement and will launch it alongside further supply chain engagement tools for members before the end of 2024, aiming to improve accountability, transparency and disclosure of steel emissions data.

Increases in membership of private-sector demand coalitions have been relatively moderate since COP 28. An additional 2 members joined the FMC's steel commitment, bringing the total number of members to 27. SteelZero saw its members increase by 5, to 45.

¹⁸ Some off-take agreements are made for a given value of steel rather than a quantity; for these, an estimate was made on the value per tonne of near-zero emission steel to convert to a quantity.

Developments on demand are also underway at the intersection of the private and public sector. SteelZero – an effort primarily targeting the private sector – is working to engage subnational governments on demand creation, including through developing an endorsement framework to be launched in 2024 on public-private partnerships, called the Industrial Decarbonisation Enablement Alliance. The [first official government endorsement](#) of SteelZero occurred in May 2024, by the Governor of Chungnam Province in Korea.

Figure 5.3. Number of companies committed to purchase near-zero and low-emission steel



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Notes: FMC = First Movers Coalition. Figures as of July 2024. [FMC members commit](#) to purchase near-zero emission steel by 2030. [SteelZero members commit](#) to purchase low-emissions steel by 2030 and net zero steel by 2050. Individual company commitments include publicly announced commitments of the purchase of near-zero emission steel by 2030, including letters of intent, memoranda of understanding, and offtake agreements.

WHAT MORE NEEDS TO BE DONE?

For a share of near-zero emission steel production to be established by 2030, firm demand commitments need to be secured well in advance. Here, increased public sector leadership is needed. Governments need to send a clear signal to markets that a “green premium” for first movers on near-zero emission production will be covered, by whichever combination of policy mechanisms they find most suitable, thus helping derisk industry projects and providing best practice examples that the private sector could learn from. If governments themselves are not yet demonstrating they will help address the potential risks and additional costs associated with initial deployment for breakthrough technologies, they should not expect the private sector to do so at the speed and scale required for the transition.

Strong policy is needed to help create firm demand, and more widespread, active international collaboration through forums such as IDDI is needed to accelerate policy development and increase its effectiveness. Purchases by governments are a critical lever, given that according to IDDI, they account for an estimated 25% of steel demand. Such use of procurement policies to provide a signal incentivising rapid commercialisation at scale is complementary to direct RD&D support on specific projects (see priority action 3). Putting in place mandatory policies today and working towards advance purchase commitments to explicitly buy near-zero emission steel in 2030, even if they account for only a relatively small portion of demand, will be critical to send a signal to the market and enable increased investments in near-zero emission steel plants. To this end, either more ambitious and clear commitments are needed within existing green public procurement

policies (e.g. turning pledges into clear targets for the quantity – either in terms of absolute volume or the share of total volume – of near-zero emission steel that would be procured if it is available) or new and expanded purchasing, public sector testing, and first customer programmes are needed to enable government to signal a commitment to buy near-zero emission steel (or at least steel with emissions performance that exceeds that already available on the market today and involves investment in near-zero emission capable production facilities). This could include specific programmes of spending, such as major infrastructure projects planned for 2030, ship-building or defence equipment purchases. More governments should engage through existing initiatives like IDDI to exchange on policy mechanisms, including any novel tools being tested, and work towards a more ambitious aggregated public sector demand signal.

Of course, policy targeting near-zero emission steel should in no way replace important ongoing efforts to increase commitments to purchase low-emissions steel and institutionalise emission accounting for materials in public procurement policies. Efforts here should also be accelerated by a larger number of countries joining IDDI, making pledges, and quickly turning pledges into concrete policies and tenders, thus sending a clear and broad aggregated signal to markets that embodied emissions performance is a new norm criterion in government procurement choices globally.

In addition to green public procurement, governments should look into adopting other mechanisms to support scale-up of near-zero emission steel. This may include regulatory policies, such as design standards or near-zero emission material mandates (comparable to zero emission vehicle mandates in the transport sector), including the possibility for these to be designed as [tradeable performance standards](#), near-zero emission material use quotas or embodied carbon limits placed on specific end uses such as buildings or vehicles, or other policies that firmly secure the business case for steel producers, such as carbon contracts for difference. Here, experience-sharing among governments would be useful to learn from new policy efforts and to understand which policies have been successful in de-risking projects. Participating in international initiatives like the Climate Club's Global Matchmaking Platform (see more below) could be a means to this end.

Scaling up demand for steel from projects in EMDEs is also currently a major gap. While demand creation within EMDEs should continue to be pursued by the governments of those countries, cross-border demand-creation mechanisms could also offer a possibility to help support projects. Here, there could be learning from the hydrogen space, where the innovative [H2Global mechanism](#) is aiming to accelerate global hydrogen market creation (see discussion in the Hydrogen Chapter). The market-based mechanism relies on an intermediary corporation – Hintco – that runs global auctions for hydrogen supply, and in doing so connects sellers and buyers that may otherwise have difficulty connecting due to the early stage of market development. The [results of the first pilot auction](#) for renewable ammonia, which relied on funding from the German government, were announced in July 2024 – 1 successful bidder was chosen out of 22 bids from 5 continents. The detailed experiences from this first auction could provide learnings for the steel sector. Expansion of the mechanism to steel could be a possibility if there is interest from governments and/or multilateral climate funds or multilateral development banks (MDBs) to offer support, as the mechanism requires funding for de-risking, and to cover part of the green premium (see S4 and S5 for further discussion on low-emission steel trade and finance). Discussions are also emerging about [book-and-claim schemes](#) that could offer cross-border support for projects without requiring physical trade of materials; however, these may be most needed for materials other than steel that are less frequently internationally traded.

There is also a need to continue expanding private-sector offtake agreements, where possible within pooled buyers' clubs – such as those of FMC, RMI and SteelZero – to send

an aggregated demand signal. This particularly includes within segments other than automakers that are major sources of steel demand, including construction, ship-building and wind turbine manufacturers. Here, establishing the first few offtakes as examples, and sharing their experience and learning broadly, will be critical to boosting market confidence. Currently, in some segments, despite there being some willing buyers, the business case is still not strong enough to move forward – for example, there is an insufficient quantity of buyers and/or the costs are still too high to invest. Governments might consider support mechanisms to help facilitate such private-sector offtake examples, such as through offering tax breaks in the first few years of projects to help them secure finance – such de-risking support, along with demand from private-sector buyers, may together provide sufficient confidence for first projects to move forward. Additionally, as discussed above, governments might consider options to enter directly into offtake agreements themselves for public sector projects.

RECOMMENDATION S2 HAS BEEN UPDATED AS FOLLOWS:

Governments and companies should increase purchase commitments to cover a significant share of their future steel demand, joining relevant initiatives aggregating these commitments and ensuring high quality through appropriate legal and implementation frameworks, such as advance purchase commitments. Firm commitments for near-zero emission steel in particular, not only low-emission steel, should be increased. Governments should also look into adopting other mechanisms to support lead market scale-up, such as low- and near-zero emission material mandates or performance standards, and including the possibility of cross-border demand-creation mechanisms.

STRONGER COLLABORATION ON DEVELOPMENT AND DEMONSTRATION, MAKING USE OF SUCCESSFUL CO-OPERATIVE MODELS

OVERVIEW

Last year, we recommended that governments and companies should collaborate via existing initiatives to fast-track sharing of technology learning, business case development and policy support to accelerate the development of pilot projects. The participation of EMDEs in key RD&D initiatives should be increased in support of this aim.

At COP 28, countries under the Steel Breakthrough agreed to collaborate internationally on R&D to develop emerging solutions and scale up the number of demonstration projects for near-zero emissions steel. This includes establishing mechanisms to share lessons widely and update on progress and future ambitions at COP 29.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress against our recommendation on research and innovation collaboration in the steel sector, including through new funding mechanisms as well as knowledge-sharing initiatives.

Two new collaborative funding mechanisms, though still in early stages, show some promise in the area of international collaboration on R&D. The United Nations Industrial Development Organization (UNIDO) [launched the Accelerate-to-Demonstrate](#) (A2D)

Facility in May 2023 to accelerate the commercialisation of innovative solutions in several key areas for the energy transition, including industrial decarbonisation, through lighthouse pilot and demonstration projects in EMDEs. This Facility responds to a key need in the international collaboration space – the need to scale up innovative industrial decarbonisation projects in EMDEs (see the Cross Cutting Chapter for more details).

Beyond funding, the Mission Innovation [Net Zero Industries Mission](#) (NIM) has several programmes underway to promote cross-border knowledge-sharing. One of its key programmes in this area is the [Net-Zero Industries Award](#), which recognises outstanding innovation in industrial decarbonisation, and in doing so brings to the fore people and projects working towards industrial decarbonisation. The intent of the programme is not only the award itself, but rather to build networks and share knowledge among the actors working on these topics. The first edition in 2023 received 68 applications and recognised 13 of those with awards. In the 2024 edition, a new category was added highlighting projects in EMDEs, an important step to promoting collaboration with EMDEs. Other efforts that NIM is undertaking include a global seminar programme, consisting of several virtual workshops and webinars covering topics such as intellectual property rights and knowledge-sharing requirements within government funding offers; establishing a network of contacts from research laboratories and universities; and establishing a resource library, including project summary reports on key demonstration projects.

WHAT MORE NEEDS TO BE DONE?

Despite positive efforts on knowledge-sharing, funding and demonstration projects, the technologies needed for deep decarbonisation of the steel industry have not yet reached commercial maturity. This is concerning, given that commercial availability of technologies is a fundamental pre-requisite for the Steel Breakthrough objective for near-zero emission steel to be the preferred choice in global markets, with production established and growing in every region by 2030. To be on track for this goal, commercialisation of key technologies, including fully hydrogen-based DRI and CCS-based routes, urgently needs to be reached within the next 1 to 2 years, to provide sufficient time for scale-up and initial deployment globally by 2030. This will require building on ongoing efforts to develop multiple demonstration projects in parallel, in different regional contexts, with strong sharing of learnings among them. Innovation towards scale-up and cost reductions on enabling infrastructure for these technologies – namely renewable and low-emissions hydrogen and CO₂ transport and storage – is also critical. Accelerated innovation on other technologies such as iron ore electrolysis is also needed, even though commercialisation may take somewhat longer.

Given the urgency, a step-up is needed from governments globally to facilitate high-quality knowledge exchange and practical technology collaborations across borders, including with EMDEs. While continued knowledge-sharing is useful across the broad range of technologies that are potentially beneficial for industrial decarbonisation, a targeted focus is needed to accelerate learnings for the handful of deep decarbonisation technologies showing the greatest promise. Working through existing collaborative forums, governments could find ways to bring together the key relevant actors – including steel producers, technology providers, engineers, researchers, financiers, and government regulators – for open exchange on process-related challenges of establishing demonstration projects, [trust-building](#), and the possibility to establish practical partnerships focused on these key technologies. This might include technical and policy dialogues with active involvement of governments, and could include visits to demonstration plants by government officials and technical experts from other countries. Additionally, joint funding calls between countries could encourage cross-border collaboration. Models being trialled in the private sector –

such as subsidiary models (e.g. US-based [Boston Metal's expansion to Brazil](#)) and bilateral agreements across geographies (e.g. collaboration between Swedish [Stegra \(formerly H2 Green Steel\) with Anglo American](#) in South Africa and Brazil on use of high-quality iron ore in DRI production) – could also provide learnings that could be built on and expanded by others, if needed with the aid of governments. On top of that, government-to-government exchanges would be useful for sharing experiences on policy development to foster innovation and set the enabling conditions for first-of-a-kind projects.

An important area to continue working through at the international level and with a focus on the industrial decarbonisation context is how to balance the protection of intellectual property rights (IPR) with the need for accelerated international knowledge-sharing and technology collaboration. While IPR is sometimes raised as a potential barrier to sharing technology learnings and technology diffusion, it can actually be an enabler. For example, as discussed in a recent [NIM](#) webinar on the topic, several solutions are possible, such as patenting (since knowledge can be shared more freely once IP is protected), requirements for knowledge-sharing within government funding programmes, and encouraging companies to voluntarily set different technology licensing terms for EMDEs. A frank and open dialogue on this topic among governments and industry actors could help to further break down walls, surface solutions and accelerate collaboration across borders, including drawing on existing broader work on IPR and technology development, such as that by the [UNFCCC](#) and the [OECD](#).

Additionally, an increased focus on innovation in EMDEs is still needed to accelerate the pace of learning. This can include increased support to established mechanisms like the A2D Facility, or engagement via other technical assistance offers (see S5) to support EMDEs to engage in such collaborations, and for governments to establish the needed enabling policy environments to foster innovation.

RECOMMENDATION S3 HAS BEEN UPDATED AS FOLLOWS:

Governments and companies should collaborate via existing initiatives to fast-track policy support, sharing of technology learning, business case development, and practical technology collaboration partnerships, towards rapid commercialisation of a portfolio of technologies that can achieve near-zero emissions. These partnerships should support the delivery of pilot and, most importantly, commercial-scale demonstration projects in all major emerging and developing countries well in advance of 2030. Increased open conversations are needed on the role of intellectual property rights in accelerating knowledge-sharing and technology collaboration.

ALL MAJOR STEEL PRODUCING COUNTRIES TO ENGAGE IN OPEN AND INCLUSIVE DIALOGUES ON TRADE AND NEAR-ZERO EMISSION STEEL

OVERVIEW

Last year, we recommended that governments should urgently launch a strategic dialogue on trade, including leading producer and consumer countries, to agree on ways to ensure near-zero emission steel can compete in international markets.

At COP 28, countries under the Steel Breakthrough agreed to launch such a dialogue, serving as an enabling framework for increased co-operation, improved co-ordination and potential collective action, to support the trading of near-zero emission steel by COP 29.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress against our recommendation on trade and the steel transition. While discussions remain relatively general at this stage, dialogues have been taken forward that are relevant to steel decarbonisation within global markets.

Perhaps the most substantial progress in this area this year has been the launch of a series of strategic dialogues on spillovers from mitigation policies under the Climate Club among its 42 member governments. These dialogues are addressing topics including carbon leakage from domestic industrial decarbonisation policy adoption and impacts on competitiveness of domestic industries in the context of global markets, as well as possible policy solutions to limit such impacts. Three dialogues are scheduled over the course of the year, focusing sequentially on 1) what kind of spillovers exist and how they come into play, i.e. understanding carbon leakage; 2) key instruments to prevent negative spillovers and carbon leakage, including experiences from countries to apply such instruments; and 3) the solution space and possible ways forward for joint steps within the Climate Club. While the possibility of collective steps will be raised in the third dialogue in Q3 2024, it is likely that further dialogues over the course of 2025 will be needed to agree to any substantial steps.

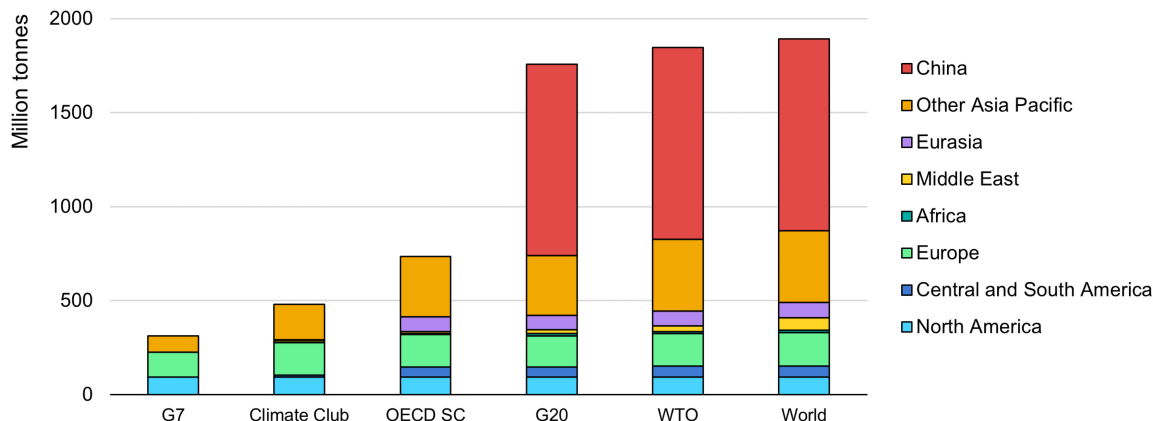
While the opening of a constructive space to start exchanging at the international level on these potentially difficult topics is a positive step forward, there is still no formally established forum that assembles all the major steel producers and consumers specifically for open dialogues on the role of trade in the steel sector's transition to net zero emissions. The Climate Club might offer an opportunity but, so far, some of the major EMDE steel producers have not joined the initiative. Half of the world's ten largest steel producing countries are in the Club and participating in these strategic dialogues, but none of the EMDEs among the top-ten producers.

Relevant discussions in other forums also continue; however, to date these have tackled less directly the three-way intersection of steel, emissions and global markets. At the WTO, relevant ongoing discussions include that on the EU Carbon Border Adjustment Mechanism (CBAM) in the [Committee on Trade and Environment](#), on circularity and scrap in the [Trade and Environment Sustainability Structured Discussions](#) and on steel decarbonisation standards in the Committee on [Technical Barriers to Trade](#). However, in most cases these discussions are at the higher, cross-cutting nature, rather than focused on issues for steel specifically, or on technical matters such as standards, and are not yet of a strategic nature in terms of potential collective steps. On the other hand, traditional venues for international discussions on steel trade and competitive conditions, such as the OECD Steel Committee and the [Global Forum on Excess Steel Capacity](#), are increasingly looking at the intersection of emissions and global steel markets. There have so far been some high-level discussions on relevant issues in these forums, including on the role of scrap in international steel markets and on the impact of global steel excess capacity on the achievement of net zero goals. However, the discussions are not yet focused on the strategic question of how to collectively help facilitate trade of low- and near-zero emission steel.

Efforts initiated by governments themselves may also prove relevant. In the first half of 2024, the EU Commission announced it will launch a [dedicated taskforce](#) to help advance carbon markets globally, through diplomatic efforts to encourage and support other jurisdictions to introduce or improve carbon-pricing mechanisms. This comes against a backdrop in which the [Global Arrangement on Sustainable Steel and Aluminium \(GASSA\)](#) between the United States and the European Union did not result in an agreed approach to emissions accounting by the October 2023 target. Continued co-operative efforts are

needed to keep moving these kinds of dialogues forward, where possible in multilateral forums.

Figure 5.4. Steel production by international forum and by region, 2024



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Notes: WTO = World Trade Organization. OECD Steel Committee (OECD SC) includes both full member countries and “participant” countries. Climate Club membership is accurate as of September 2024 but is likely to change.

WHAT MORE NEEDS TO BE DONE?

While the ongoing dialogues are moving in a positive direction, further developments are needed on several fundamental areas.

First, the dialogues need to move from general discussion and exchange of experiences towards the possibility of collective outcomes and co-ordinated steps forward. While this is a challenging topic, as noted, discussion on ways to compromise and move forward together is needed. For some aspects of the discussions, there may be benefits in cross-fertilisation and potentially pooling efforts, drawing on the respective strengths of the relevant forums, including the WTO’s expertise on trade policies, the OECD Steel Committee’s knowledge of the steel sector and capacity issues, and the Climate Club’s ambition and strategic outcomes-oriented approach.

Second, there is a need for the largest steel producer and consumer countries to be involved in these dialogues, because without them it will be difficult to achieve the necessary level playing-field for clean steel in global markets. The member countries involved in the Climate Club and the OECD Steel Committee dialogues, for example, so far cover only 25% and 40%, respectively, of global steel production. This is not to say these discussions should not continue, but finding ways to bring to the table all major producing countries would help foster truly global and effective solutions. Without this, a patchwork of uncoordinated unilateral policies might restrict countries’ access to each other’s markets and, at the same time, fail to achieve a global transition in the sector at the pace required by internationally agreed climate change goals. For some developing economies, technical assistance (see next section) may be a helpful enabler for meaningful involvement in such strategic discussions.

Third, the dialogues could benefit from also including a component oriented towards how to boost trade in near-zero emission iron and steel – in a sense, the other side of the coin to current discussions around how to mitigate potential negative outcomes related to carbon leakage and competitiveness. Such a framing could help open the possibility of

additional co-operation and focus on the benefits of the net zero transition, such as the possibility for front-runners in clean steel production to gain a competitive advantage and for “green” iron trade to reduce the costs of the transition while bringing additional economic benefits to iron ore exporters with strong renewables potential, which in several cases are EMDEs. Bringing a just transition lens to such discussions will be important, to ensure that the different situations of different countries and potential effects on employment are a key part of discussions. Learnings could be drawn from other efforts to recognise certain goods within international trade discussions, such the Asia-Pacific Economic Cooperation [list of environmental goods](#) that has also served as a basis of [past discussions in the WTO](#), so that low- and near-zero emission iron and steel could be more directly covered in relevant discussions. Ongoing work at IEA on [secure, resilient and affordable manufacturing](#) and trade of clean energy technologies and materials (see *Energy Technology Perspectives 2024*, forthcoming at the end of October) and at OECD on green iron trade as a lever for decarbonisation (see *The green iron revolution: building new evidence base and fostering a global dialogue*, forthcoming) could help inform further co-operation in this area.

RECOMMENDATION S4 HAS BEEN UPDATED AS FOLLOWS:

Governments should deepen and expand strategic international dialogues on the role of trade in the steel sector’s transition, with the purpose of agreeing ways to ensure near-zero emission steel can compete in international markets, including conversations both on carbon leakage and on enablers of near-zero emission iron and steel trade. Governments of all major steel producing and consuming countries should actively engage in international dialogue and explore possibilities for collaboration in this area.

IMPROVING THE EFFECTIVENESS OF TECHNICAL AND FINANCIAL ASSISTANCE FOR INDUSTRY DECARBONISATION PROJECTS

OVERVIEW

Last year, we recommended that countries should establish an improved match-making function focused on industry decarbonisation and including steel that can better respond to requests for financial and technical assistance in EMDEs.

At COP 28, countries under the Steel Breakthrough agreed to further enhance the overall public offer of international assistance towards deep decarbonisation of the steel sector by COP 29, including enabling technologies and infrastructure, with the goal of mobilising private investment at scale in EMDEs.

WHAT PROGRESS HAS BEEN MADE?

We assess that moderate progress has been made against our recommendation on financial and technical assistance since last year, with a handful of country-focused collaborations and a global match-making platform in development, plus continued work on enabling conditions for finance. Many of these initiatives are still in the early stages, however, and are yet to deliver tangible results.

Within the past year, a few direct bilateral country partnerships on technical assistance for industrial deep decarbonisation have been launched. If they prove successful, they could provide models to expand to a larger number of countries. One of these is the [Brazil-UK Industry Decarbonisation Hub](#), launched in late 2023 in partnership with UNIDO and

LeadIT. Its objectives include sharing knowledge, identifying support from international actors tailored to outcomes, and providing support to access international climate finance. Another is the [India-Sweden Industry Transition Partnership](#), launched at COP 28 under the LeadIT platform, with the objective to support India's transition priorities through a co-ordinated and bespoke offer of bilateral and multilateral technical and financial co-operation.

Additionally, country partnership with MDBs and international platforms are also underway, targeted at more ambitious, deep decarbonisation compared to previous support programmes. The EBRD is working towards the launch of the Türkiye Industrial Decarbonisation Investment Platform (TIDIP) by COP 29. A step along the way was the [launch of roadmaps](#) for several industries, including steel, in March 2024. The investment platform is intended to be a facilitating mechanism for policy and industry to come together on deep decarbonisation, to identify projects, project needs, and work towards implementation through undertaking feasibility studies, securing finance and working towards the needed enabling policy environment.

The Industrial Transition Accelerator (ITA) – which was launched at COP 28, is run by the Mission Possible Partnership (MPP) and is cofounded by the UAE Ministry of Industry and Advanced Technology and Bloomberg Philanthropies – is similarly using a country-focused model to work towards bringing deep decarbonisation projects to the final investment decision (FID) stage through its newly developed series of Project Support Programmes. Focusing on EMDEs, the ITA will select three to four countries or regions, and two to four focus sectors per geography. Partnerships will be established with governments and also work with both domestic and international players from the industry, energy provision, demand pull and finance spheres to set the necessary enabling conditions to bring projects to FID. The first of these partnerships, focused on Brazil, launched a [call for expressions of interest](#) from decarbonisation projects in mid-2024, with iron and steel as a priority sector. Other geographies that may be pursued include India and the Middle East and North Africa region.

OECD's Clean Energy Finance and Investment Mobilisation (CEFIM) programme is also engaging directly with target countries to implement its step-by-step [Framework for industry net-zero transition](#). This work includes a focus on enabling conditions for investment and financial instruments for selected cases/technologies in EMDEs. The Project and Technical Advisory Committees bring together actors from governments, industry, finance institutions, think tanks and academics. The programme is being run for the steel sector in [Indonesia](#) and [South Africa](#), with a focus on energy efficiency and biomass use in scrap-based electric arc furnaces, renewable H₂-DRI, and CCUS on blast furnaces.

These country partnerships are positive steps forward, but a broader offering extending to all EMDEs will be needed to accelerate industrial decarbonisation globally. Here the [Global Matchmaking Platform](#) (GMP) can potentially play a key role. Launched at COP 28 under the Climate Club and with UNIDO as a project delivery partner, the GMP is under development over the course of 2024, working towards the first few pilot examples of matches by the end of the year. The platform aims to facilitate connections for EMDEs – regardless of whether or not they are members of the Climate Club – to existing international technical and finance assistance offerings, as well as to leverage new finance and facilitate technology co-development. An initial positive step on the GMP is [Germany's announcement](#) in July 2024 that it will earmark funds to support EMDEs on including industrial decarbonisation in their updated Nationally Determined Contributions, to be allocated to the United Nations Development Programme (UNDP)'s Climate Promise and the UNIDO Net Zero Partnership, and channelled through the GMP.

Beyond country partnerships and facilitation towards securing finance, there remains a need for provision of finance itself. While the majority of finance will ultimately come from the private sector, targeted public sector grants and de-risked finance offerings – in many cases channelled through MDBs – are critically needed to mobilise private finance. In this space, progress has so far been quite slow in terms of funds dedicated specifically to industrial deep decarbonisation. The [Climate Investment Funds' \(CIF\) Industry Decarbonization Program](#) was launched in 2022 at COP 27 as the world's first multilateral investment platform dedicated to industrial decarbonisation. However, it has yet to provide finance to projects, with [donor support relatively weak so far](#), totalling USD 90 million. To help provide access to a larger pool of funds, the programme was recently shifted to the Clean Technology Fund. The aim is for the first call for expressions of interest from potential recipient countries to go out around the Clean Energy Ministerial in October 2024, after which selected countries would be invited to develop Industry Decarbonisation Investment Plans. It is expected that a handful of projects (roughly 4 to 5) could be supported in this first round, with the first projects likely to be approved sometime in 2025. The International Finance Corporation is also exploring options for a programme dedicated to industry, but few details are publicly available yet.

Beyond country partnerships and finance provision, some initiatives are looking at cross-cutting issues related to finance and enablers of finance. For example, the ITA is developing a programme of work focused on strengthening conditions for investment globally, which focuses on policy approaches to stimulate green demand and uptake of carbon pricing, alongside a toolkit on de-risking offtake to underpin finance. The programme will be disseminated within ITA's existing stakeholder network and add value in particular through cross-sectoral experience-sharing. Another example is the analyses being undertaken by the OECD as inputs to the GMP – a mapping of currently available financial and technical assistance offerings for industry decarbonisation and study on enabling conditions.

WHAT MORE NEEDS TO BE DONE?

A large gap remains to be filled on international finance targeted towards industrial deep decarbonisation, including for the steel sector. Governments should consider stepping up their contributions to relevant funds, including, for example, the CIF Industry Decarbonisation Program, as well as via direct partnerships.

In addition to increasing the funds available, active engagement is needed to ensure assistance offers are tailored to the needs of recipients. For the recently announced country-focused partnerships noted above, it will be important to show clear progress towards tangible outcomes – i.e. policies adopted and projects taking steps to reach FID – and to share learnings. Additional partnerships are also needed to target the broader range of countries, noting that many of the partnerships to date have been focused on the largest EMDEs like Brazil and India; while these are critical, other countries are also in need of assistance. Ramping up both recipient and donor government engagement in the Climate Club's newly founded GMP – as well as engaging philanthropies, institutional investors and other sources of public finance (e.g. International Financial Institutions) – could be a key means to surface needs and make connections to appropriate funds and technical assistance offers.

One of the most commonly cited critical enablers of finance for industrial deep decarbonisation projects is having in place a robust, stable enabling policy framework in the country in question. Such policies – which may include carbon pricing, and regulatory policies – help create a business case for projects, reduce risk and provide market

confidence to mobilise private-sector investments. At the international level, additional exchange of experiences and good practice, as well as hands-on technical assistance on policy development, would be useful. This includes moving beyond road-mapping exercises into other supporting policy measures. It is likely to be useful for governments and MDBs to address both national policy frameworks and international financial support within the same collaborative initiatives, because the success of one may depend considerably on the other.

Greater collaboration is also needed between governments and financial institutions, to move towards both MDBs and private-sector investors including climate risks into their investment decisions. While there are several finance sector initiatives working towards this goal, such as the [Glasgow Financial Alliance for Net Zero \(GFANZ\)](#), the [Paris Aligned Asset Owners](#) and the [Institutional Investors Group on Climate Change \(IIGCC\)](#), alignment of the financial sector with 1.5 °C pathways is still not the norm. A push from governments to encourage or require broader alignment would be an important step forward, including a focus on the industry sector in particular. Such alignment is particularly important given that industrial assets are long-lived, so that investments in the near-term do not lock in high emission capacity or result in stranded assets. A possible initial objective could be to align investments to support only facilities that have a technologically feasible path to near-zero in the longer term, even if they may not be near-zero emission for the start – for example, DRI facilities that could later convert to use 100% renewable hydrogen. A collective international goal or pledge from governments could help signal to financial institutions and markets to move in this direction. This could perhaps draw on learnings from other sectors where governments have come together to collaboratively and constructively address emissions-intensive capacity and investments, such as the [Powering Past Coal Alliance](#) and its [Finance Taskforce](#). Such discussions would require complementary discussions on assistance to EMDEs, to better enable their active engagement towards such collective goals.

RECOMMENDATION S5 HAS BEEN UPDATED AS FOLLOWS:

Governments should increase support for, and engagement with, improved match-making functions focused on steel deep decarbonisation that can better respond to developing country requests for financial and technical assistance. This should include donor countries, recipient countries, international financial institutions, national development banks, philanthropic organisations, private financial institutions and companies, with regular meeting of ministers. Governments should share best practices to enhance enabling policy frameworks, as well as collectively set guardrails for finance in collaboration with financial institutions, so that new capacity additions and major retrofits of existing capacity are suitable for future conversion to near-zero emission technologies and do not become stranded assets.

RECOMMENDED REPORTS

We recommend the following reports for more detailed descriptions of the technologies for steel sector decarbonisation and of the actions that countries and businesses can take:

- ResponsibleSteel (2024), [Charting progress to 1.5°C through certification](#)
- Net Zero Steel (2024), [Facility level global net-zero pathways under varying trade and geopolitical scenarios](#)
- E3G (2024), [Raising ambition on steel decarbonisation: 2023 steel policy scorecard](#)

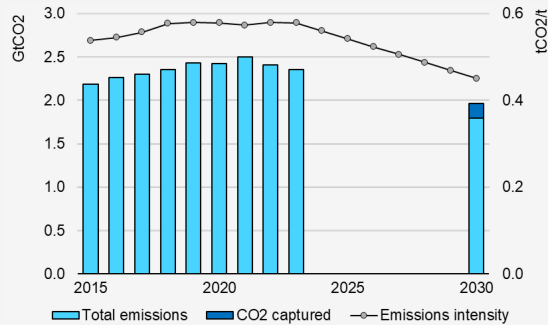
- Agora Industry, Wuppertal Institute, Lund University (2024), [Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking](#)
- IRENA (2024), [Decarbonising hard-to-abate sectors with renewables: Perspectives for the G7](#)
- IEA (2023), [Steel and aluminium Net Zero Emissions Guide](#)
- IEA (2023), [Emissions Measurement and Data Collection for a Net Zero Steel Industry](#)
- IRENA (2023), [Towards a Circular Steel Industry](#)
- AFID (2023), [Solutions to decarbonise heat in the steel industry](#)
- IEA (2022), [Achieving Net Zero Heavy Industry Sectors in G7 Members](#)
- MPP (2022), [Making Net-Zero Steel Possible](#)

CHAPTER 6. CEMENT

STATE OF THE TRANSITION

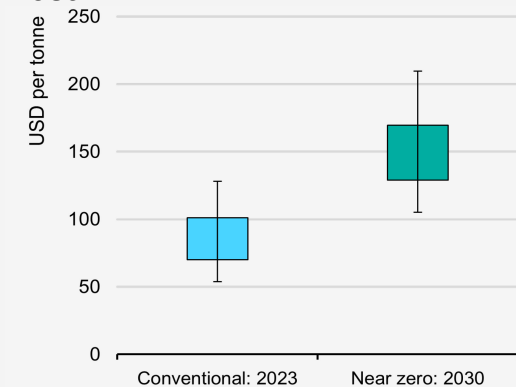
The cement sector is not on track to meet net zero by 2050, with no substantive decline in global emissions over the past decade. While an increasing number of projects for carbon capture and storage (CCS) and other decarbonisation technologies are [being announced](#), policy is not yet strong enough globally to drive the number and scale of projects needed across all major geographies.

Emissions¹⁹



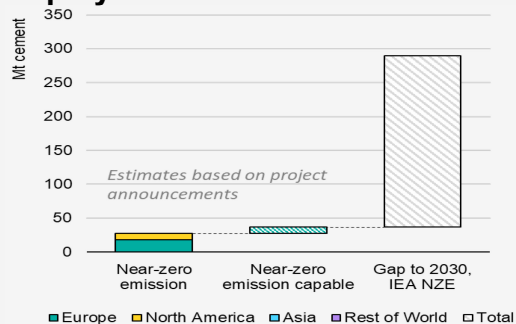
- Total CO₂ emissions from the cement sector are higher today than in 2015. Declines in the past 2 years are due to declines in global production rather than emissions intensity.
- By 2030, total emissions and emissions intensity need to fall by around 20% in the IEA Net Zero Emissions by 2050 Scenario (NZE Scenario). Key contributors include increases in alternative fuels and supplementary cementitious materials (SCMs), improved material efficiency in buildings and initial deployment of carbon capture, utilisation and storage (CCUS).

Cost²⁰



- During the 2020s and even beyond, costs of producing near-zero emission cement are likely to remain much higher than for conventional cement. A range of different technologies are under development, with current estimates putting near-zero emission cement at a premium of approximately 75% on average versus conventional cement (range of about 30-125% depending on regional circumstances).
- The overall cost of the transition will benefit from other strategies such as material efficiency that are less costly or may even lower costs. However, the green premium will still need to be addressed.

Deployment²¹



- Based on currently-announced projects, it is estimated that 27 Mt of fully near-zero emission cement production will be in place by 2030, and 10 Mt near-zero emission capable.²²
- The project pipeline has increased considerably in recent years but remains a long way from what is required to get on track with net zero. In the NZE Scenario, around 7% of global cement production capacity is near-zero emissions by 2030.

¹⁹ LH axis = total emissions (bar); RH axis = emissions intensity (line).

²⁰ Levelised cost of production (LCOP) per tonne of cement. Based on IEA analysis. Estimates are based on regional averages. Costs do not include any policy supports, e.g. carbon pricing or subsidies. The box represents the range of expected typical LCOP values, while the whiskers include the average LCOP in higher and lower cost regions.

²¹ IEA (2023). [Energy Technology Perspectives 2023](#).

²² 'Near-zero emission' refers to projects that, once operational, will be near-zero emission from the start, as defined in the IEA report [Achieving Net Zero Heavy Industry Sectors in G7 Members](#). 'Near-zero emission capable' refers to projects that will achieve substantial emissions reductions from the start – but fall short of near-zero emissions initially – with plans to continue reducing emissions over time such that they could later achieve near-zero emission production without substantial additional capital investments in core process equipment; project announcements that are still only at the concept stage are also included in this category due to the higher uncertainty of their completion.

STATE OF INTERNATIONAL COLLABORATION

Since the [Breakthrough Agenda Report 2023](#), international collaboration on cement deep decarbonisation has continued to move forward, with noteworthy developments including several collaborative research consortia formed under the [Global Cement and Concrete Association \(GCCA\) Innovandi](#) programme, and the launch of a number of country-specific partnerships to boost technical and financial assistance. Nevertheless, many of the developments have yet to deliver substantial tangible results – both acceleration and an expanded reach will be needed to get on track for the Cement and Concrete Breakthrough’s ambitious objective of making near-zero emission cement the preferred choice in global markets, with efficient use and near-zero emission cement production established and growing in every region by 2030. Strengthened leadership from governments is needed to create demand and enable deployment of near-zero emission production technologies, nationally and internationally. Resource gaps need to be filled to empower initiatives to move forward at the speed and scale required.

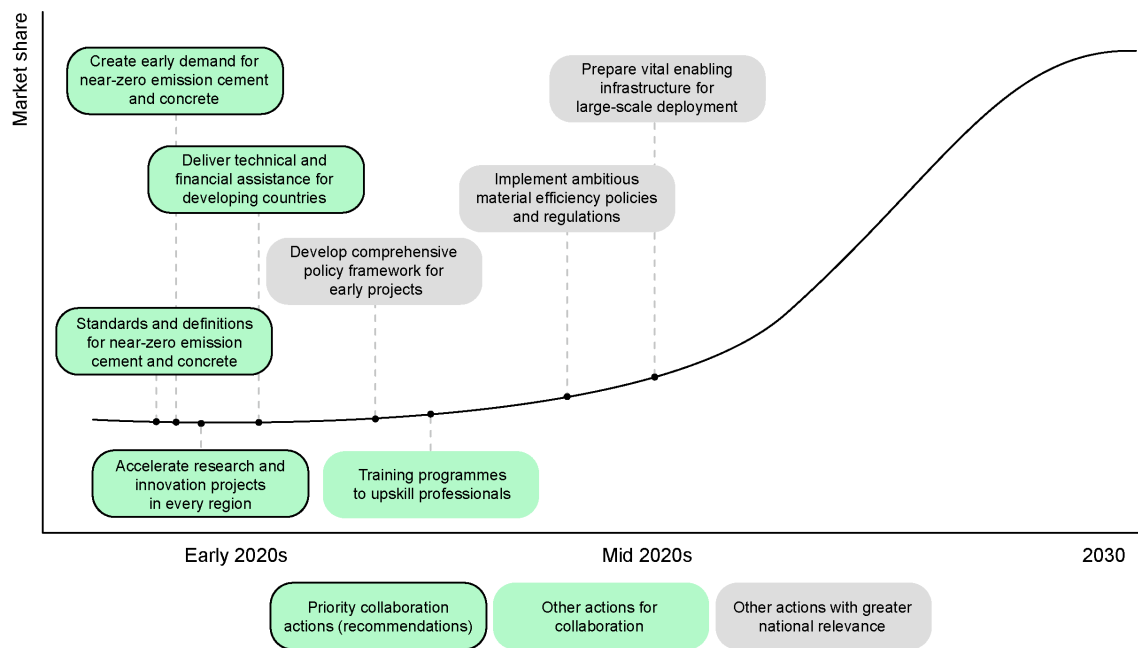
In this chapter, we assess progress against priority actions in the areas of standards, demand creation, research and innovation, and finance, and we make recommendations on the most urgent and high-impact opportunities in need of international collaboration in each of those areas. The assessment is measured against the ambitious goals of the Cement and Concrete Breakthrough, focusing on the speed and scale of international collaboration needed to start deploying near-zero emission technologies and solutions this decade, to prepare for widespread diffusion thereafter. Near-zero emission technologies in the cement and concrete context primarily include CCS, fully decarbonised fuels, and use of alternative raw materials in ways that can achieve deep emissions reductions. Major step changes in the efficiency with which clinker, cement and concrete are used are also discussed under some priority areas, as these solutions push the boundaries of current best practices. This focus on near-zero emission technologies and solutions does not imply that no progress is occurring on strategies to partially reduce emissions – including more moderate increases in use of SCMs, alternative fuels and material efficiency – nor that these strategies are not important components of the overall [cement sector pathway](#) to net zero emissions. It does, however, reflect that large-scale deployment of near-zero emission technologies will be required to fully decarbonise the sector, and also that the development, deployment and diffusion of near-zero emission technologies is where the greatest gains from co-ordinated international action are likely to be found.

While the Cement and Concrete Breakthrough was launched at COP 28 at the end of 2023, many forums for cement decarbonisation have been underway much longer. As in other sectors, our assessment reflects the state of international co-operation generally, rather than any co-operation that is specifically attributable to the Breakthrough Agenda.

Our assessment and selected key developments are summarised in the table below, and the following sections address each area of international collaboration in turn in more detail. To note that there is considerable overlap between activities for the cement and steel sectors, given that both fall under industrial decarbonisation, and so in several instances the cement chapter cross-references the Steel Chapter for additional details.

Area	What key progress has been made?	What more needs to be done?	2024
C1. Standards	<ul style="list-style-type: none"> • Measurement: GCCA methodology revisions underway to include innovative technologies, IDDI PCR Harmonisation and accounting methods dialogues. • Definitions: GCCA definitions proposal for concrete in the final stages of development, strategic exchanges towards identifying common ground on definitions in Climate Club and WPID. 	<ul style="list-style-type: none"> • Measurement methodologies: leadership on identifying and implementing priority revisions. • Definitions: agreement on common principles for definitions and a process for determining equivalency of definitions. • Chain of custody: clarity around innovative chain of custody models. • Construction standards: revisions to facilitate maximised uptake of SCMs. 	Moderate
C2. Demand creation	<ul style="list-style-type: none"> • Public sector: IDDI procurement commitments by four countries. • Private sector: FMC First Suppliers Hub launched; increased membership in ConcreteZero. 	<ul style="list-style-type: none"> • Public sector commitments to near-zero emission cement/concrete procurement; demand-creation policies beyond procurement. • Private sector commitments for near-zero emission cement/concrete. • Commitments in emerging markets and developing economies. 	Minimal
C3. Research and innovation	<ul style="list-style-type: none"> • GCCA Innovandi Open Challenge consortia creation and third open call; work on conditions for CCS first-of-a-kind projects. • Mission Innovation Net Zero Industries Mission Award and seminar programme. • UNIDO A2D Facility launch. 	<ul style="list-style-type: none"> • More and strengthened practical partnerships between countries on technology collaboration, including at different stages of TRL. • Enabling policy environment for first-few-of-a-kind innovative technology deployment. • Open dialogue on the role of intellectual property rights in accelerating technology collaboration. 	Moderate
C4. Finance and investment	<ul style="list-style-type: none"> • Key examples of direct country partnerships/platforms on industrial deep decarbonisation have been launched: UK-Brazil Industry Decarbonisation Hub (with UNIDO and Lead-IT), Sweden-India Partnership (Lead-IT), Türkiye investment platform (EBRD) and Canada-Thailand (with UNIDO). • Launch of the Climate Club Global Matchmaking Platform Initiative. • ITA launching national and regional project support programmes. 	<ul style="list-style-type: none"> • Expanded financial and technical assistance, matched to country needs. • Financial sector alignment towards the net zero goals, in order to channel funding appropriately. 	Moderate

Figure 6.1. Critical path to 2030 for the cement sector



IEA. CC BY 4.0

Source: [Breakthrough Agenda Report 2023](#)

AGREE COMMON STANDARDS, DEFINITIONS AND GUIDELINES FOR CEMENT AND CONCRETE PRODUCTION AND USE

OVERVIEW

Last year, we recommended that countries and companies should work through existing collaborative forums to agree on definitions for low- and near-zero emission cement and concrete by the mid-2020s, as well as guidelines for the efficient use and reuse of building material.

In June 2024, countries under the Cement and Concrete Breakthrough agreed to work together to accelerate the development of standards for low-emission and near-zero emission cement and concrete. To that end, countries agreed to expedite the development of common definitions and working towards interoperability and net zero compatibility of emissions measurement standards, in order to announce at COP 30 a common timeframe for formal adoption. Countries also agreed to share knowledge to accelerate the adoption of emissions reporting, and to develop a definition of “alternative fuel” to enable the use of waste to replace coal in cement production.

WHAT PROGRESS HAS BEEN MADE?

Overall, we assess that moderate progress has been made against our recommendation on the common understanding of definitions and standards. There have been positive steps forward on emissions measurement methodologies and definitions/thresholds. However, governments, in particular, have not yet come to clear agreements on these topics, which are needed in the near term as a foundation for other enabling mechanisms.

Work towards interoperability and net zero compatibility of measurement methodologies has continued. The GCCA is in the process of updating its CO₂ Protocol to be applicable to innovative technologies, including CCUS, hydrogen and use of calcined clay, as well as recarbonation. As noted in the Steel Chapter, the Industrial Deep Decarbonisation Initiative (IDDI) is taking forward discussions on alignment of standards, including through release of its Product Category Rules (PCR) Harmonisation guidelines and working group discussions on key accounting issues, including chain of custody and CCUS. Determining an agreed emissions accounting method for CCUS, which is one of the identified accounting issues for discussion, will be particularly important for the cement sector, given that CCUS has a critical role in the sector's decarbonisation.

With regards to definitions and related certification schemes, developments continue, led by several different organisations, but a clear standard has not yet been established. One of the most notable developments is the work of the GCCA – in collaboration with the IDDI – to develop definitions for low- and near-zero emission concrete, building from many of the principles underlying the [IEA's definitions for cement](#). The GCCA circulated a methodological working paper for review in early 2024, and the final numerical proposal is expected to be made public in Q3 2024. If the proposal is robust, the GCCA definitions may be something that stakeholders could coalesce around internationally, avoiding some of the difficulties posed by the existence of multiple different proposals, as is becoming the case in the steel sector.

A number of other activities are also underway, but indications of their outcomes are not yet clear. The German Cement Association (VDZ) is currently drafting a possible CO₂ label and monitoring scheme for low- and near-zero emission cement, which implements the results of a [broad stakeholder process](#) led by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and builds upon the IEA definition proposal. The First Movers Coalition (FMC) is currently undertaking a commitment review for its cement and concrete commitment, which includes consultations on its thresholds for cement and concrete; the results of the review should be completed by the end of the year – to date, few details have been made publicly available on the extent to which the thresholds may or may not change. [ConcreteZero](#) is also updating its commitment requirements, having undertaken work in the first half of 2024 to assess international industry best practice and pathways aligned to net zero. Publication of the refined framework is expected by the end of the year.

As noted in the Steel Chapter, work is also underway towards identifying common ground among governments on definitions in the Climate Club and the IEA's Working Party on Industrial Decarbonisation (WPID). An agreement by COP 29, if reached, could drive forward important progress in this area.

As with steel, chain of custody is becoming an increasingly important topic when it comes to standards for cement and concrete. Here, discussions in the IDDI and the FMC and ConcreteZero commitment review may deliver important insights. Additionally, the launch of the [Center for Green Market Activation](#) in June 2024, with book-and-claim schemes for cement as one of its areas of focus, may serve as an emerging forum for international collaboration on this topic (see the next section for additional discussion on the potential role within demand creation).

With regards to international collaboration on standards to support more efficient use of cement, the [Alliance for Low-Carbon Cement and Concrete](#), an industry-led coalition formed in 2023 with support from Breakthrough Energy, is undertaking advocacy work for performance-based standards in the European Union. If such efforts prove successful, resulting learning could be shared internationally and expanded to other regions.

WHAT MORE NEEDS TO BE DONE?

As discussed in detail in the Steel Chapter, tangible steps forward at the international level to agree on definitions for low- and near-zero emission cement and concrete is a pressing near-term need to enable market creation in time for the 2030 Cement and Concrete Breakthrough objective. Strengthened leadership and clear steps forward from governments are needed – see the Steel Chapter for further details on possible direction. This would help provide clarity in light of the various ongoing activities mentioned above led by industrial associations and international initiatives. Additionally, there is a need to formalise proposals for definitions by taking them forward into international and verifiable certification and labelling schemes, or otherwise to clearly lay out formal processes for assessing performance against definitions employing existing labelling schemes such as environmental product declarations.

With regards to emissions measurement methodologies, countries should aim to reach agreement quickly so that the focus can move on to more substantial measures, many of which may require emissions measurement as an underlying enabler. Similarly, as noted in the Steel Chapter, political decision-making from governments through forums such as IDDI, WPID and the Climate Club is needed to speed progress in resolving key outstanding technical issues. For the cement sector, priority areas for which commonly agreed accounting rules and clarity are needed include CCUS, fossil waste emissions, and recarbonation. Governments and relevant initiatives should work together with and through the International Standards Organization (ISO), and national standards bodies, to drive forward necessary priority revisions across the various relevant standards, such as the PCR harmonisation recommendations of the IDDI and revisions in line with the IEA's Net Zero Measurement Principles.

Collective government oversight and clarity is likely to also be needed on emerging alternative chain of custody models. This can be expected to require further technical discussions, where possible building from ongoing work and analysis by organisations including IDDI and the Center for Green Market Activation, as well as in coherence with developments in the steel sector. Governments could perhaps work towards a collective statement or guidelines on suitability and use cases for different chain of custody models and verification procedures, to ensure that such approaches help support emissions reductions and avoid issues such as double counting.

Additionally, ensuring that existing standards enable maximised efficiency of using concrete, cement and clinker is an area that requires more attention, and for which sharing of best practices internationally could help further accelerate progress. This would support both additional incremental emissions reductions in the near term, and set the enabling conditions for deeper decarbonisation – such as cements with very low clinker ratios – in the medium term. Governments could advance progress by accelerating processes to ensure that key building and construction standards – including those that they use for their own public procurement – promote and do not restrict efficiency measures, including building designs that make more efficient use of concrete, cements with greater use of SCMs and thus lower clinker ratios, and other lower-emission cements made from alternative raw materials. Moving from prescriptive standards (e.g. that mandate a minimum clinker ratio) to performance-based standards (e.g. that instead require minimum performance in terms of concrete strength) could be a key step in this direction while still ensuring robust safety requirements are met. Such reviews of structural requirements in building codes could take place in tandem with reviews of building energy codes and whole-life-carbon assessments (see Buildings Chapter).

Inputs from the cement sector itself, which holds key expertise on the properties of cement and concrete, will be important for such standards reviews, and sharing experience among governments and industry stakeholders would be beneficial. The forum where such discussion could take place globally is not entirely clear, but the GCCA – which has experience on these topics – would be a key stakeholder to involve, as well as the Alliance for Low-carbon Cement and Concrete. Developing a set of international guidelines on requirements and design of performance-based standards could be explored to help establish international best practice for ensuring safety without putting up unnecessary barriers to the adoption of lower-emissions materials.

RECOMMENDATION C1 HAS BEEN UPDATED AS FOLLOWS:

Governments and industry should work through existing collaborative forums and with international standards bodies to identify and implement by the end of 2025 priority revisions for interoperability and net zero compatibility of cement and concrete emissions accounting methodologies. Governments should collectively provide clarity on principles for near-zero and low-emission cement and concrete definitions, commit to adopting definitions within national policies by the end of 2025, select methods for determining equivalency of certification schemes and provide guidelines on chain of custody models. Governments should exchange best practices and the latest standards, so that building codes and public procurement practices undergo accelerated revisions by end of 2025 to facilitate maximum possible use of supplementary cementitious materials (SCMs).

RAPIDLY SCALE UP HIGH-QUALITY DEMAND COMMITMENTS FOR NEAR-ZERO EMISSION CEMENT AND CONCRETE

OVERVIEW

Last year we recommended that countries and companies should work through existing collaborative forums to co-ordinate and scale up early efforts to create a market for near-zero emission cement, including via high-quality, multi-year purchase commitments and/or policy support.

In June 2024, countries agreed to work together under the Cement and Concrete Breakthrough to rapidly grow demand offtake for low- and near-zero emission cement and concrete, by joining or signalling intent to join the Clean Energy Ministerial (CEM) IDDI Green Public Procurement Pledge by COP 29, and by working together to develop packages of co-ordinated high-quality public and private procurement and purchase agreements for these products by COP 30.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been minimal progress against our recommendation. Activities continue to lay the groundwork for potential future high-quality commitments, but there has been little increase in demand commitments for near-zero emission cement and concrete, which are essential for the decarbonisation of the sector. This notably includes a lack of widespread awareness and commitments from the public sector, which should be the most direct route for Cement and Concrete Breakthrough countries to show leadership. There has been slightly more momentum on demand creation for low-emission cement and concrete, but this is still far from the scale and stringency needed to drive widespread

progress on solutions that achieve deep emissions reductions along the path to net zero emissions.

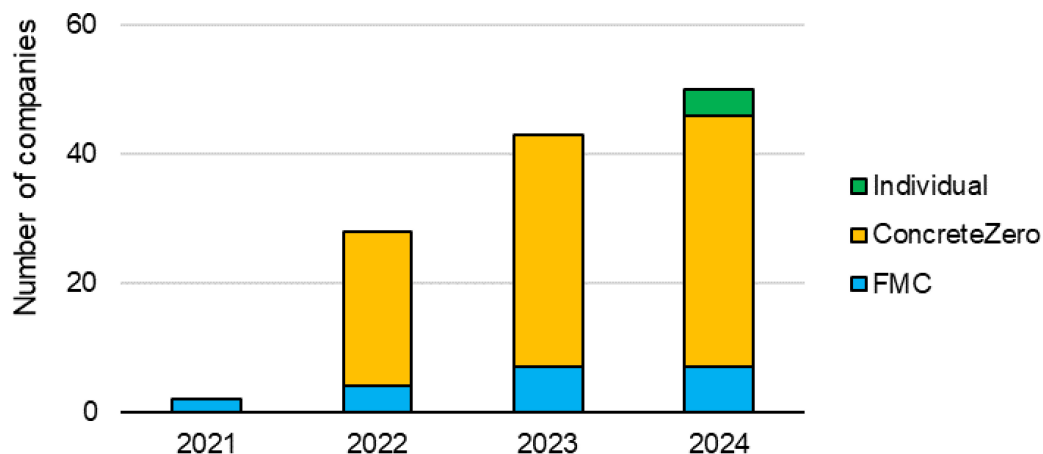
On the public sector side, the main progress has been pledges from four countries under the IDDI for procurement of low-emission construction materials including cement. However these have not yet been translated into policies that are sufficiently ambitious to start incentivising investment in near-zero emission cement plants, as would be needed to achieve the Breakthrough Cement objective. One exception is support for two innovative cement companies under the [US Green Proving Ground program](#) (see the Steel Chapter for additional details on public sector demand creation).

On the private sector side, little progress has been made in terms of offtake agreements for near-zero emission cement and concrete. To date, only a few offtake agreements for lower-emission cement have been made public, with no stated quantities, including three for [Cemvision's cement](#) made from alternative raw materials and one from [Heidelberg's evoZero marked concrete](#) that employs CCS, although only for about half of emissions. The progress has been even slower for near-zero emission cement and concrete than for comparable sectors like steel, with interested buyers noting a relative absence of potential projects that would meet near-zero emission thresholds, while supply chain complexities and lack of clarity on carbon accounting methodologies are further hindering connections between interested supply and demand actors. The FMC is undertaking a number of activities that could help support private sector demand scale-up for near-zero emission cement, including launch of the [First Suppliers Hub](#); workshops to bring together both supply, demand, finance and government actors to try to secure offtake agreements; and launch of a [cement and concrete procurement guide](#) (the full extent of FMC activities are discussed in more detail in the Steel Chapter²³). A key conclusion of the recent FMC discussions is that a book-and-claim system – as discussed under the above Priority Action on standards – will be integral to secure demand in the near term for near-zero emission cement, as it would enable connecting supply with willing buyers that do not necessarily share the same geography.

Increases in membership of private sector demand coalitions have been relatively moderate since COP 28. ConcreteZero saw its membership increase by 5, to reach 39 members. Membership in the FMC's cement commitment remained rather low, with only seven members.

²³ Note that FMC did not run a NearZero Cement and Concrete Challenge as it did this year for steel.

Figure 6.2. Number of companies committed to purchase near-zero and low-emission cement and concrete



IEA. CC BY 4.0

Notes: FMC = First Movers Coalition. Figures as of July 2024. [FMC members commit](#) to purchase near-zero emission cement or concrete by 2030. [ConcreteZero members commit](#) to purchase low-emissions concrete by 2025 and “net zero” concrete by 2050. Individual company commitments include publicly announced commitments to purchase near-zero emission cement or concrete by 2030, including letters of intent, memoranda of understanding, and offtake agreements.

WHAT MORE NEEDS TO BE DONE?

Many of the same actions are needed to drive forward progress as for steel (see Steel Chapter for additional details), including:

- Joint work to create and aggregate firm demand commitments by governments within mandatory procurement policies or dedicated purchasing programmes for near-zero emission cement and concrete in particular, even if initially in relatively small quantities of total demand. This is critical given that the public sector accounts for an estimated 40% of concrete demand.
- Expanding the number of countries committed to procurement of both low- and near-zero emission cement and concrete, with pledges being quickly converted to policies with clear timelines for increasing ambition, in order to create a larger pooled demand signal.
- Consideration and sharing of experience on other policies to secure business cases, such as near-zero emission material mandates, design regulations, carbon contracts for difference and embodied carbon limits on final products such as vehicles or buildings.
- Creating the enabling regulatory environment for uptake of low- and near-zero emission cement, including through moving to performance-based building codes and standards as discussed in Priority Action 1 above.
- Exploration of cross-border demand-creation mechanisms.
- Private sector offtake agreements, if possible, within pooled buyers’ clubs.

The case for accelerating demand creation for near-zero emission cement is even more urgent than for steel, considering the near absence of secured offtake agreements. Here, sharing learnings from successful offtake agreements in other sectors could be useful.

Pooling interested demand and policy support to secure a few first successful offtake agreements for cement made with breakthrough technologies – namely CCS, cement produced from alternative raw materials that avoid release of CO₂ or concrete produced with very low clinker content in applications for which such concrete could not typically be used – will be a critical step forward to boost market confidence.

With regards to cross-border demand creation and support for scale-up in emerging markets and developing economies (EMDEs), the case of cement is also somewhat different from steel given that cement is less commonly traded internationally. Yet collaboration on systems to scale up demand in EMDEs is critical, given that they account for 85% of total global cement production. The top ten producing countries – of which eight are EMDEs – account for 75% of global production, so co-ordination on demand from initial projects in even a relatively small number of countries could provide important learnings in different regional contexts and potentially have a large effect on the global industry. Here, book-and-claim systems that do not involve physical trade of materials may be more suitable than models like H2Global's auction mechanism (see the Hydrogen and Steel Chapters for more information). Such systems could enable buyers in advanced economies to create demand for near-zero emission cement produced in emerging economies. Work in this area is starting to take off. For example, in June 2024, the [Center for Green Market Activation](#) was launched. It is a US-based non-profit organisation with a global focus, whose primary aim is to develop book-and-claim schemes for hard-to-decarbonise sectors including concrete. Here, some form of collaborative government oversight and guidance may be useful, to help ensure robustness of and clarity on claims and their underlying calculation methodologies.

RECOMMENDATION C2 HAS BEEN UPDATED AS FOLLOWS:

Governments and companies should work through existing collaborative forums to co-ordinate and scale up early efforts to create a market for near-zero emission cement in particular, not only low-emission cement, including via high-quality, multi-year advance purchase commitments and/or direct policy support (including procurement and near-zero emission material mandates or performance standards), and including systems targeted at scaling up demand from projects in emerging economies.

FACILITATE PRIVATE SECTOR COLLABORATION ON NOVEL TECHNOLOGIES, USING PUBLIC SUPPORT TO DRIVE COST REDUCTIONS IN ALL REGIONS

OVERVIEW

Last year, we recommended that countries should work together with effective private sector collaborative forums to accelerate the pace of learning between a wider set of countries, with a particular focus on developing economies, in order to support the delivery of pilot and demonstration scale projects in all major EMDEs well in advance of 2030.

In June 2024, countries agreed to work together under the Cement and Concrete Breakthrough to support more robust knowledge-sharing and enhanced international assistance for deep decarbonisation of the cement and concrete sector by COP 30, with a goal of accelerating the delivery of a growing number of globally significant priority demonstration projects for near-zero emission cement technologies.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress against our recommendation on research and innovation collaboration in the cement sector, including through private sector-led research collaborations, new funding mechanisms and industry-wide knowledge-sharing initiatives.

Some of the most promising work on R&D collaboration is being led by the GCCA, in that it is facilitating high-quality partnerships on tangible projects. One of the primary platforms for this is the GCCA Innovandi, consisting of its [Research Network](#) and [Open Challenge](#). The Research Network brings together industry and academia for collaboration, including through financing of projects and regular meetings. The Open Challenge, which is run annually with a different target technology, is aimed at start-ups working on promising technologies, and establishes programmes for selected start-ups to work together with cement and concrete companies to accelerate towards subsequent stages of the innovation pipeline. The 2023 challenge resulted in the formation of [four consortia](#), each consisting of between six and ten partners from diverse geographies, to accelerate technologies involving new materials and ingredients for low-emissions concrete. This type of intensive collaborative partnership could be instrumental in advancing progress on the technologies needed for the cement sector transition. The 2024 challenge is targeting CCUS technologies, which are key for the cement sector transition.

Additionally, the GCCA's [2050 Net Zero Roadmap Accelerator Program](#) is taking forward hands-on analysis and collaboration with target EMDE countries to bring to market key technologies for cement decarbonisation. There are currently more than a dozen countries involved in road-mapping activities, with activities to progress beyond road-mapping most advanced for India and Nigeria. GCCA is collaborating on aspects of the programme with the CEM CCUS initiative and the Global CCS Institute, and has received funding from the Global CCS Foundation. Objectives relating to CCS include to map potential CO₂ storage hubs that are in proximity to CO₂ sources, to identify one to three potential lighthouse projects for pre-feasibility studies, and to work with governments on the required enabling policies.

As further detailed in the Steel Chapter, a number of developments have also occurred targeting R&D for industrial decarbonisation more broadly than in the cement sector alone. The first funding call under the United Nations Industrial Development Organization (UNIDO)'s [Accelerate-to-Demonstrate](#) Facility is a positive step forward in advancing R&D in EMDEs. The Mission Innovation [Net-Zero Industries Mission](#) is undertaking several activities to increase international knowledge-sharing on R&D, including the [Net-Zero Industries Award](#), a global seminar programme, and developing a network of contacts and resource library.

WHAT MORE NEEDS TO BE DONE?

Despite positive efforts on partnerships, knowledge-sharing, funding and demonstration projects, the technologies needed for deep decarbonisation of the cement industry have not yet reached commercial markets, which puts in jeopardy the Cement and Concrete Breakthrough's objective for near-zero emission cement production to be established and growing in every region by 2030. Commercialisation of key technologies for CO₂ capture applied to cement plants is urgently needed, as is scale-up and cost reductions of CO₂ transport and storage, to have sufficient time to build initial projects before 2030. Cements made from alternative raw materials that can wholly replace conventional clinker or achieve very low clinker ratios are at earlier stages of development. Accelerated R&D in this area

is therefore critically needed to expand the portfolio of technology options for achieving near-zero emissions, particularly for regions where CO₂ transport and storage infrastructure may prove challenging.

Many of the actions needed to accelerate progress are similar to those needed for the steel sector, including the following (see the Steel Chapter for additional details):

- Accelerating targeted, high-quality knowledge exchange, with governments taking leadership. Here, continued and deepened technical dialogues on the potential of different technologies and challenges to their commercialisation could likely help, involving diverse relevant stakeholders from different regions, perhaps in partnership between existing forums (e.g. MI NIM, GCCA Innovandi, the Cement and Concrete Breakthrough).
- Increasing practical technology collaborations across borders, with joint funding calls providing a possible model to encourage such collaboration. Where possible, these should target reaching final investment decisions and successful completion of large-scale demonstration projects that can achieve near-zero emissions, including through public subsidies.
- Sharing best practices among policy makers on measures to create a strong enabling environment for first-of-a-kind projects, as well as for building the necessary enabling infrastructure (e.g. CO₂ transport and storage).
- Providing targeted funding to EMDEs as an enabler of R&D, such as for project feasibility studies and to adopt enabling policies, through existing technical assistance facilities.
- Convening open dialogues on how to balance the protection of intellectual property rights with the need for accelerated international knowledge-sharing and technology collaboration.

RECOMMENDATION C3 HAS BEEN UPDATED AS FOLLOWS:

Governments should work together with effective private sector collaborative forums to accelerate policy support, the pace of learning, business case development, and practical technology collaboration partnerships between a wider set of countries, towards rapid commercialisation of a portfolio of technologies that can achieve near-zero emissions. These partnerships should support the delivery of pilot and, most importantly, commercial-scale demonstration projects in all major emerging and developing economies well in advance of 2030. Increased open conversations are needed on how to protect intellectual property rights while accelerating knowledge-sharing and technology collaboration, as is knowledge-sharing on enabling policies for first-few-of-a-kind technology deployment.

IMPROVE THE CO-ORDINATION OF ASSISTANCE PROGRAMMES FOR COMMERCIAL-SCALE PROJECTS IN DEVELOPING COUNTRIES

OVERVIEW

Last year, we recommended that countries should establish a match-making function focused on industry decarbonisation and cement that can better respond to developing country requests for financial and technical assistance.

In June 2024, countries under the Cement and Concrete Breakthrough agreed to work together to strengthen the international financial and technical assistance offer through match-making for decarbonisation in the sector by COP 30, with a particular focus on ensuring that developing countries have better access to assistance, and supporting a more thorough understanding of the regulatory roadblocks that prevent projects from reaching investor support, with the goal of mobilising private investment at scale in emerging and developing economies.

WHAT PROGRESS HAS BEEN MADE?

We assess that moderate progress has been made against our recommendation on financial and technical assistance since last year, with several country-focused collaborations and a global match-making platform in development, plus continued work on enabling conditions for finance. Many of these initiatives are still in the early stages, however, and are yet to deliver tangible results.

Most of the relevant technical and financial assistance programmes target industrial decarbonisation in the broader sense, and so several key developments noted for steel also apply to cement, including the following (see Steel Chapter for more details):

- Launch of direct bilateral country partnerships on technical assistance for industrial deep decarbonisation, including between Brazil and the United Kingdom, and between India and Sweden.
- Progress on country partnerships with multilateral development banks and international platforms targeting industrial deep decarbonisation, including the European Bank for Reconstruction and Development (EBRD)'s work towards the launch of the Türkiye Industrial Decarbonisation Investment Platform (TIDIP) by COP 29, and on a low-carbon cement pathway in Morocco, and work to take forward the Industrial Transition Accelerator (ITA)'s Project Support Programmes (for which cement has been selected as a priority sector for the Brazil Programme).
- Developments of the Global Matchmaking Platform under the Climate Club, targeting the first few pilot examples of matches by the end of the year.
- Preparation for the first call for expressions of interest from potential recipient countries to be launched by October 2024 under the Climate Investment Funds' (CIF) Industry Decarbonization Program, after which selected countries would be invited to develop project investment plans.
- Analyses and activities on cross-cutting issues related to finance, including by the ITA and OECD's [CEFIM programme](#).

One recent finance development is targeted at the cement sector: In June, the government of [Canada announced it will work with Thailand](#), in partnership with UNIDO, through a technical assistance and investment support offer to help accelerate cement and concrete decarbonisation.

WHAT MORE NEEDS TO BE DONE?

Many of the same actions are needed to drive forward progress as for steel (see Steel Chapter for additional details), including:

- Increase government contributions to funds and partnerships targeted to industrial deep decarbonisation, including the cement sector, in particular in ways that best mobilise additional private sector funding.
- Target tangible outcomes from existing partnerships and share learnings.
- Expand the number of country-focused technical and financial assistance partnerships, including to a broader range of EMDEs.
- Increase donor and recipient engagement in match-making mechanisms to ensure assistance is tailored to address needs.
- Increase sharing of good practice and technical assistance on development of strong, stable enabling policy frameworks to mobilise private sector finance.
- Broader financial sector alignment to eventually restrict new investment for the cement sector to net zero-compatible investments, including a possible collective push from governments to achieve such an objective.

With regards to the final point, in EMDEs where cement production is projected to increase, it may be quite challenging to align investments to support only those facilities that have planned into their design a technologically feasible path to near-zero in the longer term. Unlike the steel sector, where the direct reduced iron (DRI) route provides a clear option for a plant to transfer to near-zero emissions more gradually over time, investments in leading technologies for near-zero emission production in the cement sector – such as CCS – are much more lumpy, that is, would occur for an individual plant all in one go. However, even in the short term while CO₂ capture technologies are not yet widely deployed, investors could require that cement plants demonstrate clear technical and space capacities to later retrofit with carbon capture. Inclusion of the cement sector in climate-aligned finance discussions at the international level would still be useful.

RECOMMENDATION C4 HAS BEEN UPDATED AS FOLLOWS:

Governments should increase support for, and engagement with, improved match-making functions focused on cement and concrete deep decarbonisation that can better respond to developing country requests for financial and technical assistance. This should include donor countries, recipient countries, international financial institutions, national development banks, philanthropic organisations, private financial institutions and companies, with regular meetings of ministers. Governments should share best practices to enhance enabling policy frameworks, as well as collectively set guardrails for finance in collaboration with financial institutions, so that new capacity additions and major retrofits of existing capacity are suitable for future conversion to near-zero emission technologies and do not become stranded assets.

RECOMMENDED REPORTS

We recommend the following reports for more detailed descriptions of the technologies for cement sector decarbonisation and of the actions that countries and businesses can take individually.

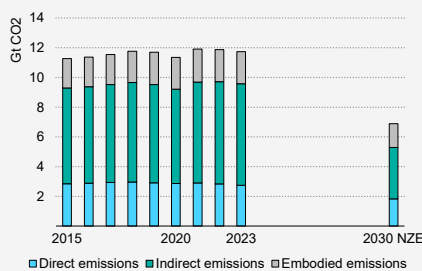
- IEA (2024), [Net Zero Emissions Guide – Cement](#)
- MPP (2023), [Making Net-Zero Concrete and Cement Possible](#)
- US DoE (2023), [Pathways to Commercial Liftoff: Low-Carbon Cement](#)
- GCCA (2023), [GCCA Cement Industry Progress Report 2023](#)
- IEA (2022), [Achieving Net Zero Heavy Industry Sectors in G7 Members](#)
- GCCA (2021), [Concrete Future – GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete](#)

CHAPTER 7. BUILDINGS

STATE OF THE TRANSITION

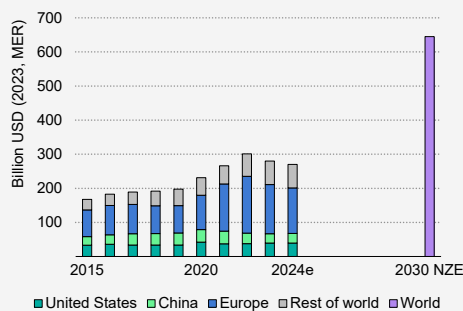
Buildings represent more than a third of global final energy consumption and energy-related emissions and are crucial to decarbonisation and resilience at the community level, but a major shift will be needed to put the sector on track to reach net zero by 2050. Building emissions have grown at an average of 0.7% per year since 2015, and global growth in floor area looks set to continue, outpacing improvements in efficiency.

Emissions²⁴



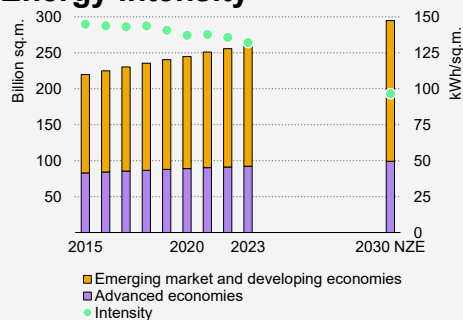
- Direct CO₂ emissions from buildings fell in 2023. This was largely due to milder temperatures rather than energy efficiency improvements or fuel shifting.
- Operational and embodied emissions fall by at least 45% and 25% respectively by 2030 in the IEA Net Zero Emissions by 2050 Scenario (NZE Scenario).

Investment²⁵



- In 2023, energy efficiency investments in buildings [dropped 7% from the 2022 peak](#), a decline projected to continue in 2024.²⁶
- Highly energy-efficient buildings are broadly cost-competitive over their lifetime, but financial support is needed to reduce upfront cost barriers and scale investments to achieve a near-zero emissions building stock.

Energy intensity²⁷



- Total floor area is set to continue increasing, especially in developing economies, where 80% of growth to 2030 and 2050 is expected. Many of those countries currently lack robust building and energy codes.
- Energy intensity needs to fall by at least 30% from 2024 to 2030 – 4 times faster than from 2015 to 2023 – to align with the NZE Scenario.

²⁴ Global energy combustion and process emissions from the buildings sector in the NZE Scenario, 2010-2030. Embodied emissions refer to cement, steel and aluminium. In the NZE Scenario, all material-demanding sectors are competing for near-zero emission materials. Bricks and glass would represent an additional 3% of global emissions.

²⁵ In energy efficiency (incremental spending to acquire equipment that consumes less energy than would otherwise have been used to provide the service), and electrification. 2024e = estimated values. Source: IEA (2024), [World Energy Investment 2024](#).

²⁶ There is currently no evidence available on the cost of climate resilient buildings with respect to regular construction practices.

²⁷ Built floor area at the global scale and average buildings final energy consumption intensity.

STATE OF INTERNATIONAL COLLABORATION

In this chapter, we evaluate the progress made through international collaboration over the past year against the recommendations for the buildings sector from the [Breakthrough Agenda Report 2023](#). Our assessment focuses on key areas of collaboration: standards and certifications, demand creation, finance and investment, research and deployment, and capacity and skills. The findings are summarised in the table below, followed by detailed sections on each area of collaboration. In addition, in this section we highlight high-level, cross-cutting achievements that are relevant to all the priority areas for collaboration.

The Buildings Breakthrough was formally [launched in December 2023](#) at COP 28, supported by 28 countries and the European Commission, and this grew to 29 countries in June 2024. Geographic representation is strong in Africa, Europe, North America and East Asia, and further opportunities exist to strengthen representation from Latin America and Central Asia.

In March 2024, the Government of France and United Nations Environment Programme (UNEP) hosted the inaugural [Buildings & Climate Global Forum](#), which brought together, for the first time, government representatives from over 60 countries alongside industry experts and business leaders to share knowledge and boost ambition in the sector. A key output was the [“Declaration de Chaillot”](#), supported by 69 countries. This establishes shared objectives and common commitments, many of which reflect aspects of the recommendations in this report. The Declaration also committed to establish an [Intergovernmental Council for Buildings and Climate](#), offering a new platform to strengthen collaboration dedicated to the buildings sector transition.

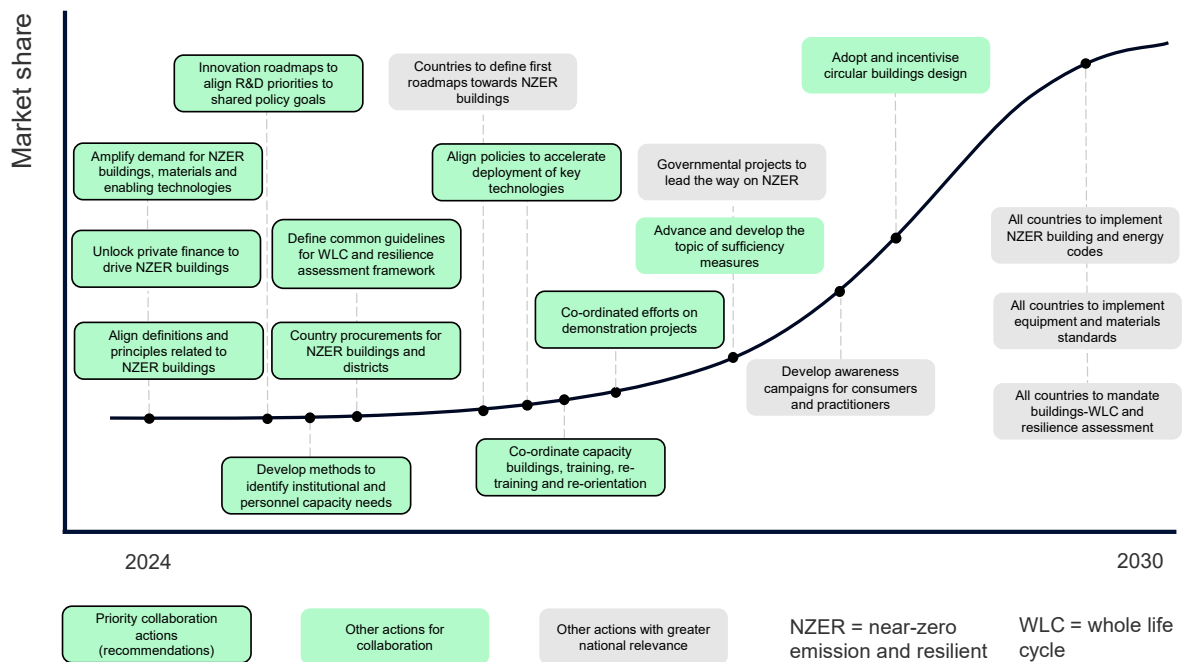
The Forum also saw the launch of the [Priority Actions of the Buildings Breakthrough](#) by the member countries. As of July 2024, 26 of the 29 member countries have set out how they will support particular priority actions. Operationalising these priority actions is now underway, facilitated by the [Global Alliance for Buildings and Construction](#) (GlobalABC). As progress under the Buildings Breakthrough initiative advances, it will be crucial for countries to ensure that GlobalABC has sufficient resources to facilitate the transition of the initiative from commitment to implementation. International collaboration in industry to support decarbonisation of the sector was also seen at the Forum, through the launch of the [Market Transformation Action Agenda](#), endorsed by 84 private sector companies and organisations.

As noted earlier in this report, there are interdependencies between areas of international collaboration for a particular sector, and progress in one area can support progress in another. The buildings sector is no exception: for instance, establishing clear definitions for “near-zero” and “resilience” (B1) directly supports the ability to identify and amplify demand (B2) and mobilise finance (B3). Additionally, deployment efforts (B2) must be paired with targeted capacity-building (B5), aligned finance (B3), and the confidence fostered through shared research and demonstration (B4).

Area	What key progress has been made?	What more needs to be done?	2024
B1. Standards and certification	<ul style="list-style-type: none"> Emerging platforms to build consensus on definitions and principles. Proposals to harmonise whole-life carbon assessment, and to 	<ul style="list-style-type: none"> Agree on shared qualitative definitions and principles for near-zero emissions and resilient buildings. Develop common guidelines for codes, standards and public 	Moderate

	emphasise the importance of comparable data.	disclosure programmes aligned with such principles.	
B2. Demand creation	<ul style="list-style-type: none"> Significant new intergovernmental commitments pave the way to increase demand for low-carbon materials via public procurement. 63 countries committed to improving air conditioner efficiency and establishing energy performance standards globally. 	<ul style="list-style-type: none"> Countries should work together to strengthen demand, via public procurement, through co-ordinated implementation of new commitments. Align policies and targets to accelerate clean heating and cooling adoption globally. 	Moderate
B3. Finance and investment	<ul style="list-style-type: none"> Several new assistance programmes were launched, yet overall financial support remains below the sector's needs. Annual global investment into the energy efficiency of buildings has fallen in 2024. 	<ul style="list-style-type: none"> Collaborate to enhance financial assistance, focusing on de-risking private investment and building local capacity. 	Minimal
B4. Research and deployment	<ul style="list-style-type: none"> Research advances for sufficiency, heating, cooling and existing buildings. Testing of new cross-technology collaboration modalities. 	<ul style="list-style-type: none"> Agree research priorities that support the implementation of international commitments. Co-ordinated efforts on demonstration projects. 	Moderate
B5. Capacity and skills	<ul style="list-style-type: none"> Training opportunities from some initiatives. Launch of a dedicated initiative to support the Buildings Breakthrough. 	<ul style="list-style-type: none"> Methods, tools, guidance and resources to systematically identify and address institutional and personnel capacity needs. Support to developing economies to develop, implement and upgrade building codes, including energy codes. 	Moderate

Figure 7.1. Critical path to 2030 for the buildings sector



Source: [Breakthrough Agenda Report 2023](#)

WORK TO AGREE KEY DEFINITIONS AND INCREASE THE COMPARABILITY OF CODES, STANDARDS AND CERTIFICATION OF NEAR-ZERO AND RESILIENT BUILDINGS

OVERVIEW

Last year, we recommended that governments should provide clarity around definitions and nomenclature for near-zero emission and resilient buildings, and work together towards whole-life carbon and resilience assessments that are compatible with those definitions. We also recommended developing shared international mechanisms, platforms and formats for data-sharing on best-in-class near-zero emission and resilient projects, in order to create benchmarks for such projects in different countries.

This recommendation has been taken forward into the Buildings Breakthrough [priority actions](#), and in June 2024, the governance and terms of reference for the next steps towards broader consultation – and ultimately action – were established under the lead of the [World Green Building Council \(WorldGBC\)](#), with the support of a broad range of partners. Prior to that, under the umbrella of the GlobalABC’s Materials Hub, several initiatives contributed to the publication of [10 Whole Life Cycle Recommendations for the Buildings Breakthrough](#) with the ambition to raise awareness on the significance of addressing whole-life cycle emissions in implementing the Buildings Breakthrough objectives.

Codes, standards and certification, both public and private, are critical tools to improve building resilience and energy performance. As of 2023, more than [80 countries](#) have in place building energy codes which set requirements on energy performance, but

transitioning towards near-zero emissions and resilient buildings will also require whole-life carbon and resiliency assessments, which are currently much less common, to become the norm. Defining common principles, definitions and guidelines for near-zero emissions and resilient buildings and their whole-life carbon and resilience assessments will improve international comparability and consequently guide investment, improve knowledge-sharing, and ultimately support countries' national efforts.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress made on our recommendation of last year, primarily towards agreeing definitions and principles for whole-life carbon assessment, while definitions for resilient buildings are still lagging behind.

The launch of the Buildings Breakthrough initiative included an [“explanation of terms”](#), which is a first step towards a common understanding of the principles to define near-zero emissions and resilient buildings. Furthermore, the Declaration de Chaillot includes shared operational objectives around urban planning, buildings construction and retrofitting (Article 5), which could provide a foundation for defining the principles. However, intergovernmental discussions to agree such definitions and principles have yet to occur.

Progress on definitions has been made at the regional and national level in 2024, such as in the US Department of Energy's [national definition](#) of a “zero emission building” in a guidance report that could be useful in other contexts (this targets the operational phase, but not yet embodied emissions). In Europe, the new [Energy Performance of Buildings Directive](#) (EPBD) establishes a definition for [Zero Emission Buildings](#),²⁸ with reference to International Standards. These examples should be used by international forums and initiatives to support consensus-building.

Some industry bodies have launched guidance and recommendations to advance the harmonisation of whole-life carbon assessments. This includes the Royal Institution of Chartered Surveyors' (RICS) [Global Harmonisation Principles](#), the Low Carbon Building Initiative's [harmonised framework for whole life cycle \(WLC\) measurement](#), and the [Nordic Sustainable Construction working group](#) on harmonisation of life cycle assessments. In addition, the [Market Transformation Action Agenda](#) identifies the need to drive harmonisation on whole-life carbon, harness the data, and align standards, as a key lever for change. WorldGBC has set up a [Zero Carbon and Climate Resilience Readiness Framework](#) which tackles five strategic pillars: Government, Technical Solutions, Data, Finance and Mindset. The Leaders of the Urban Future, an investor-led group, [set out their principles](#) and levers for achieving decarbonisation and driving transparency in real estate. Progress on protocols for data collection and sharing has also been advanced by the launch of the [Global Buildings Data Initiative](#).

WHAT MORE NEEDS TO BE DONE?

Countries should agree on definitions and principles for near-zero emission and resilient buildings. These principles, which should be qualitative in nature, would signal the alignment of countries behind a shared orientation for the sector, providing a common foundation from which to strengthen collaboration towards national implementation. The

²⁸ The EPBD also requires whole-life carbon reporting from 2030, with a framework defined via roadmaps by member states from 2027 – a notable step forward for the sector, which other countries could follow. International consultations, spearheaded by the [#BuildingLife](#) initiative, facilitated knowledge-sharing and provided guidance to policy makers in the European Union.

Intergovernmental Council for Buildings and Climate could provide a platform for such discussions.

Countries should work together to agree common guidelines to support the establishment and implementation of national and regional codes, standards and public disclosure certificates compliant with such principles. Guidelines should include key indicators and quantifiable metrics for performance assessment (for instance, metrics for building energy performance, onsite renewable energy generation, or resilience) and the scope to which they apply (for example, defining which physical elements of the building and types of energy consumption are to be included). A common set of indicators would reduce the administrative burden for actors that operate internationally, and consequently reduce the administrative costs and increase transparency for investors. Guidelines can be supported by the experiences of early-mover countries and initiatives, including the work recommended under the Cement Breakthrough.²⁹

The process of establishing shared guidelines should focus on aligning key indicators and quantifiable performance metrics, rather than developing a prescriptive global standard. The goal is to facilitate collaboration among countries and international actors by enabling them to use a common language while recognising the need for regional flexibility to reflect local practices and contexts.

Building on shared guidelines, countries should work to align the types of data reported in public disclosure certificates for buildings and to understand which private certification ratings could offer an equivalent proxy. Such alignment helps support both international knowledge-sharing and investment in near-zero and resilient buildings.

Where possible, countries should also collaborate to set milestones for the implementation of such standards and certificates within national and sub-national roadmaps. These roadmaps strengthen credibility and confidence in the pace of the transition, helping de-risk private investment in the sector.

RECOMMENDATION B1 HAS BEEN UPDATED AS FOLLOWS:

Governments should agree on shared qualitative definitions and principles for near-zero emission and resilient buildings, and agree on common guidelines for codes, standards and public disclosure certificates, including reporting indicators for performance assessment. Such guidelines should support comparability of performance, while allowing for flexibility to reflect local practices and context.

AMPLIFY DEMAND FOR NEAR-ZERO EMISSIONS AND RESILIENT BUILDINGS, CONSTRUCTION MATERIALS AND CLEAN ENERGY TECHNOLOGIES

OVERVIEW

Last year, we recommended that governments should jointly create and strengthen procurement commitments for near-zero emission and resilient buildings, as well as joining existing low-carbon material procurement alliances. We also recommended countries

²⁹ i.e. to review building codes and work towards performance-based specifications for buildings structure, in order to remove barriers to greater uptake of near-zero and low-emissions buildings materials (e.g. supplementary cementitious materials [SCMs]).

establish new joint commitments on deploying clean and efficient heating and cooling technologies.

The second [priority action](#) launched in March 2024 is focused on creating the enabling conditions to deliver on this recommendation, with efforts led by One Planet Network's ["Sustainable Public Procurement Programme"](#).

International co-ordination on procurement commitments can create shared markets that drive down costs for key construction practices, materials, appliances and equipment. Furthermore, co-ordination on policy commitments can signal longer-term trends in demand for near-zero and low-emissions products. These commitments create the confidence required to encourage private investments in near-zero and low-emissions technologies and materials.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress made against our recommendation of last year, with most progress made on cooling. We identify slowing progress in demand-side commitments for near-zero and low-emission buildings and materials. In general, progress on demand for "near-zero" emissions buildings is more advanced than that of "resilience".

If implemented, multiple new intergovernmental commitments would significantly increase demand for low-carbon buildings and materials. For instance, signatories of the Declaration de Chaillot have committed to ambitious public procurement policies (Article 6.4), particularly relating to public building procurement, and to promoting production of low-carbon construction materials (Article 6.5). Similarly, the Launch of the Forest and Climate Leaders' Partnership (FCLP) initiative ["Greening Construction with Sustainable Wood"](#) at COP 28 saw 17 countries commit to advancing policies for low-carbon construction and increasing the sustainable use of wood in construction. The FCLP is working with [Built by Nature](#) to help countries co-ordinate on shared principles for responsible timber construction.

Recognising that co-ordinated international action on sustainable cooling can save 78 billion tonnes CO₂ equivalent (CO₂-eq) between now and 2050, the launch of the [Global Cooling Pledge](#) at COP 28 saw 63 countries commit to work together to increase the global average efficiency of new air conditioners by 50% by 2030, and to establish Minimum Energy Performance Standards (MEPS) and model building energy codes, amongst other objectives. Implementing this pledge would significantly advance the demand for both energy-efficient air conditioning and passive cooling solutions.

In contrast, while heating in buildings is responsible for [10% of global CO₂ emissions annually](#), there is currently no comparable intergovernmental commitment on clean heating. This is despite the [IEA recognising](#) heat pumps,³⁰ powered by low-emission electricity, as the central technology for sustainable heating, and noting that heat pumps can contribute [over half of the decrease](#) in fossil fuel demand in space and water heating by 2030 needed to meet announced energy and climate-related commitments. Nevertheless, international co-ordination efforts are emerging on clean heating, with the

³⁰ The [IEA defines "heat pumps in buildings"](#) as equipment that delivers heat directly to households and residential or commercial buildings for space heating and/or domestic hot water provision. It includes natural source heat pumps, including reversible air conditioners used as primary heating equipment. It excludes reversible air conditioners used only for cooling, or used as a complement to other heating equipment, such as a boiler.

Clean Heat Forum organising quarterly stakeholder meetings to exchange policy updates and best practice.

Moderate progress has also been made by national governments joining procurement commitment platforms. As of July 2024, four governments have signed the IDDI's Green Procurement Pledge to reduce emissions from public construction projects by creating market demand for low- and near-zero emission steel, cement and concrete through public procurement. Moreover, a further three countries have committed to the Statement of Intent.

Progress by non-state actors joining procurement pledges is slowing. Signatories of WorldGBC's Net Zero Carbon Buildings Commitment increased to 180, up from 175 in 2023. Cities involved in C40's Net Zero Carbon Buildings Accelerator increased to 29, up from 27 in 2023. Furthermore, membership of C40's Clean Construction Accelerator increased to eight cities, up from seven in 2023, with two cities now requiring embodied carbon data reporting. Business members on the [EP100](#) campaign increased to 127, up from 123 in 2023, with members saving 54 million tonnes of GHG emissions over the same period. (See the Steel and Cement chapters for further progress on material-level demand).

The adoption of whole-life carbon assessments is increasing the demand for near-zero buildings. Notable progress has been made recently, with some regions setting specific carbon limits. For instance, from July 2024, [California](#) requires embodied carbon disclosure and improvement for large commercial buildings. Similarly, in 2023, [Vancouver](#) mandated whole-life carbon assessments for major buildings, and [New South Wales](#) introduced requirements for non-residential buildings to quantify embodied carbon emissions. [Denmark](#) also tightened its embodied carbon limits in 2024, and the [European Union's new directive](#) will require members to introduce whole-life carbon assessments from 2028.

WHAT MORE NEEDS TO BE DONE?

Countries should work together to create and scale up demand for near-zero emission and resilient buildings, both new-builds and retrofits, and the materials and technologies that enable them. Additionally, countries should co-ordinate policies to support the diffusion of clean and efficient heating and cooling technologies. This will de-risk investment in the sector by signalling a need for the skills, knowledge, materials and technologies required to deliver such buildings.

International commitments over 2023 and 2024 have demonstrated a degree of consensus on some priorities for the decarbonisation of buildings. Countries should adopt public building procurement processes for near-zero emissions and resilient buildings.³¹ Building on these, countries should move to agreeing on specific measures to increase demand for specific materials and technologies. For example, countries that have signed shared commitments to low-carbon construction can strengthen demand signals by establishing time-bound procurement commitments for near-zero and low-emissions materials, or commit to the adoption of whole-life carbon assessments as a policy measure for public procurement.

Similarly, countries should build on the commitments within the [Global Cooling Pledge](#) by aligning and co-ordinating policies, particularly MEPS, to accelerate deployment of high-efficiency air conditioning. Alignment of this kind would see the least efficient products

³¹ Buildings are more than the sum of their parts. Near-zero and resilient buildings require quality and performance to be assured and controlled throughout the design, construction, and operational life of the building. To this end, the procurement processes of such buildings should permit and encourage continuous quality control, innovation and collaboration among all stakeholders.

phased out from global markets, and countries could build on the model regulation guidelines established by [United for Efficiency](#).³² The [Cool Coalition](#), a network of governmental and non-governmental partners, could provide a platform for this co-ordination and alignment. In addition, countries should complement these efforts by normalising the adoption of passive cooling solutions in building design, as outlined in Recommendation B5.

Countries should work together to support the deployment of clean heating technologies, particularly heat pumps, by co-ordinating on targets and timelines for regulations and sharing policy best practices.³³ This would help provide the confidence in large-scale future demand needed to unlock investment in research, manufacturing, and installation training, and investment will, in turn, help reduce upfront costs that remain a barrier to adoption. The [Clean Heat Forum](#) provides a platform for such co-ordination and alignment but could be strengthened through wider governmental participation. Such targets and strategies could offer a meaningful contribution towards the implementation of the [Global Renewables and Energy Efficiency Pledge](#) launched at COP 28 – buildings [offer around 40% of the gains](#) needed to achieve the energy efficiency component of this commitment, with a key role played by electrification and efficiency.

The absence of shared principles for a “resilient building” hinders the ability to track, finance and procure such buildings. As action on definitions under recommendation B1 emerges, countries should build on these to support clearer and more precise demand signals for resilient buildings and their supporting technologies.

RECOMMENDATION B2 HAS BEEN UPDATED AS FOLLOWS:

Governments should jointly create procurement and policy commitments for near-zero emission and resilient buildings, both new and existing, and strengthen commitments on near-zero and low-emission materials and appliances. Governments should co-ordinate policies, especially MEPS, to improve efficiency of air conditioners in all markets. Countries should co-ordinate targets and regulatory trajectories, and share policy best practices, for clean and efficient heating technologies like heat pumps.

CO-ORDINATE EFFORTS TO INCREASE TECHNICAL AND FINANCIAL ASSISTANCE TO UNLOCK PRIVATE INVESTMENTS

OVERVIEW

Last year, we recommended that countries should increase funding for near-zero emission and resilient building projects and improve co-ordination of assistance through a dedicated match-making platform. Despite ongoing technical assistance programmes, the scale of funding remains far below the investment need, especially in emerging markets.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been minimal progress against our recommendation overall. Various programmes and initiatives have made some progress, but overall, efforts remain insufficient to meet the sector's needs.

³² U4E (2019), [Model regulation guidelines for energy-efficient and climate-friendly air conditioners](#).

³³ Including measures to improve building envelope performances.

In 2023, the [International Finance Corporation \(IFC\) reported](#) that global domestic and foreign private green debt finance for decarbonisation in construction has increased twenty-fold in the last 5 years, but only 10% was issued in emerging markets. Moreover, they identified a USD 1.5 trillion investment need in emerging markets, underscoring the need for increased financial and technical support.

Nevertheless, several new assistance programmes took steps forward in the past year. For example, in 2023, the UK Government provided an additional GBP 36 million in funding to support the UK-IFC [‘Market Accelerator for Green Construction’](#) programme. This provides blended concessional finance for financial intermediaries in 22 countries, including 8 African countries, to expand their green building portfolios. In 2024, the Partnership for Energy Efficiency in Buildings (PEEB) launched two new programmes which target [cool buildings in hot climates](#) and in [Southeast Asia](#). PEEB is now collaborating with 21 countries. In 2023, the [Green Climate Fund](#) approved a Rwanda Green Investment Facility which will, in part, support finance for green buildings. The [Transformative Actions Program](#) project pipeline included one new “buildings” project in 2023. In addition, the international [Clean Cooking Declaration](#) unlocked USD 2.2 billion in funding in 2024.³⁴ While cooking represents only around 8% of buildings’ total energy consumption and 17% of buildings direct CO₂ emissions today, the process to unlock funding could be replicable elsewhere.

Efforts to support the scale-up of financial assistance must also include awareness-raising on the mechanisms available. Wider progress by non-state actors is emerging to support the scale-up of investment for the sector’s transition. In 2024, the Cities Climate Finance Leadership Alliance launched their [Net Zero Carbon Buildings Instrument Database](#), providing a platform to raise awareness for the types of financial instruments available to public authorities. Moreover, a new [international alliance of industry partners](#) has been launched to support capacity-building around green bonds and loans. Furthermore, a new [collaboration of development banks](#) has formed in the buildings sector. The Urban Land Institute’s “C Change Programme” is working to establish a common industry methodology to assess [transitional climate risks](#) as part of property valuations, and has established a new taskforce to develop a [real estate carbon pricing strategy](#). These initiatives, while principally focused on the European region, have potential to be replicated elsewhere.

In addition, regional sustainable finance taxonomies provide guidance to investors on whether an economic activity is environmentally sustainable, and often include provisions for investment into construction activities. As of February 2024, [47 sustainable finance taxonomies](#) had been issued globally, of which at least [14 recognise real estate](#) activities.

Annual investment in energy efficiency in the buildings sector decreased in 2023 and 2024, [reversing the upward trend](#) seen since 2018. Rising interest rates will have contributed to this reduced investment. It should be noted that tracking total direct investments into near-zero emission and resilient buildings is challenging. Moreover, assistance funds on buildings are often provided as part of a wider fund mandate, which complicates tracking efforts, making it hard to bring the topic into focus at political dialogues.

WHAT MORE NEEDS TO BE DONE?

As recommended last year, countries should increase the scale of funding available to support near-zero emission and resilient building projects. While most of the finance will

³⁴ Today, nearly one-third of the global population still cook their meals over open fires or on basic stoves, and a lack of clean cooking contributes to 3.7 million premature deaths annually ([IEA, 2023](#)).

ultimately come from the private sector, targeted policies and public sector investments can de-risk and mobilise private finance.

International financial and technical assistance programmes should be expanded to better address the following priorities:

- Providing blended financial instruments that de-risk and catalyse private investment into the sector (i.e. guarantees, first-loss mechanisms, concessional loans).
- Identifying policies and regulations that de-risk and promote private investment.
- Building capacity of local banks and lenders to allocate capital for the decarbonisation and resilience of buildings, including through green loans and mortgages.
- Supporting countries to build and aggregate a pipeline of bankable projects.
- Addressing gaps in the data that underpins financial risk assessments on real estate assets.³⁵

These programmes must be informed by enhanced public-private sector collaboration involving development banks, private financiers (including institutional investors), banks and insurers. Programmes will need a degree of regionalisation to reflect differing contexts of countries. Existing organisations operating on these topics include the [Climate Bonds Initiative](#), [Convergence](#), the [Green Finance Institute](#), the [Green Guarantee Company](#), the [Institutional Investors Group on Climate Change](#), [IFC](#), the [Net-Zero Banking Alliance](#), and [PEEB](#).

There is broad expert agreement on the scope to better align the technical screening criteria of sustainable finance taxonomies with the criteria of building certifications.³⁶ This alignment could be supported by the work under recommendation B1. Such alignment would help direct investment within the sector. However, there is a lack of evidence to discern if alignment would bring in new investment beyond the re-allocation of existing capital. As a result, while such work is important, this is not a priority action for our recommendation this year.

RECOMMENDATION B3 HAS BEEN UPDATED AS FOLLOWS:

Countries should work together to expand international financial and technical assistance programmes that support investment in near-zero emission and resilient buildings, to address the following priorities more strongly: providing blended financial instruments, identifying policies and regulations that reduce private investment risk, building capacity among local banks and lenders, developing and aggregating project pipelines, and addressing key data gaps for financial risk assessments. These efforts must involve development banks, private finance, banks, and insurers.

³⁵ The C-Change programme's [Transitional Risk Assessment Guidelines](#) outline the data requirements for assessing transitional risk, which forms part of the investment risk.

³⁶ A [recent report](#) by an international alliance of industry partners provides a mapping of sustainable finance taxonomies against a range of green building certifications.

CO-ORDINATE SUPPORT FOR RESEARCH, DEVELOPMENT AND DEMONSTRATION TO ACCELERATE THE DEPLOYMENT OF KEY TECHNOLOGIES AND CONCEPTS

OVERVIEW

Last year, we recommended that countries and companies work together to identify relevant knowledge gaps that can be overcome via joint research, especially by facilitating the expansion of existing collaboration platforms. We also recommended improving communication of high-quality research to make the results more accessible to decision-makers, and to deliver training to facilitate deployment of innovative technologies.

The fourth [priority action](#) launched in March 2024 reflects this recommendation, although the current operational focus of the group is mostly on technology deployment rather than on research and demonstration. The [Solar Impulse Foundation](#) is leading efforts to operationalise this priority area on deployment, with ambitions to develop a “solution deployment platform”, while the identification of initiatives to co-ordinate on priority actions for research is still ongoing.

International collaboration on research, demonstration and deployment will not only help advance near-zero emission and resilient solutions, but also strengthen market confidence around key technologies, materials, construction practices and policies, in turn encouraging further investment.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress towards the recommendation of last year, principally in heating, cooling, sufficiency, retrofits of existing buildings and building design.

The [Innovation community on affordable heating and cooling of buildings](#) involves 11 countries and operates under Mission Innovation with the aim of catalysing global research on heating and cooling. New projects are commencing, such as on [urban heat adaptation](#).

A [new data working group](#) jointly led by the International Institute of Refrigeration and the Cool Coalition was developed to establish a robust method to estimate current and future emissions from the refrigeration sector.

Throughout 2023 and 2024, the [IEA Technology Collaboration Programmes](#) (TCPs) have been testing pilot co-ordination groups to engage researchers, primarily from academia and research centres, in order to enhance cross-technology collaboration on selected topics, including heat pumping technologies. These groups also aim to enable collaboration in areas that directly respond to governments’ policy and research needs.

Furthermore, in 2023, the 10 TCPs working on buildings – involving a total of 34 countries – released a [report](#) that highlights research priorities for the deep renovation of existing buildings over the next 5 years, including for low-rise and high-rise buildings, both residential and commercial. The top priorities include improved engagement with consumers and markets, improved reporting metrics and digitalisation/machine learning. Currently, participating countries in the IEA buildings TCPs are mostly advanced economies, but participation in international research programmes and exchanges of this kind would also be beneficial for emerging and developing markets.

In February 2024, [the ABC21 project](#) (Africa-Europe BioClimatic buildings for XXI century) was completed under the H2020 framework. It has examined different designs and materials, and provided guidelines, for improving the energy performance and sustainability of African and European buildings in warm climates.

International technology prizes and awards over 2023 also helped to showcase technologies under demonstration or best-in-class in operation. For instance, in its eighth edition, the 2023 [Global District Energy Climate](#) awards identified five success stories of thermal networks integrating innovative solutions, including waste heat recovery in Madrid and zero carbon district cooling systems in Chicago.

In June 2024, the [LAB - Living Art of Building](#) research centre started to establish itself. The LAB is distributed across several locations in Germany and focuses on working towards a resource-efficient construction sector – especially in emerging markets and developing economies – with the aim of involving more than 1 200 scientists.

With regards to advancing knowledge on less-researched topics, the newly established Sufficiency Hub of the GlobalABC worked to deepen understanding of the role of sufficiency³⁷ in the buildings sector through the organisation of several expert workshops.

WHAT MORE NEEDS TO BE DONE?

Countries should work together to agree near-, medium- and long-term research priorities that support the implementation of international commitments, particularly the achievement of the Buildings Breakthrough goals.

Key research priorities could include innovation combining traditional passive techniques with recent calculation tools and materials; resilience assessments; innovative and traditional-vernacular construction techniques and materials; social acceptance of critical technologies; behavioural change; heat pumps and renovations in multifamily buildings; low-Global Warming Potential refrigerants and refrigerant-free cooling equipment; grid-interactive buildings; affordable resilience measures for informal construction; and sufficiency policies and practices.

Moreover, research outcomes need to be communicated beyond the academic audience to inform public and private decision-makers. Governments and public institutions including universities can support this process by improving access to and sharing of high-quality research. Creating opportunities for exchange among decision-makers and researchers can also help to scale up the impact of research.

There is also a need to increase the participation of emerging markets and developing economies in existing research networks. This will be key to gaining a comprehensive understanding of research needs for the sector, and also for enabling global deployment of emerging solutions. Developing a directory of networks and institutions active on certain research topics could be a first step in this direction.

Countries should also co-ordinate efforts on the demonstration of critical technologies, construction practices, tools and business models for public projects, and put in place the necessary infrastructure to enable sharing learning from the testing and operation of innovative technologies. Demonstration projects help to build confidence among developers, investors and legislators about technical feasibility and market viability of a

³⁷ Sufficiency is defined by the Intergovernmental Panel on Climate Change (IPCC) as “avoided demand for energy, materials, land and water while delivering human well-being for all within planetary boundaries”. Sufficiency interventions include density, compactness, bioclimatic design, multifunctionality of space, repurposing of existing unused buildings and moving from ownership to usership of appliances.

technology/material. If successful, demonstration projects can help decrease the risks and costs of future projects.

Demonstrations should prioritise technologies and construction practices that can build confidence in the deployment of near-zero emissions and resilient buildings, and strengthen their social acceptability. For example, district-level renovations offer several benefits compared to renovations at the level of individual buildings (reduced energy, emissions, cost, time, disruption to traffic, bureaucracy), but involve advanced technical aspects and face complexities related to local planning, which could benefit from experience derived from project demonstrations. Similarly, high upfront investments are associated with the transition to highly efficient non-fossil low-temperature district heating networks, and there is a need to better understand the role of digitalisation in these networks. Demonstration projects on thermal networks, integrating renewables and heat storage, can create knowledge beyond theoretical models, reduce the time to market for new products, and build public support for the benefits of such schemes, which is especially needed given that these often require locking occupiers into long-term energy agreements. Other key areas include affordable passive cooling solutions, and innovative “product-as-a-service” business models.

RECOMMENDATION B4 HAS BEEN UPDATED AS FOLLOWS:

Countries should work together to agree shared research priorities that support the implementation of international commitments. Countries should facilitate improved communication of high-quality research to inform the decision-making process and strengthen existing research networks to bring in new expertise, especially from emerging markets and developing economies. Countries should develop shared demonstration projects of key technologies, construction practices, tools and business models at scale, using government projects to lead the way.

IMPROVE THE TRAINING AND CAPACITY-BUILDING OFFER FOR STAKEHOLDERS ALONG THE VALUE CHAIN, IN BOTH THE PUBLIC AND PRIVATE SECTOR – WITH A FOCUS ON BUILDING AND ENERGY CODES

OVERVIEW

Last year, we recommended that countries and companies should jointly identify knowledge gaps and define training and capacity-building priorities, strengthen the role of existing networks to share knowledge, and provide guidance, tools and resources to build capacity across all regions.

We identified the need to focus on supporting developing economies – who will contribute most significantly to floor area growth – with implementing and increasing the stringency of building energy codes.

We also recommended countries should work together, informed by industry stakeholders, researchers and accreditation bodies, to assist in curriculum design, and on the implementation of training programmes and accreditation frameworks to enhance the transferability of skills and qualifications, and ultimately promote near-zero and resilient building practices.

The [priority actions](#) launched in March 2024 reflect this recommendation. Notably, the current operational focus of the working group is on mapping gaps and priorities for capacity-building for both institutions and personnel, as well as defining actions to tailor existing tools to address such gaps, rather than the actual delivery of training. The [International Code Council](#) (ICC) is currently leading efforts to operationalise activities under this priority action.

International collaboration has a critical role in addressing gaps in the skills and training needs related to the reduction of thermal energy needs, energy-efficient active systems, resiliency and sustainability within the built environment workforce. It can also play a critical role in developing understanding of the institutional capacity needs required to effectively implement, maintain and progressively upgrade regulations, such as building and energy codes compatible with near-zero emission and resilient buildings.

WHAT PROGRESS HAS BEEN MADE?

We assess that there has been moderate progress made against our recommendation.

The [Buildings & Climate Global Forum](#) represented an opportunity for countries and the broader buildings community to share knowledge and best practices. Relevant commitments were also made through the Declaration de Chaillot on implementing mandatory building and energy codes for all buildings (Article 6.1), and moreover, on enhancing skills and capacity-building, and developing the tools to share best practices (Article 6.7 and 6.9).

The ICC recently launched the [Building Capacity for Sustainable and Resilient Buildings](#) initiative, supported by 11 organisations and companies, specifically to support the Buildings Breakthrough. The initiative focuses on capacity-building resources (e.g. policy, tools) needed to create a regulatory ecosystem for building codes, including energy codes. In its early stages of identifying and developing content, the initiative aims to assist countries and businesses in enhancing their building-related policies and enforcement capacity. It calls on its public and private sector signatories to commit to [certain actions](#), including allocating dedicated resources for adopting a strong regulatory framework.

The [IEA Energy Efficiency training week in Nairobi](#), in March 2024, trained around 200 energy efficiency policy makers and practitioners across Africa to highlight the role efficiency can play in meeting energy and climate goals in emerging and developing economies. The training included sessions on buildings, as well as on appliances and equipment. Furthermore, in April 2024, an [online training](#) on Appliance Energy Efficiency Policy was launched in collaboration with the Super-Efficient Equipment and Deployment Initiative to provide an additional introductory resource on the fundamentals of energy efficiency policies. Such training programmes also provide opportunities to build networks and share knowledge with policy makers. However, beyond an introduction to energy efficiency regulation, they do not provide further assistance to countries in developing and implementing regulations.

For the private sector, the [Minoro online platform](#) was developed by over 20 organisations as a free resource to guide informed decisions to accelerate emissions reduction in buildings from their design to operation.

One area of particular relevance for capacity-building and skills for the Buildings Breakthrough are building codes, including energy codes. As of 2023, there are more than 80 national building energy codes for residential and 77 for non-residential buildings, with [80% being mandatory](#). Notwithstanding recent updates to 20 codes since 2021, and 17

since 2023, over 30% of all codes have not been updated since 2015. Notably, [Kenya's new national building code](#), published in 2024, promotes passive cooling solutions, including solar shading and natural ventilation, amongst other sustainable design practices.

The [Global Cooling Pledge](#) commits to establish national model building energy codes by 2030 for new and refurbished buildings. There is now an opportunity to support countries with implementing this commitment, and to ensure that countries have the institutional capacity to effectively enforce the adopted codes.

WHAT MORE NEEDS TO BE DONE?

Countries should work together to develop methods to systematically identify and address institutional and personnel capacity needs targeted across all regions. This would be valuable to ensure effective and adaptive capacity-building that addresses the real needs of the country or region to help accelerate the adoption and implementation of sustainable construction practices and regulations.

Overall, countries should strengthen knowledge-sharing and technical assistance for developing training programmes, including through digital learning platforms with content accessible in different languages. These actions are particularly urgent in emerging and developing markets.

Capacity-building is foundational to the advancement of all the recommendations for the Buildings Breakthrough, for instance:

- Standards and certification: training government officials on building and energy codes and compliance assessments will be critical for their effective implementation. Co-ordinated capacity-building needs to focus on supporting developing countries with developing, upgrading and implementing building codes (including energy codes), in line with new international commitments. In doing so, countries should prioritise normalising the adoption of passive cooling solutions in building design. Passive solutions (including cool roofs, shading devices and natural ventilation) are often affordable and accessible to many developing countries, and moreover, offer a degree of resilience in the event of energy supply disruptions.
- Demand creation: developing skills among people in charge of public procurement, and skills for developing, upgrading and implementing policies to strengthen the demand for near-zero emission and resilient buildings and enabling technologies/materials.
- Finance: Skills and training are required for local banks and lenders to support them with allocating green loans for energy efficiency measures.
- Research and deployment: developing awareness and skills (such as among designers, engineers, and installers) needed to accelerate the deployment of technologies that are not yet mainstream, such as heat pumps and deep renovations.

Moving forward, countries could work together on curriculum development, and encourage exchange programmes to develop the personnel and institutional capacity to deliver on near-zero emission and resilient buildings. There is also a need to develop international guidelines and accreditation frameworks for education and training that can enhance the transferability of skills and qualifications, facilitate international mobility of professionals, and promote global recognition of education for high-performing buildings.

RECOMMENDATION B5 HAS BEEN RESTATED AS FOLLOWS:

Countries should strengthen the role of existing networks to share knowledge and provide methods, tools, guidance and resources to identify and address institutional and personnel capacity-building gaps across all regions. This includes a focus on supporting developing economies with developing, implementing and upgrading building and energy codes.

RECOMMENDED REPORTS

We recommend the following reports for more detailed descriptions of the technologies for buildings sector decarbonisation and of the actions that countries and businesses can take individually:

- Buildings and Climate Global Forum (2024), [Declaration de Chaillot](#)
- GlobalABC Adaptation Hub (2024), [Why are We Still Not Adapting](#)
- IEA (2023), [Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach](#)
- IFC (2023), [Building green sustainable construction in emerging markets](#)
- IEA EBC TCP (2023), [IEA Future Buildings Forum Think Tank Workshop 2022 Final Report](#)
- Marrakech Partnership for Global Climate Action (2021), [Human Settlements climate action pathway](#)
- UNEP (2024), [Global Status report for Buildings and Construction 2023](#)
- World Bank (2024), [Mapping Energy Efficiency: A Global Dataset on Building Code Effectiveness and Compliance](#)

CHAPTER 8. CROSS-CUTTING

LEVERAGING CROSS-CUTTING OPPORTUNITIES

There are a number of cross-cutting opportunities that are common across the existing sectors covered in this report and other areas important to clean energy transitions. Where countries work together to focus on these opportunities, they have the potential to support progress in multiple sectors simultaneously.

ESTABLISH CLEAR STRUCTURES FOR INTERNATIONAL COLLABORATION WITHIN SECTORS

Establishing effective structures for international collaboration within each emitting sector is an essential priority to enable all the forms of joint and aligned action described in this report. This does not mean centralising all the work: Energy transitions are complex efforts that involve a wide range of stakeholders working to advance progress in their respective areas and sectors. Instead, it means ensuring that appropriate and well-functioning forums, initiatives or institutions are in place to allow governments and other stakeholders to work together in each of the areas most important to accelerating the transition. It also means avoiding duplication of efforts or spreading limited resources too thinly through the proliferation of overlapping initiatives.

Effective structures for co-operation are characterised by several aspects, including active participation from countries that account for a critical mass of the global market in that sector, a focus on problems where international co-operation can make the greatest difference, frequent meetings between decision makers, high-quality input analysis and a well-resourced secretariat. In most sectors, it is hard to find an initiative that has all these characteristics. As such, strengthening these structures for collaboration in each sector should be the top priority. Governments can do this by joining initiatives and investing in them politically and financially, by commissioning research and analysis to inform discussions, and by proactively tabling proposals for collaborative action.

Sectors in which international co-operation is relatively well-established, such as the power sector, are faced with a proliferation of initiatives working across all aspects of the value chain. This runs the risk of duplicative efforts that spread limited resources – finances, human capital, time – too thinly, and reduce effectiveness and results. Here it may be useful to concentrate effort on accelerating and expanding implementation of work programmes agreed within existing initiatives, rather than creating new ones. In other sectors such as low-emissions hydrogen and steel, there is a rapidly expanding landscape of initiatives. A concerted effort to align activities within the sector and avoid duplicative efforts can help to focus attention where it is most needed and add participation and depth to the most promising initiatives. In sectors where international collaboration is at a much earlier stage, such as cement, new structures can be thoughtfully developed drawing on the experiences of successful initiatives in other sectors.

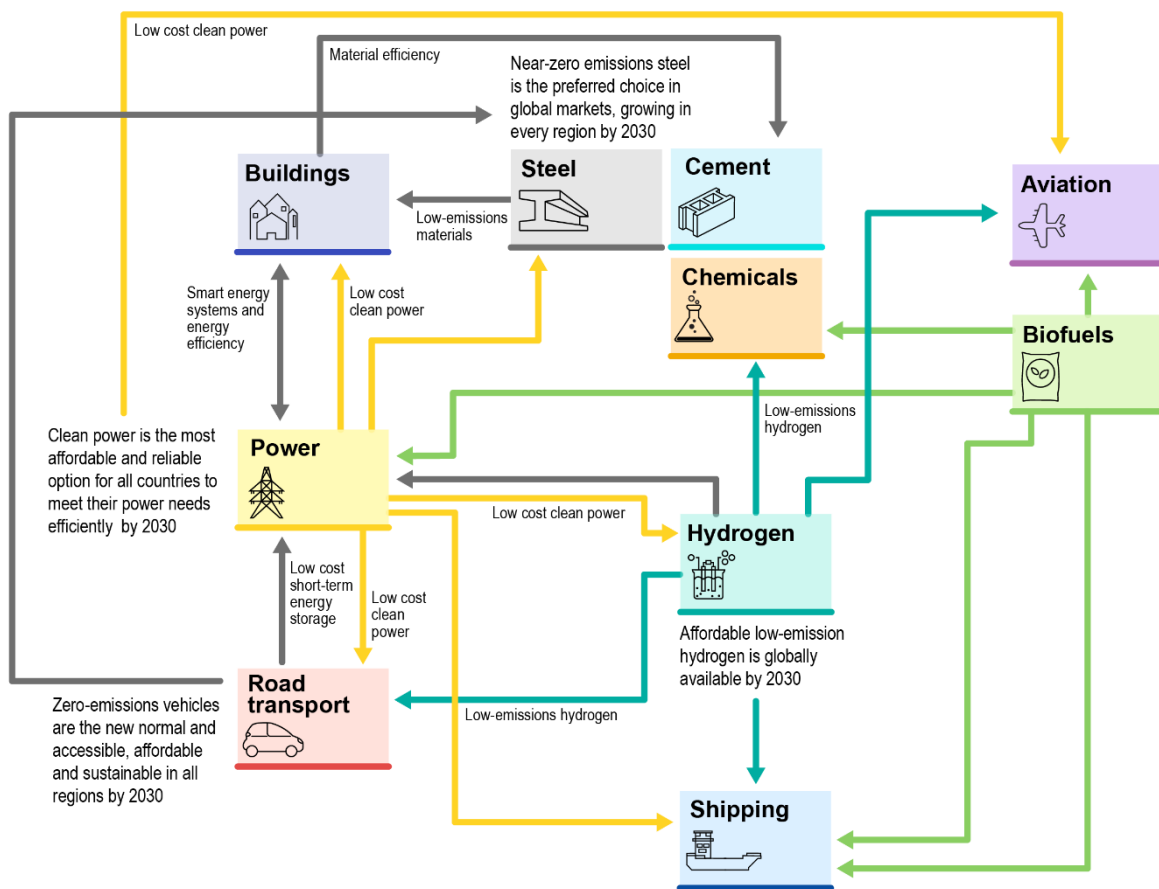
Since the [Breakthrough Agenda Report 2023](#), we have seen a growth in initiatives for practical collaboration, particularly around industrial decarbonisation. New initiatives include the Climate Club, a group of 40 governments formed in December 2023, which is intended to serve as a platform for increased collective action on industrial decarbonisation, and the [Industrial Transition Accelerator](#), which aims to advance industry decarbonisation

projects and their supply chains. This is a positive development in the sense that it reflects a new focus on an area in which co-operation is needed; on the other hand, as we note in the Steel Chapter, greater participation of the largest industrial producer and consumer countries is likely to be needed for these efforts to succeed.

The Breakthrough Agenda process is designed to develop a collective understanding of the collaborative efforts under way in each sector, and to identify where existing efforts should be strengthened and new action initiated. Over the past year, several organisations have been selected to work as “sector facilitators” in each of the sectors included in this process on a pilot basis. These are: in the power sector, the International Renewable Energy Agency; in road transport, the International Council for Clean Transportation; in buildings, the Global Alliance for Buildings and Construction; in hydrogen, the International Partnership for Hydrogen and Fuel Cells in the Economy; and in steel, the United Nations Industrial Development Organization (UNIDO) (with those for cement and agriculture to be confirmed). These organisations will use their extensive expertise and relationships to bring additional clarity to the understanding of existing efforts and new priorities for collaboration in their respective sectors. Informed by this understanding, the aim is that governments, businesses and civil society actors will be able to increase the cohesion and impact of their actions in each sector. Partnerships have also been expanded to include a focus on co-ordinating private sector engagement in collaboration with the World Business Council on Sustainable Development.

Clean energy transitions do not happen in a vacuum and progress in one sector can support progress in others. For example, scaling up clean power generation can help enable the production of low-emissions hydrogen and its derivatives, which can feed into the decarbonisation of other high-emitting sectors, such as agriculture or international shipping. For international shipping, which accounts for around [2% of global energy-related CO₂ emissions](#), international efforts are underway to reduce emissions. In July 2023, the International Maritime Organization (IMO) [adopted a revised version](#) of its GHG emissions strategy, which targets emissions from international shipping to reach net zero by or around 2050, with interim targets of 5-10% of fuels to be zero-emission by 2030. Further, IMO will adopt mandatory regulations in 2025 for a GHG fuel standard and a GHG pricing mechanism. Given the need to match the supply of low-emissions hydrogen with demand centres for shipping applications, it is important to have a baseline level of international dialogue to address any technical specification or regulatory requirements.

Figure 8.1. Interlinkages in the energy sector



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Once platforms for collaboration in each sector are put in place, countries should work to ensure that these cross-sectoral linkages enhance progress in each sector. The responsibility for effective co-ordination is primarily on the country members to ensure that the relevant experts are involved in any international discussions, and that necessary links are made within national policy on different sectors. For example, there may be interactions between work on appliance energy efficiency standards and on reducing emissions from buildings, or between efforts to increase investment in electric vehicle charging infrastructure and the balancing of electricity systems with high levels of renewable power.

In last year’s report, we suggested the creation of updated landscape maps that provide an overview of the various initiatives working in each sector. This mapping exercise is an important input into assessing the overall progress of each sector, and provides a resource to make international collaboration simpler and easier. The Breakthrough Agenda secretariat has produced updated initiative landscape maps for each sector, which are now available in the Annex of this report and on the [Breakthrough Agenda website](#).

RECOMMENDATION CC1 HAS BEEN RESTATED AS FOLLOWS:

Countries should further strengthen forums and institutions that support international co-operation in each sector, with increased political and financial support, sufficient participation, deeper analysis and communication of the potential gains from co-ordinated international action.

STRENGTHEN THE PROVISION OF TECHNICAL ASSISTANCE AND FINANCE, TO ENSURE IT IS SUFFICIENT, COHERENT, ACCESSIBLE AND EFFECTIVE ACROSS ALL SECTORS

Over the past 2 years, we have stressed the importance of improving the co-ordination of financial and technical assistance to emerging markets and developing economies in each sector. This includes ensuring sufficient assistance is available and, if available, that it is accessible and flexible. This section highlights the overall progress on these aspects while recommendations for each sector are addressed in their specific chapters.

Global energy investment increased over the past year and [is expected to exceed USD 3 trillion](#) for the first time in 2024, with around USD 2 trillion set to go towards clean technologies. Yet most of this investment is concentrated in advanced economies and China, with only around 15% of global clean energy investment going to emerging markets and developing economies, where the high cost of capital is holding back the development of new projects. Increasing the flow of investment to emerging markets is absolutely vital to reaching net zero goals.

Moderate progress from existing multilateral development banks (MDBs) is being made on this front. The World Bank Group delivered a record [USD 38.6 billion in climate finance in FY2023](#), a 22% increase on the previous year, accounting for 41% of its total financing portfolio. The World Bank has set a [target to devote 45% of its annual financing](#) to climate-related projects by 2025, and is extending debt repayment pauses following climate disasters. The Asian Development Bank committed USD 23.6 billion from its own resources in 2023, delivered through loans, grants, equity investments, guarantees and technical assistance provided to governments and the private sector, including USD 9.8 billion for climate action in Asia and the Pacific. This was its [highest-ever annual financing for climate action](#). An additional USD 16.4 billion was mobilised in co-financing through its partnerships.

There has also been some progress under the United Nations Framework Convention on Climate Change (UNFCCC) that could support mobilisation of climate finance in developing economies, though any actionable changes will likely be decided at COP 29 later this year. In 2009, countries set a goal to mobilise USD 100 billion per year to support action on climate change in developing economies, and in 2015, countries agreed in Paris to set a [New Collective Quantified Goal on Climate Finance](#) (NCQG) to eventually replace the USD 100 billion goal, which was [finally reached in 2022](#). At COP 29 in Baku, countries aim to agree on a new amount, and on which countries should contribute. While deliberations on the NCQG have been slow, in March 2024 a [workplan was released](#) to develop an approach to prepare the framework for a draft negotiating text. Technical experts have been meeting throughout the year in the run-up to COP 29, with the [tenth technical expert dialogue](#) held in Germany in June 2024.

To identify the types of financing needs and gaps specific to clean energy technologies, in early 2024 the Brazil G20 Presidency invited the IEA to help support the development of a Clean Energy Investment Roadmap for Emerging Markets and Developing Economies. The Roadmap, which will be released in advance of the G20 Leaders' Summit in November 2024, will outline actions needed to achieve an increase in clean energy investments by 2035 in line with the IEA Net Zero Emissions by 2050 Scenario (NZE Scenario). It will specifically provide analysis on concessional funding needs, identify best practices in project derisking for various clean energy technologies and propose alternatives to lower

the cost of capital. The G20 Presidency and country members will then agree whether or not to adopt the actions recommended in the Roadmap.

Reforming international finance architecture continues to be high on the priority list, as climate-vulnerable countries advocate for new financial tools, access to liquidity, disaster-responsive debt clauses, concessional and non-concessional financing and debt-for-climate-action swaps. This includes calls for increased investment by MDBs and changes in governance to give more voting power to climate-vulnerable countries. In October 2023, the heads of the world's major MDBs [issued a joint statement](#) to reiterate commitments to make reforms to strengthen financing capacity and improve collaboration. While a step in the right direction, the statement primarily works to enhance existing efforts, with no action plan for reforms. It is difficult to identify progress on a scale consistent with the ambition of the [Bridgetown Initiative](#), which was launched in September 2022. In May 2024, a new phase of the initiative was proposed ([Bridgetown Initiative: 3.0](#)), calling for four new areas of policy reforms to change the global financial architecture. The proposal is expected to be finalised this year, after which time the initiative will engage with decision makers to translate the reforms into action.

Sectoral matchmaking platforms can better co-ordinate assistance by bringing donor and recipient countries together with international financial institutions and technical partners. To date, progress on developing such platforms has been mixed. In the buildings sector, there is no convening platform to gather input from the full sectoral ecosystem (development banks, private investors, insurers, local lenders and national governments) to drive the scale of investment needed. In contrast, some progress has been made in the steel and cement sectors, where a global matchmaking platform is under development by the Climate Club in collaboration with UNIDO, following earlier examples in the power sector (notably the Energy Transition Council) and, to a lesser extent, road transport (where a Rapid Response Facility for technical assistance has been established under the Zero Emission Vehicle Transition Council). At a regional level, match-making platforms show greater progress. The Regional Platforms for Climate Projects (RPCP), a High-Level Champion-led initiative to deliver a series of regional forums and ongoing match-making sessions, helped 19 climate projects in emerging markets and developing economies raise USD 1.9 billion in investment in 2023.

Better co-ordination of technical assistance plays a vital role in enhancing decarbonisation initiatives across sectors. By aligning efforts among stakeholders – governments, financial institutions, and technical experts – resources can be allocated more efficiently. Streamlined technical guidance can help project developers navigate complex regulatory landscapes and adopt best practices, making projects more attractive to investors. Co-ordinating technical assistance ensures that financial products are tailored to the specific needs of decarbonisation projects, facilitating easier access to funding. This integrated approach will accelerate the deployment of clean technologies.

As an example, the Technology Executive Committee, the policy arm of the Technology Mechanism, with support from the Government of Germany and UNIDO, conducted a [mapping exercise](#) to review transformative climate action initiatives in hard-to-abate industries, including steel, cement, chemicals and petrochemicals. The mapping exercise will be used to inform policy and technology options to reduce emissions and ways to implement them, including through international assistance, research, development and demonstration (RD&D) and the use of blended finance to de-risk private sector investment.

Countries are now preparing to submit to the UNFCCC their inaugural Biennial Transparency Reports, which are due by the end of 2024. These are intended to provide comprehensive data, improve transparency and accuracy, and enhance accountability on

climate action. Key changes from past years include enhanced reporting guidelines; stronger emphasis on tracking progress towards nationally determined contributions (NDCs); expanded scope of information; enhanced reporting on financial, technological, and capacity-building support; enhanced transparency framework, verification and review processes; and use of common metrics and methodologies. This could help in monitoring the effectiveness of technical assistance programmes. Through the reporting and review process, UNFCCC will enhance national capacity for data collection, analysis and reporting, which will strengthen the overall ability of countries to manage and utilise technical assistance over time.

Effective mobilisation of financial and technical assistance, as well as all the other approaches to international co-operation described in this report, can support countries to develop stronger NDCs, which are due to be submitted in 2025. Conversely, countries could usefully consider including their intended approach to international co-operation in each sector in their NDCs.

RECOMMENDATION CC2 HAS BEEN RESTATED AS FOLLOWS:

Governments, financial institutions, philanthropic organisations and delivery partners should continue to improve the co-ordination of technical and financial assistance in each sector, learning from existing successful models. Further efforts are required to improve the conditions and delivery of financial assistance, in line with developing country requests.

AGREE ON NET ZERO-ALIGNED TRADING ARRANGEMENTS THAT CAN ENABLE A FASTER TRANSITION ACROSS SECTORS AND REGIONS

In 2022, we introduced the recommendation to align trading arrangements with a net zero trajectory, given that several sectors (particularly heavy industry) operate with relatively narrow profit margins and are highly exposed to trade. Last year we restated this need, especially as domestic policy measures are put in place to promote such low-emission commodities.

Over the last 2 years, we have recommended that governments, companies and relevant international organisations should establish high-level, strategic dialogues in those sectors where an unlevel playing-field is at risk of presenting a major barrier to the transition. We have seen moderate, but incremental, progress in this regard. Since last year's report, over a dozen new members have joined the Climate Club, which now includes four out of the ten largest emerging economies, up from just two last year. The group started implementing its first Work Programme in 2024, including initiating a series of strategic dialogues in the same year to understand and mitigate carbon leakage and other spill-over risks of climate policies. Still, without greater representation of large emerging economies, it will be difficult to chart a path towards agreements that could establish level playing-fields in global markets.

The World Trade Organization (WTO), a vital platform for supporting government dialogue on trade, has been expanding the work of its Trade and Environmental Sustainability Structured Discussions to include a focus on trade and climate change. Through the Working Group on Trade-related Climate Measures, members discuss how trade can be used to achieve specific climate objectives pertaining to the clean energy transition, climate change adaptation and decarbonisation of industry and transport, including carbon

measurement methodologies and standards. The Coalition of Trade Ministers on Climate is another forum to discuss the intersection of trade, finance and climate. These multilateral discussions are an important step towards establishing international consensus on the role of trade in the transition, but are not geared towards reaching specific agreements between major economies in individual sectors. Establishing strategic dialogues on trade and the transition in the sectors most exposed to international competition, with – at a minimum – the participation of countries that together account for a majority of the global market, remains an important priority.

As the clean energy transition advances, countries have started to expand their energy and climate policies to focus on developing competitive clean energy technology supply chains. Major economies are acting to combine their climate, energy security and industrial policies into broader strategies for their economies (e.g. the Inflation Reduction Act in the United States; the Fit for 55 package and REPowerEU in the European Union; the Green Transformation Promotion Strategy in Japan; the Production Linked Incentive scheme in India). For emerging markets and developing economies, participation in global clean energy supply chains presents the opportunity to advance wider development and employment goals. In 2023, the IEA [Energy Technology Perspectives 2023](#) report provided an initial detailed view into these supply chains. An updated and expanded analysis of them in the context of energy, climate, industrial and trade policy is expected in a forthcoming publication [at the end of October](#).

Competition of this kind is a sign of progress and can contribute to accelerating clean energy transitions. However, there is a risk that increased barriers to trade may result in slower and more expensive transitions. Since no country will be in a position to cover every part of the supply chain at once, international trade and co-operation are essential enablers of the transition. As countries use trade policy to seek a level playing-field for their industries, they should be mindful of potential impacts on the cost and pace of clean energy transitions.

At the same time, international attention is increasingly focused on the issue of security and resilience in clean technology supply chains. A high degree of supply chain concentration – the extent to which market shares are concentrated among a small number of production facilities, firms, countries or regions – carries major risks for the security of supply of clean energy technologies. Concentration at any point along the supply chain makes the entire chain less resilient and more vulnerable to incidents, be they related to an individual country's policy choices, natural disasters, technical failures or company decisions. Today, there is a [significant degree of concentration](#) of facilities, firms and countries across several clean technology supply chains. Many of the raw and intermediate materials and components that comprise clean energy supply chains are produced in a small number of countries or regions, with the leading producer sometimes holding a very large share of the global market for certain inputs. Diversification not only supports supply chain security and resilience, but it also provides an economic opportunity for emerging economies that can also support their decarbonisation goals.

A priority for international collaboration should be to establish ongoing dialogues on the security and resilience of supply chains, involving advanced and emerging economies across supply chains. These dialogues should act as a platform to identify opportunities and partnerships that support the development of clean technology supply chains, with the aim of reducing barriers to investment, particularly in emerging economies.

Existing dialogues on these topics are in their early stages today, primarily focused on recognising the need for supply chain security and resilience, rather than tangible plans to implement and identify investment opportunities.

Since last year's report, both the Group of Seven (G7) and Group of Twenty (G20) countries have called attention to clean energy supply chains. Previously, at the G7 Hiroshima Summit in April 2023, world leaders [recognised](#) the importance of diversifying global clean energy supply chains, which can help alleviate vulnerabilities and potential challenges for the energy transition. In April 2024, energy ministers at the G7 Torino Ministerial [reaffirmed](#) this statement and expanded it further to commit to supporting the development of clean energy supply chains in Africa, through the mobilisation of clean energy technologies and manufacturing sectors. This was followed by the [G7 Apulia Leaders' Communiqué](#), which encouraged enhancing existing and creating new international partnerships to make critical minerals and critical raw materials supply chains more diversified, transparent, resilient, responsible, circular, resource-efficient and sustainable, by supporting local value creation in critical minerals supply chains in line with WTO rules. The G20 New Delhi Summit in September 2023 [underlined](#) the need to support emerging economies in their efforts to move up the value chain. Regional discussions are also under way. In November 2023, the Association of Southeast Asian Nations (ASEAN) adopted a [set of principles](#) on sustainable mineral development.

Other dialogues have resulted in concrete steps to improve the security and resilience of supply chains. In September 2023, the IEA hosted a dialogue on [critical minerals](#), where nearly 50 countries – including large and emerging critical mineral producers and consumers – came together with leaders from industry, investment and civil society to share experiences and discuss effective courses of action on critical minerals to ensure rapid and secure energy transitions. The dialogue resulted in an agreement on six key actions, including the need for countries to explore mechanisms that include voluntary stockpiling to help enhance the resilience of supply chains. To this end, in February 2024, ministers from IEA member countries [directed the IEA](#) to develop a framework to take forward a voluntary IEA Critical Minerals Security Programme, which would look to boost the security of the supply chains for the minerals essential for clean energy technologies. In November 2023, the IEA hosted another [high-level dialogue](#), this one focused on diversifying clean technology manufacturing. The interactive dialogue, which brought together both public and private sector decision makers alongside representatives from the research community and civil society organisations, acted as a platform for sharing experience among countries and with the private sector.

While strategic dialogues can identify the *what* and *where* of supply chain security and resilience, investment in production capacity of clean energy technologies and their components can provide the *how*. Indeed, private companies can and will continue to strike deals to invest in facilities as a function of normal market activity, however, high-level agreements between countries – when implemented correctly – can provide an overall framework for co-operation and facilitate investment. There has been moderate progress in this regard. In late 2023 and early 2024, the [Minerals Security Partnership](#) (MSP), a multinational partnership to develop diverse and sustainable critical minerals supply chains, announced progress in raising financing and securing offtake agreements for [a number of projects](#), including ones targeting manganese, nickel and graphite. The financing was provided by several MSP government members. In 2024, the MSP added Estonia as its newest member, bringing the total participation to 14 countries plus the European Union. Efforts are [underway](#) to include a greater number of producer countries in the partnership, including Indonesia.

Several of these efforts, including the G20 New Delhi and G7 Torino communiqués, and IEA high-level dialogues, note a need for greater collaboration on data collection and analysis of clean energy supply chains. Internationally adopted frameworks for collecting statistics on industrial activity, such as the International Standard Industrial Classification

of All Economic Activities and the Harmonized System, [currently lack the detail to be able to isolate individual clean technologies and their components](#). Individual countries' customs authorities and other national bodies already collect data at higher levels of granularity, but rarely in a harmonised manner. Further data on clean technology manufacturing (e.g. energy use, physical production quantities, emissions foot-printing, investments, costs, employment) should also be sought and harmonised by governments internationally.

RECOMMENDATION CC3 HAS BEEN UPDATED AS FOLLOWS:

Governments, companies and relevant international organisations should establish high-level, strategic dialogues to develop a common approach to reaching a level playing-field for clean technologies in highly trade-exposed sectors. These should be focused on the goal of timely global decarbonisation; include participants representing a majority of the global market in the sectors discussed; and be informed with high-quality data and analysis. They should also identify opportunities to strengthen global clean energy supply chain security and resilience. Such dialogues and agreements can be supported with actions on data, standards, procurement and partnerships on technology collaboration and technical and financial assistance.

URGENTLY SCALE UP DEMONSTRATION PROJECTS FOR CLEAN TECHNOLOGIES IN AREAS OF GREATEST NEED

Technologies that are available on the market today are able to provide nearly all of the emissions reductions required by 2030 in the IEA NZE Scenario. However, going all the way to [net zero will require faster innovation](#), and – after 2030 – the widespread use of technologies that are still under development today.

Governments have a major role to play in shaping energy innovation priorities, including by allocating public budgets for energy RD&D. The amount spent globally on clean energy R&D [grew again in 2023](#), extending post-pandemic gains. A 13% rise in US government spending on energy R&D helped keep global public energy R&D spending on a steady upward trend, reaching USD 50 billion. However, energy innovation investment remains underrepresented in emerging and developing economies outside of China, representing just 6% of public R&D spending in 2023. Considering the active role these countries need to play in energy transitions, and the greater impact of higher interest rates on the cost of capital for innovators in these countries, their limited investment participation is a concern.

While individual country efforts to advance clean energy demonstrations continues, countries will need to work together to determine the priority gaps to address, and ensure continuous, deep, systematic and widespread sharing of learning. It is difficult to judge the extent to which this is taking place, but forums such as Mission Innovation (MI) have been taking steps to advance such activities.

In June 2024, MI's Technical Advisory Group [released the key findings](#) of the first annual review of the MI Missions' activities. The review found that all seven Missions are making progress in supporting clean technology innovation, with most of the progress focused on knowledge-sharing activities through events, awards, web-based platforms and webinars. To accelerate the knowledge-sharing across its Missions, in July 2023, MI launched the [MI Think Tank](#) to enhance dissemination on high-impact clean energy RD&D topics. The Think Tank launched and closed a call last year to bring forward cross-cutting topics, resulting in two dialogues: one on [financing clean energy demonstration projects](#) and the second on the [circular carbon economy](#).

It is clear that MI and its various workstreams are making progress to share knowledge and experiences on clean energy innovation. However, the workstreams and gatherings, as they are currently designed, are generally not set up to move forward into implementation. One notable exception is the MI Call series, a multilateral R&D call to address research challenges that cannot be tackled effectively by national research programmes on their own. However, there is little activity on this workstream, with the last joint R&D call issued in 2021.

Under Brazil's 2024 G20 Presidency, a new Research and Innovation Working Group was launched to raise the profile of science, technology and innovation policy within the G20 process and to co-operate on salient policy goals. In 2024, climate and energy is one of five topic areas, leading towards the publication in September 2024 of an [energy innovation policy compendium](#) and a clean energy technology list. These two non-exhaustive outputs were prepared by the IEA and are designed to inform and inspire governments, especially in emerging markets and developing economies, to craft effective packages of innovation support to accelerate clean energy technology development in priority areas. This work will provide a foundation for further co-operation and analysis in future years.

Some progress has also been made on identifying important areas for governments to target innovation efforts. In February 2024, the IEA convened around 250 entrepreneurs, business leaders, investors and policy makers from around 45 countries at its first-ever [Energy Innovation Forum](#). Among the technology priorities raised by ministers and corporate leaders were large-scale industrial processes for which commercialisation of known low-emissions technologies remains a challenge in key sectors such as iron and steel or cement production. A dedicated breakout session on decarbonising industrial heat highlighted recent progress towards a range of electrification options for different high-temperature heating needs. In this area, there is significant potential for collaborations between countries, industrial sectors and even among competitors at different stages of maturity.

While global energy R&D spending has been trending upwards, more efforts are needed to ensure emerging markets and developing economies are supported to participate. Some progress has been made through the Accelerate-to-Demonstrate (A2D) Facility, a programme to accelerate pilot demonstration projects of clean energy technologies in low- and middle-income countries. Launched in May 2023, the GBP 65 million initiative, funded by the United Kingdom and implemented by UNIDO, aims to accelerate the commercialisation of innovative clean energy technologies, focusing on critical minerals, clean hydrogen, and cross-cutting thematic areas (clean transport, smart energy, energy efficiency, energy storage, industrial decarbonisation and sustainable cooling). The first global funding call for project proposals from the A2D Facility was published in July 2024, and will support the implementation of catalytic, scalable pilot demonstration projects of innovative clean energy solutions in developing economies in the following four thematic areas – critical minerals, clean hydrogen, smart energy (digitalisation) and industrial decarbonisation.

RECOMMENDATION CC4 HAS BEEN RESTATED AS FOLLOWS:

Governments and companies should greatly increase spending on clean technology demonstration projects, working together to bring new technologies to commercial-scale deployment as soon as possible. Early deployment projects should be supported by match-making forums and ensuing commitments and processes in all regions.

ACCELERATE THE CONSTRUCTION OF INTERNATIONAL INFRASTRUCTURE TO SUPPORT THE TRANSITION IN MULTIPLE SECTORS

Infrastructure to transport and store electricity, hydrogen and CO₂ is an often overlooked – but critical – enabler of clean energy transitions. While individual countries can work to build this infrastructure domestically, countries should share best practices and co-ordinate on projects that span multiple borders.

For sectors at an earlier stage of development, such as hydrogen and other low-emission fuels, countries will need to work together to identify the infrastructure needed to support the development of new global supply chains connecting production centres to demand. For example, kick-starting hydrogen trade in the next few years will not only hinge on the commercialisation of emerging technologies for transport and conversion, but will also require a substantial expansion of existing port and shipping infrastructure to accommodate future levels of low-emission fuels. New fuelling infrastructure – known as bunkering in the shipping industry – will be needed to enable the use of these fuels.

Some efforts are advancing in this area. For example, in July 2023, the Clean Energy Ministerial (CEM) adopted the [Clean Energy Marine Hubs Initiative](#) (CEM Hubs), a cross-sectoral public-private platform intended to de-risk investments needed to produce low- and zero-emission fuels to be transported by the maritime sector. The CEM Hubs initiative is a first-of-a-kind partnership between the private sector and governments across the energy-maritime value chain – the International Chamber of Shipping, the International Association of Ports & Harbors and the CEM, led by governments of Brazil, Canada, Greece, Norway, Panama, Uruguay and the United Arab Emirates. Initial promising progress was made in October 2023 with the [launch of the Transatlantic Clean Hydrogen Trade Coalition](#) (H2TC) to enable clean hydrogen shipments from the United States to Europe by 2026. The Coalition aims to facilitate trade of more than three million tonnes per year of hydrogen in the form of ammonia and methanol across the Atlantic.

In the carbon capture, utilisation and storage sector, countries need to work together to harmonise technical and regulatory requirements of cross-border projects as an increasing number of countries look to export their captured CO₂ to countries with suitable storage sites. Cross-border projects of this kind are currently proposed in Europe, East Asia and Oceania. In Europe, around 20 cross-border infrastructure projects are being developed to access storage resources in the North Sea and in Southern Europe. In East Asia and Oceania, countries with limited CO₂ storage are exploring partnerships for CO₂ shipping to Australia, Indonesia and Malaysia. In addition to the technical specification requirements of transporting and storing captured CO₂, international regulatory considerations under the [London Protocol](#) may require countries to work together to ensure alignment of permitting regimes for the safe and secure storage of CO₂.

While project-level discussions are being led by the individual companies involved in each project, agreements between countries are providing the overall framework to enable these discussions. Progress on this front is promising. For example, Chevron and Mitsui O.S.K Lines [established an agreement](#) in 2022 to investigate the feasibility of transporting CO₂ from Singapore to storage locations offshore in Australia. This was complemented by a [Memorandum of Understanding](#) signed by Singapore and Australia, as well as a recent [letter of intent](#) on cross-border CO₂ storage signed between Singapore and Indonesia. In Europe, five countries (Belgium, Denmark, the Netherlands, Norway and Sweden) signed arrangements to transport and store CO₂ in the North Sea area.

For more established sectors, such as power, international efforts need to expand beyond resolving technical issues between countries and toward engaging a broader range of public and private stakeholders to successfully develop regional interconnectors. There is a need to enhance co-ordination efforts across borders between grid owners and operators, utilities, regulators and other key stakeholders.

Building the resilience of infrastructure is also gaining importance. The Coalition for Disaster Resilient Infrastructure, which is a partnership of national governments, UN agencies and programmes, MDBs and financing mechanisms, the private sector and knowledge institutions that aims to promote the resilience of new and existing infrastructure systems to climate and disaster risks in support of sustainable development, is a noteworthy example. The Coalition's first [Biennial report on 'Global Infrastructure Resilience'](#) makes the economic, political and financial case for radically upscaling investment in infrastructure resilience. The Global Infrastructure Risk Model and Resilience Index has generated a suite of publicly available financial risk metrics for each country and territory in the world, for all major infrastructure sectors (power and energy, transport, telecommunications, water and wastewater, ports and airports, oil and gas, health and education) and for most major hazards (earthquakes, tsunamis, landslides, floods, cyclonic wind, storm surge and hydrological drought). These financial risk metrics enable the estimation of the resilience dividend, understood as the full range of benefits that accrue from investing in infrastructure resilience, which can motivate governments to develop resilient infrastructure.

RECOMMENDATION CC5 HAS BEEN RESTATED AS FOLLOWS:

Wherever not already agreed, governments in each region of the world should agree on the top priority common resilient infrastructure projects that can support near-term growth in the deployment of clean solutions, such as interconnectors and hydrogen pipelines. In each of the land, sea and air transport sectors, countries and companies should identify specific international routes and hubs to be prioritised for the co-ordinated first deployment of zero-emission corridors or refuelling infrastructure.

PROVIDE CLEAR GUIDANCE ON AND VERIFICATION OF EMISSION REDUCTION STANDARDS' COMPATIBILITY WITH NET ZERO TO FACILITATE GREATER USE

Verifying emission reduction is necessary to show alignment with a net zero pathway and is an important aspect in implementing government climate policy. Procurement contracts, regulatory compliance, trade measures and access to finance are just a few examples of instances where governments may need reliable ways to verify emission reduction. As shown in the previous chapters, the development of standards to verify emission reduction in major emitting sectors is progressing, albeit slowly. For example, at COP 28, the International Organization for Standardization (ISO) presented a [Technical Specification](#) to assess the GHG emissions of hydrogen on a lifecycle analysis basis, forming the basis for a series of international standards to account for emissions across the hydrogen supply chain.

Within a given sector there may be multiple frameworks for assessing emission reduction. To continue with the hydrogen example, a growing number of countries are now adopting diverging regulatory frameworks for the certification of clean hydrogen for government funding programmes. In theory, more than one approach could lead to greater flexibility in

how governments implement their policies. However, too many will result in a fragmented global market. A key recommendation of this report is to ensure that there is alignment across these different efforts and that these efforts are aligned with a trajectory to net zero emissions.

At a minimum, governments should discuss the mutual recognition of standards in major sectors, for which they will need to collaborate. The establishment of agreed-upon principles or codes for the development of standards could provide a common base toward mutual recognition. For example, there has been moderate progress on ongoing efforts to develop general principles for standards on low-emissions steel. At COP 28, the Steel Standards Principles [were launched](#) to improve the transparency, interoperability and mutual recognition of methodologies for measuring GHG emissions in the iron and steel sector. The IEA Working Party on Industrial Decarbonisation and the Climate Club are complementing these efforts and are developing a draft common ground summary. Similar progress has been made in the building sector, with nearly 70 countries acknowledging support for shared operational objectives for buildings construction and retrofitting in the [Declaration de Chaillot](#).

While the development of methodologies and standards has progressed at a moderate pace, plans for implementation have been slow. For the hydrogen, steel and cement sectors, more work needs to be done to show how countries plan to translate the progress on international standards into national regulations.

In last year's report, we noted that emission reduction verification efforts do not necessarily provide policy officials with definitive guidance on which standards are sufficiently ambitious. This would require an assessment of the extent to which standards are compatible with net zero trajectories. We noted that such an assessment would need to include a technical assessment (i.e. what emissions would result from the application of such a standard) and a scenario assessment (what emission level would be compatible with climate goals).

ISO launched its [own guidelines](#) at COP 27 that provided recommendations to businesses to enable a common approach to the net zero governance landscape. At the time, the guidelines represented a positive step forward in improving guidance around net zero standards, but the guidelines do not encompass the aim of providing a function to conduct that assessment. Such a function would require credible international experts, with detailed knowledge of each sector.













In the buildings sector, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the International Code Council (ICC) are jointly developing an international standard (ASHRAE/ICC Standard 240P) to support quantification of GHG emissions across the lifecycle of a building in order to provide consistency in verification and reporting. The organisations, which completed the [draft standard](#) in February 2024, are working to align with and expand upon existing standards.

In parallel, the Science Based Targets initiative (SBTi) released in May 2024 the [Terms of Reference](#) for the development of the Corporate Net-Zero Standard Version 2.0. Among other areas, the SBTi standard aims to align with the latest scientific thinking and best practice (e.g. the [IPCC](#) and the [UN Secretary General's High Level Expert Group on the net zero emissions commitments of non-state entities](#)), and enhance interoperability with other SBTi standards, as well as other relevant external frameworks and standards. The draft standard is planned to be released for public consultation in Q4 of this year.

RECOMMENDATION CC6 HAS BEEN RESTATED AS FOLLOWS:













Building on existing international efforts, governments should consider the establishment of an international function to improve the collective verification of claims of different standards and their compatibility with international climate goals, across multiple sectors.

ANNEX

 POWER Initiative	 Long-term vision & action plans	 Demand creation & management	 Infrastructure & supply chains	 Finance & investment	 Research & innovation	 Market structures	 Standards & certification	 Trade conditions	 Knowledge, Capability & Skills	 Social engagement & impact	 Landscape co-ordination
21st Century Power Partnership (21CPP)	●				●				●		
Breakthrough Energy Catalyst		●		●					●		
C40 Cities							●		●		
Clean Energy Ministerial - Supercharging Battery Storage	●		●	●	●						
Clean Energy Ministerial - Transforming Solar Supply Chains	●		●	●	●						
Climate Investment Funds (CIFS)*				●	●				●		
Digital Demand-Driven Electricity Networks (3DEN)			●						●		
E3G			●		●				●		●
Efficiency for Access Coalition			●	●							●
Energy Transition Council				●					●	●	
EP100		●					●		●		
First Movers Coalition		●		●							
GEAPP		●		●				●			
Global Covenant for Mayors for Climate and Energy			●	●							●
Global Power System Transformation Consortium					●		●		●		
Green Grids Initiative (GGI)	●		●	●		●			●	●	
Green Powered Future Mission	●	●		●	●				●		
IEA 4E Energy Efficiency End-Use Equipment					●				●		●
International Labour Organization			●						●		
International Smart Grid Action Network ISGAN	●				●	●			●		
Irena's Collaborative Framework on "Enhancing Dialogue on High Shares of Renewables in Energy Systems"					●	●					
RE100										●	●
Regional and Global Energy Interconnection (RGEI)			●						●		
SEforALL				●		●				●	
Super-Efficient Equipment and Appliance Deployment (SEAD)	●				●				●		
Utilities for Net Zero Alliance*	●		●		●				●		

* No website available

Source: Breakthrough Agenda Secretariat.

 HYDROGEN Initiative	 Long-term vision & action plans	 Demand creation & management	 Infrastructure & supply chains	 Finance & investment	 Research & innovation	 Market structures	 Standards & certification	 Trade conditions	 Knowledge, Capability & Skills	 Social engagement & impact	 Landscape co-ordination
Clean Energy Ministerial's Hydrogen Initiative (CEM H2I)	●	●	●			●		●	●		
First Movers Coalition		●									
Green Hydrogen Organisation (GH2)	●	●		●			●		●		
Hydrogen Council	●	●					●	●	●		
IEA Advanced Fuel Cells Technology Collaboration Programme (AFC TCP)					●						
IEA Hydrogen Technology Collaboration Programme (Hydrogen TCP)		●			●		●				
IMO (International Maritime Organisation)							●				
Industrial Transition Accelerator (ITA)				●			●				
International Partnership for Hydrogen and fuel cells in the Economy (IPHE)	●	●					●	●	●	●	●
IRENA's Alliance for Industry Decarbonization					●		●		●		
IRENA's Collaborative Framework Green Hydrogen	●		●		●	●	●	●	●	●	
Mission Innovation's Clean Hydrogen Mission	●	●	●		●			●			
OECD Nuclear Energy Agency (NEA)		●			●						
OECD's Clean Energy Finance and Investment Mobilisation (CEFIM)				●							
RMI's Green Hydrogen Catapult		●	●					●			
UN High Level Climate Champions Team		●				●					
UNECE							●				
UNIDO's Global Programme for Hydrogen in Industry		●	●	●		●	●	●	●	●	
World Bank's Hydrogen for Development Partnership (H4D)	●			●					●		
World Business Council for Sustainable Development (WBCSD)	●	●				●					
World Economic Forum's Accelerating Clean Hydrogen Initiative	●	●									
World Economic Forum's Transitioning Industrial Clusters initiative		●	●	●							
World Trade Organisation								●			

* No website available

Source: Breakthrough Agenda Secretariat.












 **ROAD TRANSPORT**
Initiative

 Long-term vision & action plans	 Demand creation & management	 Infrastructure & supply chains	 Finance & investment	 Research & innovation	 Market structures	 Standards & certification	 Trade conditions	 Knowledge, Capability & Skills	 Social engagement & impact	 Landscape co-ordination
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Accelerating to Zero Coalition (A2Z)	●	●				●				
CALSTART	●	●	●	●	●	●		●	●	
CEM Electric Vehicle Initiative (EVI)	●	●	●				●	●		
Climate Group EV100	●	●								
Collective for Clean Transportation Finance (CCTF)		●	●	●		●		●		
FIA Foundation	●			●	●	●		●	●	
GEF E-mobility Programme				●	●		●	●		
Global Battery Alliance (GBA)	●		●		●		●		●	
Global Facility to Decarbonise Transport (GFDT)				●				●		
Global MoU on medium and heavy duty vehicles	●	●	●	●				●		
Green Grids Initiative (CGI)			●							
International Council on Clean Transportation (ICCT)			●		●		●	●		
International Transport Forum (ITF)	●		●		●		●	●		
International ZEV Alliance	●		●		●			●		
Road Transport Breakthrough										●
Smart Freight Centre		●	●	●				●		
Systemiq					●	●		●		
The Environmental Collaboratory at Drexel University					●		●	●		
The Global Fuel Economy Initiative (GFEI)		●	●	●	●		●	●		
Transport Decarbonisation Alliance (TDA)										
UC Davis					●		●	●	●	
United Nations Economic Commission for Europe (UNECE)	●		●				●	●		
United Nations Environmental Programme (UNEP) Used Vehicles Programme	●		●	●			●	●	●	
WEF Road Freight Zero & First Movers Coalition (FMC)		●	●	●						
World Business Council for Sustainable Development (WBCSD)	●		●	●		●		●		
ZEV Emerging Markets Initiative (ZEVEMI)		●	●	●		●		●		
ZEV Transition Council (ZEVTC)	●		●	●		●	●	●		
ZEVWISE	●	●	●	●				●	●	













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Source: Breakthrough Agenda Secretariat.

 STEEL Initiative	 Long-term vision & action plans	 Demand creation & management	 Infrastructure & supply chains	 Finance & investment	 Research & innovation	 Market structures	 Standards & certification	 Trade conditions	 Knowledge, Capability & Skills	 Social engagement & Impact	 Landscape co-ordination
CEM – Industrial Deep Decarbonization Initiative (IDDI)											
Climate Club											
Climate Investment Funds Industry Decarbonization Program (CIF Industry)											
First Movers Coalition											
G7 Industrial Decarbonisation Agenda*											
IEA – Industrial Energy-related Technology and Systems TCP											
IEA Working Party on Industrial Decarbonisation (WPID)*											
IRENA Alliance for Industrial Decarbonisation											
Leadership Group for Industry Transition (LeadIT)											
Mission Innovation Net Zero Industries Mission (MI NIM)											
Mission Possible Partnership											
OECD/CEFIM											
OECD Steel Committee											
ResponsibleSteel											
Steel Breakthrough											
SteelZero											
UNEP Steel Methane Program (SMP)*											
World Steel Association											
WTO Trade and Environmental Sustainability Structures Dialogue											













* No website available

Source: Breakthrough Agenda Secretariat.

 CEMENT Initiative	 Long-term vision & action plans	 Demand creation & management	 Infrastructure & supply chains	 Finance & investment	 Research & innovation	 Market structures	 Standards & certification	 Trade conditions	 Knowledge, Capability & Skills	 Social engagement & impact	 Landscape co-ordination
Industrial Deep Decarbonization Initiative (IDDI)		●					●		●		
Climate Club		●	●	●			●	●			
First Movers Coalition		●									
Global Cement and Concrete Association (GCCA)	●										
IEA Working Party on Industrial Decarbonisation (WPID)*							●		●		
Leadership Group for Industry Transition (LeadIT)	●			●					●		
MI Net Zero Industries Mission (MI NZI)					●				●		
Mission Possible Partnership	●					●					

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 BUILDINGS Initiative	 Long-term vision & action plans	 Demand creation & management	 Infrastructure & supply chains	 Finance & investment	 Research & innovation	 Market structures	 Standards & certification	 Trade conditions	 Knowledge, Capability & Skills	 Social engagement & impact	 Landscape co-ordination
2030 Breakthroughs: Built Environment Outcome	●										
Advancing Net Zero/ANZ (WorldGBC)	●	●	●	●	●	●	●	●	●	●	
Building Capacity for Sustainable and Resilient Buildings (ICC)							●		●		
Building Net Zero: Mobilising Policy Action (GBPN)	●				●		●		●	●	
BuildingLife (WorldGBC)	●	●	●	●	●	●	●				
Built by Nature Fund (BuiltbyNature)		●				●		●			
Built Environment Pathway (WBCSD)	●	●					●		●		
Carbon Risk Real Estate Monitor/CRREM (Institute for Real Estate Economics/IO)	●										
CEM-Industrial Deep Decarbonisation Initiative / IDDI (UNIDO)		●									
CEM-Mission Innovation					●						
GBPN Network (GBPN)					●				●	●	
Global Building Data Initiative/GBDI (GLOBE)							●		●		
Global repository of Efficient Solutions in the Built Environment sector (Solar Impulse Foundation)					●						
Healthy Buildings Healthy Lives (GBPN)							●		●	●	
Institutional Investors Group on Climate Change (IIGCC)	●			●							
Market Transformation Action Agenda (WBCSD)	●	●		●			●				
Net Zero Carbon Buildings Commitment (WorldGBC)		●									
Programme for Energy Efficiency in Buildings/PEEB (AFD/GIZ)		●	●	●		●			●		
Programme on Decarbonising Buildings in Cities and Regions (OECD)*	●						●		●		
Race to Resilience	●										
Race to Zero		●									
Sharm-El-Sheikh Adaptation Agenda	●										
Sustainable Finance (WorldGBC)		●		●			●		●		

* No website available

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