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Global Governance for the Decarbonisation of Energy-Intensive Industries: Exploring Sectoral Options (Deliverable 6.1b)

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Executive Summary

To achieve the goals of the Paris Agreement the deep decarbonisation of energy intensive industries (EIIs) by mid-century is essential. However, their transition is hampered by several crucial economic and political barriers, such as limited availability of mitigation technologies, high capital investment needs and long lifecycles, and strong global competition. Global governance and sector specific initiatives offer great potential to address these barriers and accelerate EII decarbonisation globally – a potential that has so far remained underexploited, however. This article identifies and assesses in detail options of global governance for closing existing governance gaps and advancing the decarbonisation of the main EIIs (i.e., steel, cement and concrete, chemicals, and aluminium). To this end, it proceeds in three steps.

It first determines the theoretical potential of international cooperation to address barriers and challenges to the decarbonisation of EIIs along six governance functions, i.e. signal and guidance, rule setting, transparency and accountability, means of implementation, knowledge and learning, and orchestration and coordination. It then identifies existing gaps in the global governance of decarbonising EIIs, by comparing the theoretical potential of global governance with the existing supply of global governance across the six functions. It finds that recently established global sectoral initiatives provide a promising basis for further enhancing governance, in particular regarding the functions of signal and guidance, means of implementation, as well as rule setting.

On this basis, the article proceeds to identifying and assessing concrete options for enhancing the global climate governance of EIIs to address the gaps identified and drive forward the transition. It analyses if and how reforming existing institutions can address the identified governance gaps, before discussing the possible creation of new institutions to address remaining gaps. Existing institutions offer a good starting to advance global governance on many functions, but a new institution can significantly enhance existing efforts and is required to address issues regarding international competition and carbon leakage and the harmonisation of standards for near-zero emission basic materials. The analysis provides priorities and ‘feasible’ steps towards a better exploitation of the potential of global governance for the decarbonisation of EIIs that can drive forward the sector's transition to climate neutrality.

1 Introduction

Achieving the objective of the Paris Agreement (PA) to stay within the 1.5°C or 2°C pathways requires the deep decarbonisation of energy-intensive industries (EIIs) by mid-century. EIIs, often also referred to as heavy industries, comprise several different industries that produce basic materials such as iron and steel, aluminium and other non-ferrous metals, cement and concrete, basic chemicals, glass, ceramics and pulp and paper. In 2019, the industry sector at large was responsible for 24% of direct and 34% of indirect global greenhouse gas (GHG) emissions, of which around 62% of direct emissions can be accounted towards EIIs (60% indirect). The main driver of EII emissions is the strong reliance of current production technologies on fossil fuels, as energy carriers for high-temperature heat, reduction agent and chemical feedstock. Process emissions are another major driver accounting for around 25% of global EII direct emissions (Bashmakov et al., 2022; IEA, 2022a). This article focuses specifically on four key EIIs, namely iron and steel, the production of basic chemicals, cement and concrete as well as aluminium, as they make up the bulk of EII GHG emissions (Bashmakov et al., 2022).

Achieving net-zero emission EIIs by 2050 is technically possible, but faces substantial technical, economic and policy barriers. This includes barriers specific to EIIs, such as long investment cycles, lack of effective mitigation technologies and high capital requirements for new production facilities, but also more general challenges such as access to green energy supply and physical infrastructure, including for the transport and storage of carbon (Bashmakov et al., 2022; Nurdiawati & Urban, 2021; Rissman et al., 2020; van Sluisveld et al., 2021). At the same time, many EIIs, in particular steel, aluminium and basic chemicals, are characterised by strong global competition, high trade intensity and small profit margins, constraining the industry's ability to finance the development and implementation of deep decarbonisation options (Åhman et al., 2017; Wesseling et al., 2017).

At the same time, global demand for basic materials is projected to increase significantly resulting in a projected slower decrease in EIIs emissions compared to other sectors (Bashmakov et al., 2022, p. 62). Demand growth is mainly driven by economic development in emerging and developing economies (Bashmakov et al., 2022), but also material needs related to the transition to climate neutrality in other sectors (e.g. new railways) and the adaptation to the impacts of climate change (e.g. flood protection) (IEA, 2020b). The challenge for EIIs is therefore to rapidly decarbonise while meeting growing demand in light of the abovementioned barriers. This is feasible but will require substantial financial and political support (Bashmakov et al., 2022; Nurdiawati & Urban, 2021; van Sluisveld et al., 2021).

Global governance and sector-specific initiatives offer great potential to address the abovementioned barriers and accelerate industrial decarbonisation globally (Kulovesi, 2012; Obergassel et al., 2022; Victor et al., 2019). Global sectoral governance is thereby particularly well suited to address the challenges facing the decarbonisation of EIIs, given its global nature (Agora Industry, 2022; Åhman et al., 2017, 2022; Hermwille et al., 2022; IEA, 2022a; Nilsson et al., 2021; Oberthür et al., 2021b; Wesseling et al., 2017). However, Oberthür et al. (2021b) find that the potential of global governance for the decarbonisation of EIIs has so far remained vastly underexploited.

This article picks up this discussion and **identifies and analyses institutional options to advance the global governance of the decarbonisation of EIIs**. Updating and complementing the analysis by Oberthür et al. (2021b), we find that existing international institutions hold significant potential to advance the decarbonisation of EIIs but that a new institution is required to fully exploit the potential of global governance. To develop our argument we proceed in three steps. Section 2 first identifies the main challenges and barriers to the decarbonisation of EIIs and then determines the potential of global governance to address these, along six governance functions international institutions can in theory

supply. Next, in Section 3, we analyse the empirical supply of global governance across the six governance functions and identify key remaining governance gaps. We find that the supply of global governance has significantly increased since the analysis by Oberthür et al. (2021b), but key gaps remain regarding the functions of rules for collective action and means of implementation. This includes a lack of harmonised standards and methodologies for near-zero GHG emission basic materials, international demand-side policies, and international policies or rules addressing carbon leakage as well as enhanced efforts on technology development and diffusion. Finally, in section 4 we assess concrete options to address the key gaps identified and to accelerate the decarbonisation of EIIs. To do so, we first develop criteria for assessing institutional options and then analyse the potential of reforming existing institutions and creating a new institution. Existing institutions hold significant potential to advance global governance on the implementation of supply-side policies as well as cooperation on technology development and diffusion but are unfit to address global competitiveness and carbon leakage. We conclude by discussing the potential design of a new institution focused on addressing remaining governance gaps.

Our analysis contributes to the academic literature on sectoral global governance and the discussion on advancing international climate policy for the industry sector in several ways. First, we develop a theoretical framework for assessing institutional options to enhance global governance that can be employed beyond this paper. We thereby specify institutional requirements needed to address key governance gaps in question that can guide policymakers interested in advancing global governance for the decarbonisation of EIIs in general. Second, we provide a comprehensive empirical analysis of the current landscape of global governance for the decarbonisation of EIIs and identify key remaining governance gaps. This highlights areas where more policy intervention and international cooperation is required, but also where significant international cooperation already exists. Finally, by analysing concrete options for addressing remaining governance gaps we offer concrete guidance and recommendations to policymakers.

This study is based on the analysis of existing academic literature, relevant reports (e.g. IPCC, IEA) and grey literature. The empirical analysis of the sectoral governance landscape was conducted through extensive desk research based on outputs of international institutions and triangulated with similar research efforts. Interim results of the mapping and governance analysis were presented and discussed with sectoral stakeholders and experts at two occasions (see Khandekar et al., 2022).

2 Assessment of Existing Sectoral Governance Landscape: Gaps and Potentials

2.1 Main Barriers to Sectoral Decarbonisation

The deep decarbonisation of EIIs by mid-century is technically possible and requires a combination of different supply and demand side mitigation strategies (Bashmakov et al., 2022; Nurdiawati & Urban, 2021; van Sluisveld et al., 2021). On the supply side, this entails energy efficiency measures and transitioning away from fossil-fuel based feedstocks and energy carriers towards emission free alternatives such as green hydrogen, biomass, or renewable electricity. Carbon Capture, Utilisation and Storage (CCUS) technologies are crucial to mitigate process emissions but can also reduce emissions from fossil-fuel based production (Bashmakov et al., 2022; IEA, 2022a). On the demand side, material efficiency improvements and changes in end-use demand behaviour, including increases in circularity, can bring substantial emission savings, especially in the short-term (Bashmakov et al., 2022; Bataille et al., 2021; IEA, 2022a). However, the decarbonisation of EIIs continues to face substantial technical, economic and policy barriers (Chiappinelli et al., 2021; Löfgren & Rootzén, 2021; Nilsson et al., 2021; Oberthür et al., 2021b; Rissman et al., 2020). In the following, we highlight the most crucial barriers and challenges from a global perspective to then discuss how international cooperation can, in theory, address them.

Availability of near-zero emission technologies

The biggest challenge facing the decarbonisation of EIIs is the lack of commercial availability of respective deep decarbonisation technologies (Bashmakov et al., 2022). While near-zero emission production technologies exist for all EIIs in principle, most are still in the demonstration or pilot phase and it will take several more years before they can be employed at large scale (Chiappinelli et al., 2021; Nurdiawati & Urban, 2021). However, to reach net-zero emission EIIs by 2050, these technologies must be market-ready by the mid-2020s for initial deployment before 2030 and rapidly diffused thereafter (Bashmakov et al., 2022; IEA, 2020b). It is therefore vital to accelerate the development of breakthrough technologies (Saygin & Gielen, 2021), but also to ensure their diffusion to areas with future demand growth, as to date low carbon technology development is mainly occurring in Europe (Hermwille et al., 2022).

Long investment cycles & high investment costs

Closely related, the implementation of near-zero emission technologies is hampered by long investment cycles inherent to EIIs and high capital investments needed for building or refurbishing production sites (IEA, 2020b; Löfgren & Rootzén, 2021). EII production plants tend to have lifecycles of up to 40 years, with major refurbishment occurring usually every 10-20 years, offering only limited windows of opportunity to implement new technologies. However, a significant share of global EII production capacity needs to be replaced or undergo major refurbishments in the current decade. Unless these opportunities are used to implement low or near-zero emission technologies, there is a strong risk to lock in fossil-fuel based production routes (Bashmakov et al., 2022; IEA, 2022a). At the same time, renovating and building EII production plants requires high capital investments in general, while low or near-zero emission production routes are even more costly. To illustrate, it is estimated that decarbonising EIIs globally requires investments of approximately 0.05-0.07% of gross domestic product annually (IEA, 2020a), although other scenarios indicate that pathways to net-zero emissions can be realized with limited additional costs (Bashmakov et al., 2022, pp. 72-73). In addition to that,

deep decarbonisation technologies require significant changes to encompassing sociotechnical systems further hampering their implementation (Åhman et al., 2022; Löfgren & Rootzén, 2021).

Competitive disadvantage due to higher operational costs

Furthermore, near-zero emission technologies have a competitive disadvantage vis-à-vis conventional production technologies due to higher operational costs**,** at least for the time being (Nilsson et al., 2021; Nurdiawati & Urban, 2021). To illustrate, the production costs for near-zero emission steel are estimated to be 20-40% higher, those of cement 70-115% higher, and 15-60% higher for basic chemicals (Bashmakov et al., 2022, p. 95). The higher operational costs are partially due to higher costs for low-emission energy carriers, compared to relatively cheap fossil fuels used in conventional technologies. At the same time, major consumers of basic materials (e.g. car manufacturers) have historically not been willing to pay the price premium for 'greener' materials, although this might be changing (Chiappinelli et al., 2021; Wesseling et al., 2017). This, combined with the high capital investment requirements, significantly limits the business case for low-emission production and increases the economic risks for investments in breakthrough technologies (Bashmakov et al., 2022; Löfgren & Rootzén, 2021).

Strong global competition & lack of international rules and climate policies targeting EIIs

Strong global competition constrains the ability of and incentives for EII producers to implement risky investment decisions. Steel, aluminium and basic chemicals – cement to a somewhat lesser extent – are highly internationally traded commodities subject to high price volatility and little product differentiation, resulting in limited profit margins for basic materials producers (Oberthür et al., 2021b; Wesseling et al., 2017). In consequence, EIIs have largely been sheltered from the effects of stringent international and domestic climate policies, mainly due to concerns over potential carbon leakage, but also fears over loss of economic competitiveness and the high strategic and economic relevance of EIIs for many regions (Åhman et al., 2022; Nilsson et al., 2021; Wesseling et al., 2017). Furthermore, the logic of the Paris Agreement on national responsibility for implementing climate policy (i.e. NDCs) creates a mismatch with the nature of the sector, which is to a large part dominated by large multinational corporations (Åhman et al., 2022; Wesseling et al., 2017).

Lack of renewable energy supply and supporting infrastructure

Finally, deep decarbonisation options for EIIs require sufficient zero-emission (i.e. green) energy supply as well as the related physical infrastructure, including for the transport and storage of carbon (Bataille et al., 2021; Chiappinelli et al., 2021; IEA, 2022a; Löfgren & Rootzén, 2021; Nurdiawati & Urban, 2021). On the one hand, this concerns the availability of abundant and renewable electricity and green hydrogen as well as a growing and reliable supply of alternative feedstocks, such as sustainable biomass or steel and aluminium scrap. On the other, this includes the physical infrastructure needed to transport and store green energy (including hydrogen) as well as to transport and store carbon to enable the application of CCUS (Åhman et al., 2022; Bataille et al., 2021; Saygin & Gielen, 2021). The development of sufficient green energy supply and the related infrastructure is an essential pre-enabling factor for an effective roll-out of breakthrough technologies but requires time and immense (public) resources. At the same time, green energy production and carbon storage potential differs highly across regions, potentially causing relocations of industries and changing global supply chains. This has potentially highly beneficial or negative implications for some regional economies and can lead to conflicts with other socioeconomic political goals, or just transition concerns (Bataille et al., 2021; Swennenhuis et al., 2022; Trollip et al., 2022).

2.2 Potential of International Cooperation to Address Barriers

International institutions hold great potential to address the above-mentioned barriers and advance the decarbonisation of EIIs globally (Oberthür, et al., 2021b). To assess this potential, we distinguish between six governance functions international institutions can in theory fulfil. The first five are adopted from Oberthür et al. (2021a; 2021b), while we add orchestration and coordination of existing institutions as an additional function (see Abbott 2012; 2018). Table 1 summarises the potential of each governance function and highlights how they can address the abovementioned barriers.

First, international institutions can provide *(1) signal and guidance* to actors to pursue a certain course of action or policy direction and align developments across different levels of governance. This can be provided through ambitious, authoritative and credible decarbonisation visions, pathways or political commitments, including timelines and regional specifications. Certainty on policy directions is an essential enabling factor for private and public investment decisions, given the longevity and capital intensity of EII facilities and infrastructure development (Bashmakov et al., 2022; Nilsson et al., 2021).

Second, international institutions can *(2) set rules and policies* to facilitate collective action or prohibit harmful or unproductive behaviour (Nilsson et al., 2021). Given the global nature of EIIs, international institutions are well placed to develop common policies creating a more level global playing field to address barriers of competition and carbon leakage (Åhman et al., 2017; Oberthür et al., 2021b). furthermore, the international coordination of demand-side policies for near-zero emission basic materials can help lower competition and cost barriers (Åhman et al., 2022; IEA, 2022a; Nilsson et al., 2021). Common definitions, standards, methodologies and certification schemes for determining benchmarks for near-zero emissions basic materials are a vital prerequisite for demand and supply side measures and can further facilitate the circularity of global flows of materials and increase transparency (Bashmakov et al., 2022; IEA, 2022a). Finally, international institutions can set clear timelines and phase-out policies (i.e. sunset clauses) or for investments into conventional technologies (Bashmakov et al., 2022; IEA, 2022b; Hermwille et al., 2022).

Closely related, international institutions can provide *(3) transparency and accountability* vis-à-vis actions and commitments of relevant actors, for example through the monitoring and verification of emissions or regular progress reviews (Oberthür et al., 2021b). Sufficient transparency and accountability is a precondition for the enforcement of rules and policies, while progress reviews can highlight persistent barriers towards decarbonisation. Furthermore, international institutions are also well placed to harmonise existing accounting and monitoring frameworks, to ensure cross-comparability or reduce regulatory burdens for transnational actors (Marcu et al., 2022).

Fourth, international institutions can provide *(4) means of implementation* for the decarbonisation of EIIs, which includes the provision of financial resources, capacity building, and technology diffusion (Oberthür et al., 2021b; Nilsson et al., 2021; Åhman et al., 2017). For example, through coordinating and strengthening existing technology development efforts or through facilitating technology diffusion to emerging economies with high near zero emission basic materials production potential (Åhman et al., 2022; Nurdiawati & Urban, 2021; Trollip et al., 2022). This can address barriers related to breakthrough technologies, high investment costs, green energy supply and supporting infrastructure.

Fifth, international institutions can foster *(5) knowledge and learning* by providing analysis, gathering data, disseminating best practices, or facilitating stakeholder collaboration and networking. This function plays a mainly supportive role but is nonetheless vital to accelerate the decarbonisation of EIIs. For example, the provision of analysis can reduce uncertainties, disseminate relevant technical

knowledge or promote effective policy frameworks, while stakeholder networking can advance cross-country learning and collaboration (IEA, 2022a; Oberthür et al., 2021b).

Finally, international institutions can *(6) orchestrate and coordinate* existing institutions and initiatives, as well as their activities. Orchestration can be achieved through supporting institutions that have similar objectives or by steering their governance and activities through persuasion or incentives (Abbott, 2012, 2018). This can foster synergies, identify and deliver opportunities for coordination, highlight governance gaps, and build trust among actors (Abbot, 2012; Tsuyuki-Tomlinson et al., 2021). Orchestration can thereby help to address barriers related to the lack of breakthrough technologies or policy uncertainty, for example by coordinating finance or decarbonisation visions.

Table 1: Potential of international cooperation to address barriers to the decarbonisation of EIIs

Governance Function	Potential of international cooperation	Barriers addressed
Signal & Guidance	• Decarbonisation visions • Certainty on policy direction	• High capital investments • Long investment cycles • Policy uncertainty
Rules for collective action	• Prohibition of unproductive behaviour • Common demand-side policies • Common definitions, standards, methodologies & labels • Rules creating a level playing field • Phase-out policies, investment requirements	• Global competitiveness & carbon leakage • Lack of demand for clean products • Lack of international climate policy • Lack of business case • (Lack of supporting infrastructure)
Transparency & Accountability	• Emissions monitoring • Progress reviews	• Precondition for implementing rules
Means of implementation	• Financial resources • Technology development & diffusions • Capacity building	• Lack of breakthrough technologies • High investment costs • Lack of supporting infrastructure
Knowledge & Learning	• Facilitates learning through analysis, data, best practices • Collaboration of stakeholders	• Lack of breakthrough technologies • Uncertainty
Orchestration & Coordination	• Synergies across existing institutions • Highlight governance gaps • Facilitates collaboration	• Lack of breakthrough technologies • Policy uncertainty • (Lack of policy frameworks)

Source: Oberthür et al., 2021a, 2021b; Åhman et al., 2022; Bashmakov et al, 2022; Nilsson et al., 2021; Wesseling et al., 2017

3 Sectoral Governance Landscape: Remaining Gaps and Underexploited Potentials

This section analyses the extent to which the governance potential identified above has been exploited by international institutions and highlights remaining governance gaps. To do so, we identify international institutions that are relevant for the decarbonisation of EIIs, determine their respective contribution to the six governance functions, and then compare the actual supply against the theoretical potential to identify remaining governance gaps. Following Oberthür et al (2021a; 2021b), we only consider international institutions that realise the common purpose of decarbonising EIIs, contribute actively to at least one of the six functions, have rules governing membership, and are of a lasting nature (Falkner et al., 2022). We include formal international and transnational institutions but also less 'institutionalised' initiatives, under the condition that they have dedicated resources and are of a lasting nature.

The mapping of the governance landscape was conducted ongoingly from January to September 2022. The work of Oberthür et al. (2021b) and Khandekar et al. (2018) was taken as a starting point and updated and complemented through desk research based on institution's websites and relevant outputs (e.g. reports and statements). Interim results of the governance mapping were discussed with sectoral stakeholders at two occasions as part of the NDC Aspects Project (see Khandekar et al. 2022). The findings were triangulated with similar research on the global governance for the decarbonisation of EIIs (Agora Industry, 2022; Future of Climate Cooperation, 2022; IEA, 2022a).

The remainder of this section summarises the main findings of the empirical analysis. The full inventory of international institutions and initiatives can be found in Annex 1. Table 2 provides a summary of the supply of global governance by function, while a detailed analysis of the governance supply by each institution can be found in Annex 2. Figure 1 provides an overview of the governance landscape and its interconnections.

3.1 Overview of the Global Governance Landscape

Overall, we identified more than 30 international institutions and initiatives that contribute to the global governance of decarbonising EIIs (see Annex 1). State-led (i.e. intergovernmental) institutions and initiatives play an important role in the global governance landscape, accounting for more than half of the institutions identified. This includes established international organisations, such as the United Nations Framework Convention on Climate Change and the Paris Agreement (UNFCCC/PA), the UN Industrial Development Organization (UNIDO), UN Environment (UNEP), the World Bank Group (WBG) and other multinational development banks (MDBs). Furthermore, the World Trade Organization (WTO), the Organisation for Economic Co-operation and Development (OECD), the International Energy Agency (IEA), as well as the G20 and G7 also provide relevant governance.

We further identified six relevant state-led international initiatives, which focus more explicitly on industrial decarbonisation and were established over the past years. The Industrial Deep Decarbonisation Initiative (IDDI) established in 2021 aims to use government purchasing power to create markets for near-zero emissions basic materials, starting with steel and cement (UNIDO, 2021). Mission Innovation (MI), established in 2015 and relaunched in 2021, is a global initiative catalysing action in the energy transition, with a specific mission on industrial decarbonisation (Mission Innovation, 2022). The Clean Energy Ministerial (CEM) is a state-led forum to advance the global energy transition and runs several sector specific initiatives, including IDDI. The G7 established the Industrial Decarbonisation Agenda (G7-IDA) in 2021, which aims to enhance collaboration on industrial

decarbonisation among G7 members. In June 2022, the G7 further announced to establish a Climate Club by the end of 2022 to support the implementation of the PA with a potential focus on decarbonising industry (Germany, 2022b). The Breakthrough Agenda, announced at COP26 and endorsed by 30 countries, comprises leader-led visions for the decarbonisation of specific sectors, including for steel and hydrogen (UNFCCC, 2021a). Finally, the European Union (EU) – United States (US) Carbon-based Sectoral Agreement on Steel and Aluminium Trade signed in October 2021 aims to restrict market access for dirty steel and aluminium in the foreseeable future (United States, 2021). Additionally, we identified two country-led institutions that also include private company members (hybrid institutions). The Leadership Group for Industry Transition (LeadIT) provides an arena for public and private cooperation on decarbonising EIIs (LeadIT, 2021), while the First Movers Coalition (FMC), which is supported by the US State Department, fosters procurement commitments by private companies to create demand for clean basic materials.

Next to that, we identified 16 relevant transnational institutions and initiatives. On the one hand, this includes international industry associations that work on a wide array of issues but have dedicated workstreams related to decarbonisation. These are the Global Cement and Concrete Association (GCCA), the Concrete Sustainability Council (CSC), the World Cement Association (WCA), the International Council of Chemicals Association (ICCA), the International Aluminium Institute (IAI), and the World Steel Association (WSA). On the other, this includes transnational initiatives that focus more closely on the decarbonisation of EIIs. The Low-Carbon Emitting Technology Initiative (LCET) is a collaboration platform of major chemicals companies aimed at the development and upscaling of breakthrough technologies. ResponsibleSteel is an industry-led initiative focusing on the certification of sustainable steel. The Global Low Carbon Metallurgical Innovation (GLCMI) Alliance was initiated in 2019 by the Chinese Baowu Steel Group as a technology exchange platform to gather research and development resources for the global steel industry. SteelZero and ConcreteZero, both run by the Climate Group, aim to foster procurement commitments for clean steel and cement by private companies. Mission Possible Partnership (MPP), an alliance of corporate 'climate leaders' established in 2021, has dedicated initiatives to advance the decarbonisation of steel, aluminium and concrete respectively (see Figure 1). Additionally, the Energy Transition Commission (ETC), the World Economic Forum (WEF), the Science Based Targets Initiative (SBTi) and Breakthrough Energy (BE) provide governance relevant to the decarbonisation of EIIs.

The remainder of this section discusses in more detail the supply and remaining gaps for each governance function. Before, however, three general observations can be highlighted. First, we observe a strong overall dynamic in the global governance landscape, manifested by the emergence of many new relevant institutions over the past years. Compared to Oberthür et al. (2021b), who identified 11 institutions, the number of institutions in our inventory has almost tripled. It is to be noted, however, that many of these new initiatives and institutions have not yet been fully implemented (e.g. G7 Climate Club) and their final impact on the governance supply remains to be seen. Second, several institutions and initiatives have emerged that focus specifically on decarbonisation EIIs, including state-led institutions such as IDDI, MI, IDA, BA or LeadIT but also transnational efforts such as LCET or FMC. While neither of these can yet serve as a focal point of the sectoral governance landscape (Oberthür et al., 2021b), it does signal a stronger political focus on the issue at hand and offers the potential for advancing international cooperation. Finally, and closely related we observe increasing interlinkages and collaboration across the governance landscape, as illustrated in Figure 1. This further highlights the strong dynamic present in the landscape and offers opportunities to enhance overall orchestration and coordination.

Table 2: Supply of Global Governance by Function

Function	Governance Supply
Signal & Guidance	• General decarbonisation visions through *UNFCCC/PA (i.e. 1.5°C target)* & *G7* • Sectoral decarbonisation pathways/roadmaps for EIIs by *UNFCCC, G7-IDA, MI, LeadIT & *IDDI* • Industry-specific decarbonisation pathways/roadmaps by *BA, GCCA, IAI, MPP & *LCET*
Rules	• National medium and long-term climate action plans (NDCs & LTS) under *UNFCC/PA* • Government led demand-side policies, incl. procurement commitments by *IDDI & *G7-IDA*, • Private actor procurement commitments for clean steel, cement and aluminium by *FMC, MPP, SteelZero, ConcreteZero,* • Standards and definitions for steel, cement and aluminium by *IEA, IDDI, FMC, ISO, RS, MPP, SteelZero, ConcreteZero*. Planned by **EU-US CBSA & *MI* • Methodologies for emission reporting by *ISO, WSA & ICCA* • *Coordination of international climate policies envisioned by *G7-CC & EU-US CBSA* • Sustainability requirements by *GCCA, WSA, WBG & RS* • Coordination on global policies relevant to EIIs, but not decarbonisation specific by *OECD, WTO & G20* • Commitment to phase-down/out of fossil fuel subsidies by *UNFCCC, G20 & G7*
Transparency & Accountability	• Reporting on industry emissions or specific EIIs emissions by *UNFCC/PA, IDDI, GCCA, *G7-CC & *MI* • Regular review of progress under *UNFCCC/GST, BA & *MI* • Certification and auditing of specific (sustainability) standards by *RS, CSC, WCO & *IDDI* • Reporting requirements for members by *GCCA, WSA, SteelZero & ConcreteZero*
Means of Implementation	• General finance for decarbonising EIIs by *UNIDO, WBG, G7, MI, CEM, LeadIT & BE* • Technology development, incl. finance and facilitation of cooperation by *G7-IDA, MI, CEM, GCCA, LCET & GLCMI Alliance* • Technology diffusion and transfer, incl. finance and facilitation of cooperation by *UNEP, UNIDO & UNFCCC* • Catalysing of private investment by *MI, MPP & BE* • Capacity building and training by *UNIDO, UNEP, WBG, OECD, IEA, IDDI, LeadIT, FMC, GCCA, ICCA, RD, ETC, WEF & SteelZero* • Support for infrastructure development by *UNIDO, G7, CEM, & *G7-CC*
Knowledge & Learning	• Analysis and data relevant to the decarbonisation of EIIs by *IEA, UNFCCC, UNDIO, WBG, OECD, BA, LeadIT, IAI, ETC, MPP, WEF,* • Provision of best practices, technological guidance and pathways by *GCCA, IDDI, ICCA, IAI, WSA, RS, MPP, LCET, SBTi* • Facilitation of knowledge sharing and stakeholder collaboration by *UNDIO, IEA, MI, CEM, IDDI, LeadIT, FMC, GCCA, ICCA, RS, MPP, WEF, LCET, SteelZero, ConcreteZero, & GLCMI Alliance*
Orchestration	• General collaboration among identified institutions and initiatives in general • Limited orchestration and coordination of existing initiatives by *G7-IDA, BA & CEM* • Cooperation on standards and supply side measures by *LeadIT, IDDI, FMC, SteelZero & ConcreteZero* • Orchestration of cooperation among non-state actors by *ETC, MPP, WCO, FMC, UNFCCC & WEF*

*Initiatives have to date been announced but not yet implemented.

For abbreviations see Annex 1. For full analysis of the governance supply see Annex 2.

Source: Own research; Oberthür et al., 2021b; Khandekar et al., 2018; Future of Climate Cooperation, 2022; IEA, 2022a

3.2 Signal & Guidance

International institutions provide relevant signal and guidance for the decarbonisation of EIIs in the form of decarbonisation visions and industry-specific roadmaps. What remains lacking, however, is an overall authoritative decarbonisation vision for EIIs that specifies the objectives of the Paris Agreement into industry-specific and regional pathways. General guidance on the decarbonisation of EIIs is provided by the UNFCCC/PA objective to limit global warming to 1.5°C/2°C and phase-out net GHG emissions by the second half of the century as well as the G7 commitment to reach net-zero emissions by 2050 and half collective emissions by 2030 (Germany, 2022a). These visions already provide general long-term policy direction but lack industry-level or regional specifications (Oberthür et al., 2021b). Additionally, several pathways and roadmaps for EIIs or specific industries have been developed by international institutions that provide more targeted guidance. For example, the Climate Action Pathways (CAP) for Industry orchestrated by the UNFCCC, provides sectoral visions and recommended actions to achieve net-zero emissions by 2050 for the main EIIs (UNFCCC, 2022). The Breakthrough Agenda provides high-level political decarbonisation visions for steel as well as hydrogen production endorsed by 30 countries (UNFCCC, 2021a). The GCCA 2050 global net zero roadmap outlines a pathway for cement decarbonisation and further comprises a collective commitment of GCCA members to reach net-zero emissions by 2050 (GCCA, 2021). Additional roadmaps and pathways for steel, aluminium and chemicals have been developed by MPP and LCET, with further efforts ongoing. Taken together, these provide relevant guidance and policy direction for relevant actors and, in the case of transnational and industry-driven efforts demonstrate increased ownership of the transition by EIIs actors.

3.3 Setting Rules

Our analysis shows that international institutions are increasingly tapping into the potential for setting rules and policies to facilitate collective action. They are thereby increasingly active on three matters, namely demand-side policies, standards and methodologies for near-zero emissions basic materials, and initial discussions on measures to address carbon leakage. While these efforts by far do not exploit the full potential of global governance, they nevertheless provide a good basis for addressing barriers related to economic challenges and, to a lesser extent, global competition. These developments underscore the strong dynamic present in the sector and are particularly noteworthy since Oberthür et al (2021b) found no relevant stringent international rules regarding the decarbonization of EIIs.

First, international demand-side policies for near-zero GHG emission steel, aluminium and cement are beginning to emerge through state-led as well as transitional initiatives. This includes efforts by FMC (for steel and aluminium), SteelZero and ConcreteZero, all of which aim to foster procurement commitments for clean materials by private actors. Furthermore, this comprises intergovernmental efforts such as the 2022 Green Public Procurement Pledge by IDDI, which aims to use governments' purchasing power to create a market for near-zero GHG emissions materials (Industrial Energy Accelerator, 2022). The G7 announced similar efforts under IDA and the proposed Climate Club. These procurement commitments are essential in that they support the creation of demand for near-zero emission basic materials, which can alleviate investment uncertainties and competitiveness barriers. However, their impact on the overall EII markets remains negligible.

Second and closely related, several standards and methodologies for near-zero emission steel, cement and aluminium have been developed. Several of these standards are linked to the abovementioned procurement commitments to establish clear benchmarks for applicable products (e.g. FMC, SteelZero, ConcreteZero), while others have been (or are being) developed as part of a broader work programme

(e.g. RS, IEA, ISO IDDI, G7-IDA). The emergence of such standards is a vital precondition for the implementation of demand and supply side policies, in that they determine what qualifies as 'near-zero GHG emission basic material' and which production routes should therefore receive support (IEA, 2022a). However, neither of these standards has yet been properly established and widely applied in practice, while standards for basic chemicals are lacking in general. To avoid competition and fragmentation, global governance should also focus on harmonising existing standards and methodologies (IEA, 2022a; 2022b).

Third, international institutions are starting to discuss common rules to address global competitiveness and carbon leakage with a view to accelerate the decarbonisation of EIIs, but this has not yet led to any tangible outcomes. Both, the G7 commitment to establish a climate club by the end of 2022 (Germany, 2022b) and the US-EU Carbon-based Sectoral Agreement on Steel and Aluminium Trade by 2024 (United States, 2021) aim to coordinate policies to address carbon leakage and accelerate EII decarbonisation respectively but are still at the proposal or negotiation stage. The EU's Carbon Border Adjustment Mechanism (CBAM) that establishes a carbon tariff on energy-intensive material imports is also worth mentioning here (see European Parliament, 2022), as it is the most comprehensive effort to address carbon leakage, although we do not consider it as global governance as such.[1]

Finally, international institutions also facilitate other rules relevant to the decarbonisation of EIIs. Under the Paris Agreement, countries are obliged to submit national climate targets – i.e. Nationally Determined Contributions (NDCs) – and long-term strategies, although NDCs have hardly included specific targets for EIIs (Sanchez & Nilsson, 2021). The G20, G7 and UNFCCC have all pledged to phase out inefficient fossil fuel subsidies in general, but with little focus on specific EIIs decarbonisation measures (Germany, 2022a; Italy, 2021; UNFCCC, 2021b). Finally, the OECD Steel Committee provides a forum to address global challenges facing the steel industry but also focuses little on decarbonisation (OECD, n.d.).

3.4 Transparency & Accountability

Concerning transparency and accountability the supply of global governance remains limited. While there is some supply of emission data and regular progress reviews, these remain constrained to specific industries. The UNFCCC/PA operates a fundamental transparency system including national GHG emissions inventories and regular reporting on measures taken and their impact, including the monitoring and reporting of industrial GHG emissions (Oberthür et al., 2021b). Several transnational institutions also gather GHG emission data, including GCCA, ICCA and WSA, but the latter two do not make it publicly available. Several institutions also foresee regular reporting obligations or progress reviews on objectives and implemented actions. For example, the Breakthrough Agenda foresees an annual assessment of the sectoral transition, but this currently only covers steel and hydrogen (see IEA, 2022b). As part of the UNFCCC/PA, the Global Stocktake regularly reviews global climate ambition towards the aims of the Paris Agreement, but it remains to be seen to what extent it will employ a sectoral approach (Obergassel et al., 2022). While limited in their scope, these efforts are important to hold actors to account, identify areas where more progress is needed and generate important knowledge on best practices or key challenges. Responsible Steel, CSC, and WCO further offer certification or audit services for standards or definitions for steel and cement, while IDDI plans to offer similar services for steel and cement. Such certification or auditing efforts are vital to govern the application of and compliance with standards and their relative lack comprises a significant gap in the

[1] Note: the EU is considered as a single supranational jurisdiction and single international actor and therefore not part of the global governance landscape.

supply of global governance. To conclude, the supply of transparency and accountability remains limited overall with gaps regarding emission monitoring, regular reviews of progress and certification of and compliance with standards. However, as more and more institutions develop rules and policies the importance of these functions increases since it will be crucial that rules are accompanied by stringent monitoring, reporting and accountability mechanisms.

3.5 Means of Implementation

Means of implementation are supplied by a vast number of the identified institution, including the provision of general finance and investments, technology development, diffusion and transfer, as well as capacity building (see Table 2). All in all, these activities help to advance the development of breakthrough technologies, but it is highly questionable whether they are sufficient to make near-zero emission technologies available by 2030. Additionally, efforts focused on the global diffusion of technology in particular towards emerging economies remain limited. To illustrate, several institutions focus specifically on financing and accelerating the development of breakthrough technologies for EIIs, including state-led institutions such as MI and LeadIT, but also industry-led institutions with a more industry specific focus, for example, LCET on chemicals, the GLCMI Alliance on steel or GCCA on cement. In addition to financing, these institutions focus on coordinating common technology development projects across their members. Regarding technology diffusion, general large-scale finance for the transition in developing countries is provided by multilateral financial institutions, such as the World Bank or the Green Climate Fund (GCF) as well as by UNIDO and UNEP. Finally, UNIDO, CEM, and the G7 provide efforts aimed at developing the global supply of green energy and green hydrogen, for example through the G7 Just Transition Energy Partnerships (JETP) that support emerging economies to transition towards a decarbonised energy supply (Germany, 2022a).

3.6 Knowledge & Learning

We identify a vast supply of knowledge and learning with almost all institutions in our inventory providing some form of analysis, data, best practices, knowledge exchange or stakeholder networking. International institutions thereby provide a variety of relevant knowledge products ranging from in-depth analysis and reports, decarbonisation roadmaps, best practices and comprehensive data, to (policy) handbooks or guidelines on a variety of relevant issues. For example, the IEA regular reviews the state of decarbonisation, possible pathways and policy options for EIIs (e.g. IEA, 2020a, 2021, 2022a). Similarly, many institutions have developed elaborate regional or industry-specific decarbonisation roadmaps that discuss different decarbonisation pathways and policy options (see Annex 2). These products help to disseminate and advance knowledge on breakthrough technologies and effective policy frameworks but also highlight persistent barriers and challenges to the decarbonisation of EIIs. Regular progress reviews already mentioned above further gather insights on best practices (i.e. what works) and consistent barriers and challenges (i.e. what does not yet work). Next to that, many institutions facilitate knowledge exchange and networking opportunities among relevant stakeholders, for example through workshops or stakeholder dialogues (e.g. MI, LeadIT) or targeted training (e.g. IDDI). This aids to further diffuse knowledge on decarbonising possibilities, and the implementation of mitigation options and can foster cooperation among involved stakeholders. Knowledge gaps remain on financing needs and broader supply-chain and socio-economic impacts such as just transition concerns and impacts on specific regions.

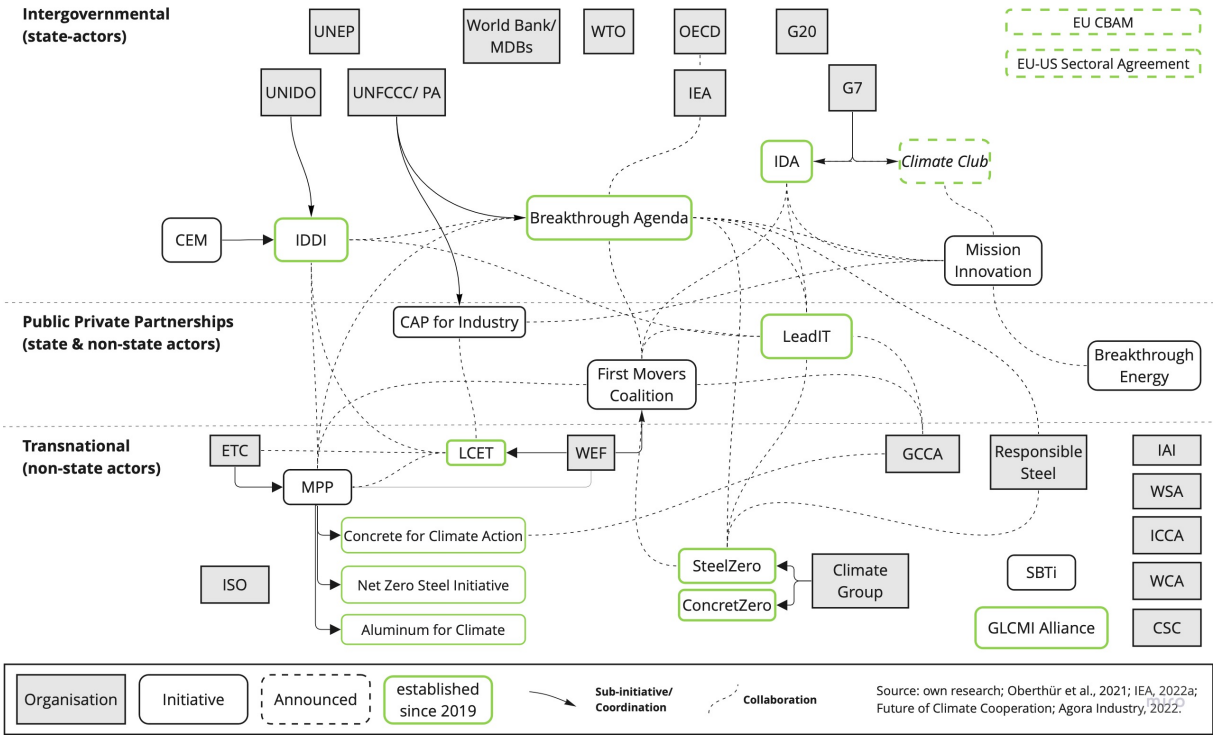

Figure 1– Global Governance Landscape for the Decarbonisation of EIIs

3.7 Orchestration & Coordination

Finally, international institutions provide little orchestration or coordination of existing activities, although cooperation on specific issues is increasingly emerging as illustrated in Figure 1. While this helps to create synergies and foster learning among institutions, an institution focused on the 'big picture' requirements for accelerating industrial decarbonisation remains lacking. The most far-reaching efforts of orchestration to date are undertaken by the G7, through IDA, and the Breakthrough Agenda, both of which explicitly aim to coordinate and advance international cooperation on industrial decarbonisation, including across MI, IDDI, LeadIT, FMC and the CEM (UNFCCC, 2021a; United Kingdom, 2021). Additionally, LeadIT aims to closely coordinate activities on standards and demand side measures together with IDDI, FMC, SteelZero and ConcreteZero. Among transnational institutions, WEF, ETC and MPP, among others, have served as platforms to coordinate and foster engagement across several other transnational initiatives and non-state actors. All in all, however, cooperation among international institutions is only starting to emerge and has so far mainly engaged with "narrower objectives that focus on just one specific part of the challenge" rather than the bigger picture (Agora Industry, 2022, p. 7). Accordingly, what remains missing is an institution that explicitly focuses on the 'bigger picture' requirements of accelerating the decarbonisation of EIIs and orchestrates existing efforts (Agora Industry, 2022; Oberthür et al., 2021b). Enhanced orchestration could especially benefit the coordination of technology development efforts or the harmonisation of standards.

3.8 Identification of Key Governance Gaps

The empirical analysis presented above demonstrates that the supply of global governance has significantly increased across all functions since the analysis by Oberthür et al. (2021b). At the same time, however, it also shows that the potential of global governance for the decarbonising EIIs continues to not be fully exploited, with governance gaps remaining across all functions. Concerning

signal and guidance room exists for an overarching and authoritative decarbonisation vision with regional and sectoral specifications. The supply of *rules for collective action* is only starting to emerge and efforts need to be significantly enhanced to accelerate the transition. Ongoing efforts on *transparency and accountability* need to be strengthened to ensure compliance with rules, political commitments and standards. The supply of *means of implementation* needs to be expanded through additional finance and investment at large scale and the focus on technology transfer and diffusion must be increased. In contrast, no major governance gaps regarding *knowledge and learning* were identified, but ongoing efforts should be continued given the complexity of the challenge at hand. Finally, to advance *orchestration* more focus needs to be put on the bigger picture requirements for the sectoral transition and better coordination of existing efforts regarding means of implementation as well as international rules, policies and standards.

At the same time, we observe significant differences in the supply of global governance across the different EIIs. A lot of focus is on steel and cement, with lesser attention given to aluminium and chemicals, as shown in Annex 1. The supply of global governance for the iron and steel industry includes procurement targets (IDDI, FMC, SteelZero), definitions (IEA, FMC, SteelZero), and technology development efforts (GLMCI, LeadIT). Regarding the cement industry, a common industry-backed pathways exist in form of the GCCA 2050 Roadmap (GCCA, 2021), and there is supply of procurement targets and related definitions (ConcreteZero, IDDI, IEA) as well as technology development (GCCA). Procurement initiatives and standards also exist for the aluminium industry (FMC, MPP), but we could not identify any international efforts on technology development. Finally, for the chemicals industry we could only identify meaningful governance supply regarding technology development (LCET), with the other governance functions being almost completely neglected. These differences in governance supply matter, because each industry has its specific challenges which ultimately need to be addressed to reach net zero emission EIIs by mid-century.

After having identified the remaining governance gaps, the next section now discusses options to address them. Given the space and resources available, the analysis thereby focuses on three key governance gaps, which are essential to address to accelerate the decarbonisation of EIIs globally. First, harmonised standards and demand-side policies are needed to provide incentives for producers to switch to low-emission production technologies. This can address barriers related to costs and the lack of a business case (Åhman et al., 2022). Second, advancing international rules and policies addressing global competition is needed to alleviate the competitive disadvantage of lower-emission basic materials and address carbon leakage concerns. Finally, expanding means of implementation is needed to accelerate the maturing and diffusion of near-zero emission basic material production technologies in this decade (Vangenechten & Lehne, 2022). Finally, on an overarching level, better orchestration of international institutions can create synergies and greater coherence of existing efforts and play an important role in advancing the transition (Agora Industry, 2022). While it will be necessary to eventually address all remaining governance gaps, focusing on these allows us to streamline the subsequent analysis and discussion.

4 Options for Enhancing Global Climate Governance for the Decarbonisation of EIIs

This section analysis concrete institutional options to advance the global governance of decarbonising EIIs. To analyse the potential of different institutional options we apply four assessment criteria, namely membership of the institution, institutional strength and capacity, legitimacy and authority, and political feasibility, which are described in more detail below. Based on these, we first analyse the potential of reforming existing institutions, which includes the scaling up of existing activities. Next, we analyse the potential of creating a new institution, which includes the fundamental reform of an existing institution, such as a significant change of its mandate or structure. Given the limited space available we thereby focus on the key governance gaps identified above.

4.1 Criteria for Assessing Institutional Options

The four assessment criteria to analyse the potential of different institutional options were derived from the literature on regime creation and the development of international institutions (e.g. Levy et al., 1995; Young, 1989) as well as on the creation of climate clubs (e.g. Åhman et al., 2022; Falkner et al., 2022; Marcu et al., 2022). While the criteria are applicable in general terms, different institutional requirements are needed to address the key governance gaps as outlined in Table 3.

First, *Membership of the institution* focuses on which actors are needed to address the governance gap in question. Given the global nature and high concentration of EII production, only a small number of actors is of key relevance here. Above all, this concerns the major emitters of industry emissions, such as China, US, EU, India, Russia, and Australia. The involvement of emerging economies with favourable structural conditions for near-zero emission EII production, such as South Africa, Saudi Arabia, Brazil or Indonesia can also be beneficial to advance decarbonization globally (see Saygin & Gielen, 2021; Trollip et al., 2022). Cooperation can start with a smaller number of ambitious members and grow over time and in some cases already unliteral or minilateral efforts can have a meaningful impact (see Table 3). Finally, while the involvement of countries is essential to advance global governance, the inclusion of relevant transnational institutions and actors can help to increase legitimacy and effectiveness of an institution, if appropriate and helpful to the aim (Åhman et al., 2022). For EIIs, this includes in particular multinational basic material producers but also existing industry and civil society organisations.

Institutional strength and capacity refers to the capacity, competence and expertise of an institution to address the relevant governance gap (Patt et al., 2022). This includes the institution's ability to ensure effective implementation and to promote and enforce compliance. Here, relevant aspects are organisational and political capabilities, financial and staff resources, economic performance, powers of decision-making and implementation (including for promoting or enforcing compliance), the degree of institutionalisation, and the existence of a permanent secretariat. The legal nature of the institution is also relevant, including the role of statutes/treaties, and the bindingness of obligations on members. Finally, we consider the potential of the institution to influence other international institutions and across the sectoral system at large, for example through activities such as technology transfer or financial support for low-carbon infrastructure (Patt et al., 2022).

Next, we consider the institution's *legitimacy and authority* as perceived by other actors, both in terms of process (input legitimacy) and in terms of outcome (output legitimacy) (Bäckstrand et al., 2018). This criterion is closely linked to the question of membership and distribution of resources and distribution of costs and benefits, in particular in a North-South context. This is especially relevant for

the governance of EIIs since basic materials production is dominated by industrialised countries as well as China and India, but demand is growing mainly in emerging economies. To achieve a high degree of legitimacy, international cooperation should thus contribute to an "increase in equity with respect to the costs, benefits, and burdens of mitigation actions, taking into account current and historical contributions and circumstances" (Patt et al. 2022, p. 13; see also Falkner et al., 2022). The consistency of the institution's actions with other relevant agendas or institutions is also considered, both, internally within the sector as well as externally with the wider UNFCCC process or the Sustainable Development Goals (SGDs) (Patt et al., 2022).

Finally, *political feasibility* assesses whether there is a realistic political chance and potential pathways for institutional reform or the creation of a new institution. One crucial aspect is whether there are sufficient incentives for the main actors whose cooperation or consent may be required. Another crucial aspect is the question of potential leaders or champions to drive forward cooperation (Young, 1989). When assessing options for institutional reform, we also consider the compatibility with the established objectives of the institution (as reflected in statutes), the prospect for agreement on institutional reform, and the potential for institutional rigidity or lock-in, such as consensus requirements. For the assessment of new institutions, we specifically consider linkages to existing institutions and venues as starting point, as well as existing pathways towards fully functional institutions.

Table 3: Criteria for assessing institutional options for key governance gaps

Governance Gap	Institutional requirements
Harmonised Standards	• Development of standards requires high technical expertise, but membership is less important • Standards can include equity considerations, e.g. differing benchmarks • For harmonisation, standard requires high authority to avoid existence of multiple/differing standards • Certification/Auditing requires high technical expertise and capacity, but can be carried out by different institutions
Demand-side policies	• Membership accounts for significant share of (potential) demand for basic materials • Capacity to enforce standard and finance 'green' premium by members • Equity concerns can arise if policies exclusively target industrialised economies
Carbon leakage & competitiveness	• Membership accounts for significant share of global EII market • Capacity to enforce rules vis-à-vis non-members • Can be perceived as protectionist • Potential concerns about compatibility with global climate and trade regime
Means of implementation	• Uni- and minilateral efforts can have impact, but broader membership is preferred, incl. emerging economies and countries with high low-emissions basic materials production potential. • Capacity to provide means of implementation, i.e. sufficient financial resources • Equity questions can arise if financing is limited to industrialised economies

Source: Åhman et al., 2022; Falkner et al., 2022; IEA, 2022a; Patt et al., 2022: Young, 1989

4.2 The Potential of Existing Institutions (incremental change)

This section analyses the potential of reforming existing international institutions to address the core governance gaps identified above. To do so, we apply the assessment criteria outlined above to the institutions identified in the empirical analysis. Given the available resources and space, this section synthesises the main findings of our analysis and does not consider each institution individually.

Advancing demand-side policies & harmonising definitions for near-zero emission basic materials

Considering the institutional requirements outlined in Table 3, we find that reforming existing institutions holds some potential to advance the supply of demand-side policies. However, a far-reaching harmonisation of standards by existing institutions seems politically unlikely. A new institution is better placed to facilitate coordination on the latter but can also support the former.

To advance the supply of demand-side policies, existing procurement efforts on steel, aluminium and cement can be expanded, both, in terms of membership and scope of financial commitments. As a matter of fact, FMC, SteelZero, ConcreteZero and IDDI are already actively working on increasing membership. Enhancement of state-led procurement efforts such as IDDI or MI holds particularly great potential and could, for example, be joined by all G7 and EU members (see Agora Industry, 2022). Given the already strong dynamic in this field, the enhancement of existing demand side efforts is not only politically feasible but seems likely. However, next to steel, aluminium and cement, it will be important to implement demand-side policies for basic chemicals as well. Here, the development of a new Breakthrough can be a good starting point, while IDDI, FMC, MI and MPP can expand their work towards EIIs not yet covered as well. Finally, government-led institutions like MI, CEM, or IDDI hold the potential to serve as fora to coordinate demand-side policies in theory, given that their membership account for a significant share of global basic material demand (see Annex 1). However, currently none of these institutions is planning to pursue this, and it is questionable whether this will be politically feasible. G7-IDA or the climate club might be better placed to pursue such efforts.

As mentioned above, the existence of different competing standards for near-zero basic materials should be avoided to ensure coherence and transparency (IEA, 2022a). However, a far-reaching harmonisation of standards does not seem politically feasible in the current institutional setup. While several institutions are working towards elaborating new standards or harmonising existing ones, neither of these has required legitimacy or authority to foster universal acceptance of a given standard. Nevertheless, the IEA standards on steel and cement might be a promising champion in this regard, given that the IEA holds high technical expertise and that they have been endorsed by IDDI (see IEA, 2022a). In the short term, a group of like-minded countries such as the G7, G20, or Breakthrough Agenda can set (or develop in the case of aluminium or basic chemicals) a respective standard, with a view that others will follow suit. However, an institution with broader membership might be better placed to pursue this work, such as WTO, UNFCCC or a new institution, given that agreement within the first two seems politically unlikely. Finally, next to the development of standards, it will be essential to enhance the needed certification capacity for its enforcement, here existing institutions, such as ResponsibleSteel, national certification services and planned efforts (e.g. IDDI) provide a good starting point.

Addressing Competitiveness & Carbon Leakage

Applying the criteria outlined in Table 3, we find that reforming existing institutions is not sufficient to address competitiveness and carbon leakage barriers. Albeit some promising starting points such as the G7 Climate Club, the EU-US Carbon-based Sectoral Agreement and EU CBAM exist, these only

include industrialised countries, raising questions regarding legitimacy and acceptance are still undergoing negotiations. Accordingly, to meaningfully address this gap these would either have to be fundamentally reformed or a new institution would have to be created. The G7 Climate Club is the most promising emerging institution to address carbon leakage at the international level. G7 members represent a significant share of global EII production and demand and further host most of the current breakthrough technology demonstration projects (IEA, 2022a; Hermwille et al. 2022). They further possess sufficient resources and means to enforce binding rules. However, although the Club aims to explicitly involve non-G7 countries, strongly G7 driven international rules are likely to raise legitimacy concerns, in particular regarding equity and compatibility with the UNFCCC regime and WTO rules. Additionally, and not negligible for the analysis, the design and purpose of the G7 Climate Club remain unclear as negotiations are still ongoing, with terms of reference only to be expected by the end of 2022.

The planned EU CBAM presents the most advanced effort to address international carbon leakage to date but faces similar political and equity challenges. It is also still being negotiated and will not be in force before 2025 (European Parliament, 2022). Regarding membership, the EU accounts for a significant share of global basic materials production and demand, but it does not foresee the inclusion of non-EU/EEA members. The EU has the capacity to negotiate and enforce binding rules domestically and vis-à-vis third countries. additionally, while it has certainly sparked an international debate on carbon leakage debate, CBAM is primarily designed to address the issue of carbon leakage within the EU and has been perceived as protectionist and not in line with WTO rules. It therefore currently does not provide an option to address carbon leakage from a global governance perspective but could nonetheless be a point for international cooperation on carbon pricing among like-minded countries (Falkner et al 2022; Mehling et al., 2022). Similarly, the still-being-negotiated EU-US Carbon-based Sectoral Agreement is another interesting option to coordinate trade measures addressing competitiveness and carbon leakage of EIIs. However, details on design remain vague and it faces similar legitimacy concerns as the G7 Climate Club and EU CBAM. Especially, since its main objective is to address competitiveness and oversupply issues, with climate concerns only being of secondary nature (see United States, 2021).

LeadIT, MI, CEM and IDDI have interesting membership to address this gap in theory, in that they comprise industrialised and developing countries accounting for a significant share of the basic material market (see Annex 1). However, given their current focus on technology development, catalysing investment and demand creation neither has the political mandate nor the institutional capacity to meaningfully address competitiveness and carbon leakage. Finally, the UNFCCC would be a great place to address this gap, given its universal membership and high degree of authority and legitimacy. However, given the requirement for unanimity for decision-making, it is politically unlikely that these issues will be considered there in the near future. Likewise, the **WTO**, which would be the natural institution to address trade and competition-related issues, has been plagued by institutional gridlock for many years and further requires unanimity in decision-making.

Acceleration of technology development and diffusion and infrastructure development

Existing institutions hold great potential to advance the provision of means of implementation globally, without much need for far-reaching reforms. Given the complexity of the landscape, the sheer scale of the challenge at hand and the limited time available a new institution focused on orchestrating and coordinating existing efforts would nonetheless be beneficial to advance global governance. A new institution could also foster technology diffusion or support for the development of required infrastructure.

To advance the development of breakthrough technologies, existing efforts can be scaled-up through increasing allocated finance and investment and by expanding respective membership. Government-backed institutions such as LeadIT or MI hold the highest potential to significantly increase financial means. However, also transnational (e.g. Breakthrough Energy) and company-led institutions (e.g. LCET) hold have potential to mobilise further resources and drive technology development. What is key here is that efforts are expanded to the chemicals and aluminium sector, which have so far received less attention and funding for technology development. Industrialised countries can provide leadership on technology diffusion to emerging economies, either bilaterally or through country-led institutions such as LeadIT, MI, IDA or the G7 Climate Club. Explicit financing for technology diffusion thereby provides a good window of opportunity for G7 countries to showcase leadership and willingness to invest in a global (and not just western) industrial transition – which might also help to increase the legitimacy of industrialised country projects such as the Climate Club or CBAM (IEA, 2022). Similarly, government-led institutions such as G7, G20, MI or CEM can establish bi- or minilateral strategic investment partnerships with emerging and developing economies, similar to the G7 JETPs, to support the development of infrastructure required for the implementation and diffusion of breakthrough technologies.

To increase the availability of finance for the development and diffusion of near-zero emission production technologies, multilateral financial institutions and bilateral donors of international climate finance can phase out financing for non-decarbonised or high-carbon EII facilities. For example, through a moratorium on re-investing into new facilities above certain emission intensity benchmarks (Hermwille et al., 2022), or the requirement that investments in conventional technologies must be retrofit-ready, to ensure new technologies can be swiftly implemented once there are available on the market (IEA, 2022a). Finally, these efforts can be supported by high-level coordination and knowledge sharing to exploit synergies. For example, established institutions with large analytical capacity such as the IEA and UNDIO can regularly review global progress on technology developments (e.g. IEA, 2021; 2022b), while transnational institutions such as, WEF, MPP, LCET, or CET can serve as platforms to coordinate non-state actors on the development of breakthrough technologies. The beforementioned governance options can easily be implemented since the relevant institutions have the needed capacity to administer investments and are not subject to complex decision-making structures. In terms of legitimacy, international cooperation on technology development and diffusion is perceived as rather uncontroversial, in particular, if equity concerns are addressed (Patt et al., 2022).

Conclusion – the potential of reforming existing institutions

To sum up, reforming existing institutions holds great potential to address gaps related to demand-side policies, technology development, and (to a lesser extent) technology diffusion. We find that is in particular true for the government-led initiatives IDDI (and CEM in broader terms), MI, LeadIT and G7-IDA, for several reasons. All of these initiatives explicitly aim at accelerating the decarbonisation of EIIs but focus on different aspects of the transition and thereby nicely complement each other. As shown in Annex 1, they have overlapping membership and comprise relevant industrialised and developing economies accounting for a significant share of global EII supply and demand. Furthermore, these institutions have the capacity needed to carry out their governance supply, which includes dedicated staff and resources and backing by governments that can provide financial resources at large-scale. Finally, given their focus on specific issues of the transition and lower degree of institutionalisation, they are flexible enough to be further developed in terms of the scope of activities and size of membership. Taken together, they thus provide a very promising starting point to advance global governance. At the same time, however, reforming existing institutions does not allow to significantly

advance global governance on issues of competition and carbon leakage, but also to enhance high-level orchestration. Reforming existing institutions with theoretical potential to address these gaps is either not politically feasible (e.g. UNFCCC, WTO) or would require significant changes to their mandate and purpose. We, therefore, conclude that a new institution is needed to fully exploit the potential of global governance and advance on the key governance gaps identified.

4.3 Towards a New International Institution

The previous section found the creation of a new institution is needed to address global competitiveness and carbon leakage, the harmonisation of standards and enhance technology diffusion, while it can also help to address the other key governance gap. This section, therefore, analyses the creation of a new institution focused on accelerating the global decarbonisation of EIIs in this decade and beyond, for example an International Industry Decarbonisation Alliance. The remainder of this section discusses the new institution's potential governance supply and analyses how it would need to fulfil the four assessment criteria. The analysis presented takes into account recent policy proposals on international cooperation on industrial decarbonisation (Agora Industry, 2022; Åhman et al., 2022; IEA, 2022a; Hermwille et al., 2022; Vangenechten & Lehne, 2022) and can inform the current political discussion on creating a climate club focused on industry decarbonisation.

Main Objective & Supply of Governance Functions

The main purpose of the new institution is to serve as a global platform for cooperation to accelerate the global decarbonisation of EIIs by orchestrating existing efforts and enhancing international cooperation on the key governance gaps. Primarily the institution should aim to provide global governance on (1) means of implementation for technology development and diffusion, as well as rules on (2) the harmonisation of standards and certification, (3) demand-side policies, and (4) cooperation on global competition and carbon leakage. It should thereby strive to not duplicate existing governance efforts but instead orchestrate, coordinate and complement these. In doing so, it can become the focal point of global sectoral governance and play a key role in advancing the global transition of EIIs. In the following, we sketch out the potential governance supply of the new institution, which, taken together, can constitute the institution's 'carrot' or 'club good' (Berglas, 1976; Falkner et al., 2022).

First, to advance means of implementation, the institution can provide financial resources at large scale to accelerate the development of breakthrough technologies and their global diffusion. Investments should best exploit existing windows of opportunity, such as planned major refurbishments of facilities or focus on regions with favourable framework conditions to build new global supply chains for green materials (Trollip et al., 2022). Means of implementation efforts can also include financing for the development of supporting infrastructure or decarbonisation of energy systems in emerging economies, for example through JETPs, or the facilitation of capacity building and training, knowledge exchange and stakeholder collaboration. Provided that access to finance and commonly developed (or financed) technologies is exclusively available for members, the facilitation of such means of implementation comprises a key 'carrot' for countries to join the institution. This might be particularly interesting for countries that are unable to finance such investments alone but could greatly benefit from new green supply chains, such as emerging and developing economies with the potential to produce near-zero emission basic materials at low costs (e.g. South Africa, see Trollip et al. 2022).

Second, the new institution can facilitate the harmonisation of standards and methodologies for near-zero emission basic materials and provide certification capacity (see IEA, 2022). The institution can either adopt appropriate existing standards or develop new ones in cooperation with institutions with

high technical expertise such as IEA or ISO. Once set, the standard can be applied throughout the institution's governance activities, such as demand-side policies or finance for technology development. Provided its membership accounts for a sufficiently large share of global EII production and demand, the institution can thereby become a primary rule-setter, potentially also influencing other international institutions and initiatives as well as other countries and transitional actors. Taking part in driving the harmonisation of applicable standards, labels and certification early on offers members the opportunity to set the pace and direction of the global transformation of EIIs.

Third, the institution can facilitate cooperation on demand-side policies to foster global demand for near-zero emission basic materials. On the one hand, it can support existing demand-side efforts (see Section 3) and push forward reforms as suggested in Section 4.2. On the other, it can serve as a forum for members to coordinate national demand-side policies, for example through the application of a harmonised standard as discussed above. Taken together, this can create a global market for 'green' basic materials, which could be exclusively accessible to members of the institution. Being part of this market reduces investment risks for industrial companies, enabling them to switch production routes and to become pioneers of EII decarbonisation and reap the benefits that come with it (Åhman et al., 2022). Fourth, in the medium- to long-term, the institution can also address challenges related to international competition and carbon leakage, by serving as a forum to establish common policies to level the playing field vis-à-vis non-members. For example, by coordinating existing carbon pricing policies across its members or exploring the development of common external carbon border adjustments (CBAs) (Marcu et al., 2022; Mehling et al., 2022).

Finally, the institution can orchestrate activities of other relevant institutions and initiatives. While this does not benefit members exclusively, it is vital in accelerating the global transition of EIIs and creating synergies across existing activities. The institution can regularly review the state of the sectoral transformation to highlight remaining barriers and possible ways to address them, similar to the recent Breakthrough Agenda Report (see IEA, 2022b). Next to that, the new institution can involve existing institutions in its work programme to create synergies and learning, including intergovernmental (e.g. IDDI, LeadIT, MI) as well as transnational institutions (e.g. LCET, MPP, FMC).

Institutional requirements

To be able to supply the above-mentioned governance functions the institution would need to fulfil certain requirements regarding the criteria of membership, institutional strength and capacity as well as legitimacy and authority, as outlined in Table 3.

First, to have a transformative effect on the sector at large its members should account for a significant share of global EII production and demand. Ideally, this includes major EIIs producers and consumers but also emerging and developing countries, in particular those with rising demand or favourable framework conditions such as Brazil, South Africa, Indonesia or Saudi Arabia. The explicit involvement of such countries can help to advance its legitimacy and acceptance (see Table 3). The institution, however, can start with a smaller group of ambitious countries and grow over time, if it initially focuses on 'softer' governance issues of definitions, demand-side policies or means of implementation. While primarily focused on countries, the institution can be open to other relevant actors, for example as observers, such as international initiatives, transnational organisations or private EII companies (Falkner et al., 2022). In particular the involvement of the latter can be beneficial as they are key actors in the development of breakthrough technologies. Finally, membership should be open to all interested parties but linked to clear criteria, for example a political commitment to achieve net-zero EIIs by 2050 or the inclusion of an industry sector reduction target in the next NDCs. Openness and a

clear path to membership not linked to political considerations by current members are key to enhance the legitimacy and acceptance of such an institution.

The degree of institutional strength and capacity needed depends on the governance the institution will ultimately supply, as shown in Table 3. While the harmonisation of standards, demand side policies and means of implementation can be conducted in an ad-hoc forum, the administration of direct financing or common policies requires a more institutionalised permanent and some degree of bindingness (IEA, 2022a). Accordingly, the institution requires some common rules and degree of institutionalisation from its start, also to provide for possible policy ' lock-in' or 'spillover' effects, but these can be deepened over time as the institution grows and evolves. In addition to that, the institution requires substantial financial resources to supply the abovementioned means of implementation. Industrialised countries can provide the lion's share thereof, which will help to address equity concerns. In the longer term, other sources of income are imaginable as well, for example the channelling or orchestration of existing public and private financial flows (e.g. IDDI, LeadIT, JETPs, BE). Finally, the institution requires a permanent secretariat or technical support unit to manage its day-to-day activities, provide capacity building and conduct progress reviews and ensure continuity (IEA, 2022a). The support unit can potentially be hosted by an existing international organisation such as UNIDO or OECD provided that it has designated financial and personnel resources.

Finally, the institution requires a high degree of legitimacy and authority to provide effective governance and become the new focal point of the sectoral landscape. Above all, it must be perceived as a vehicle to advance the transition globally and not as a 'protectionist' project of industrialised countries. To avoid the latter, involvement in the deliberations on its purpose and institutional design should be as inclusive as possible from the start, explicitly targeting interested emerging producers and countries from the Global South. Finally, coherence with the existing international climate policy regime (i.e. UNFCCC/PA) is essential and the creation of parallel or rivalling structures is to be avoided. Aligning its objectives and activities with those of the UNFCCC and the sustainable development agenda is therefore important.

Political feasibility – the road towards a new institution

Creating such a new international institution is an ambitious endeavour, but we find it politically feasible given the strong sectoral dynamic, political leadership by the G7, and the provision of short-term tangible benefits.

To start with, interest in stronger international cooperation on the decarbonisation of EIIs appears politically feasible given the strong sectoral dynamic and already far-reaching participation in relevant institutions by key EII producers beyond the G7 and EU. As shown in detail Annex 1, India (member of IDDI, LeadIT, MI and Steel Breakthrough), South Africa (Member LeadIT and MI, JETPs with G7) and Indonesia (JETPs with G7), or Brazil (member of MI), are already quite active in the global governance landscape and could potentially be interested in further cooperation. These countries and members of existing decarbonisation initiatives such as MI, IDDI, LeadIT, and the Breakthrough Agenda are likely potential members of a new institution and together account for a sizeable share of global EIIs supply and demand.

The G7 provide can political leadership for advancing international cooperation, which it has already demonstrated it is willing to do with its proposed climate club. The G7 alone represent a sizeable share of EIIs and its members have sufficient political and financial resources to champion the creation of a new institution, albeit their current proposal falls short on several aspects as discussed above. The G7 can use this political momentum but open up the discussion on potential design and activities towards

other interested countries and non-state actors, under the explicit condition of equal participation in the deliberation and decision-making process or by offering the co-chair to a non-G7 country.

The key question will be whether the potential governance supply described above provides sufficient incentives to convince these and other countries to join the creation of the new institution. Large-scale finance for technology development and implementation provided by industrialised countries, exclusive infrastructure development partnerships and access to lead markets in industrial countries can be the key package of 'carrots' to incentivise membership. Beyond that, the possibility to shape the global transition of EIIs in terms of harmonising standards, common policies and coordination on carbon pricing measures can be an important incentive. These club goods would stand, at least initially, against relatively low-key obligations, for example the requirement to adopt the harmonised standard or label across national policies, as discussed above.

Finally, the new institution can prioritise cooperation on politically less contentious issues that nonetheless provide tangible and timely benefits to its members. It could employ a stepwise approach, prioritising financing of breakthrough technologies, the harmonisation of standards or coordination of demand-side policies. This would provide short-term tangible benefits for members but does not necessarily require a high degree of formal institutionalisation or permanent rules. In contrast, discussion on measures to address issues of competitiveness and carbon leakage vis-à-vis non-member can be left for a later stage. Such an approach has the benefit that it provides sufficient time for the institution to develop and institutionalise before the more difficult challenges are addressed.

5 Conclusion

This article identified and analysed institutional options to advance the global governance of the decarbonisation of EIIs by addressing remaining global governance gaps. To do so, we first determined the potential of international cooperation to address major barriers to the decarbonisation of EIIs across six governance functions international institutions can supply. We then empirically analysed the existing supply of global governance. We find that the supply of global governance has increased significantly across all functions with particularly noteworthy developments on demand-side policies (rules function) as well as means of implementation including targeted financing for technology development. Additionally, several new international institutions that focus specifically on the decarbonisation of EIIs have emerged over the past years. Nevertheless, significant key governance gaps remain. These include the need to harmonise existing standards and methodologies for near-zero emission basic materials, a lack of international demand side policies and a lack of international policies or rules to address carbon leakage as well as further enhance the supply of means of implementation. Additionally, we observe strong differences across the global governance on the different EIIs, with much focus on steel and cement and little attention on chemicals and aluminium.

Reforming existing institutions hold some potential to address these key barriers and advance global governance, in particular regarding the implementation of supply-side policies as well as cooperation on technology development and diffusion. However, existing institutions lack the necessary legitimacy and membership to address barriers related to the harmonisation of standards and global competitiveness and carbon leakage. Addressing this issue hence requires the creation of a new institution, which can also help to advance governance on the other gaps. To fully exploit the potential of global governance, we therefore suggest the creation of a new institution focused on advancing international cooperation on decarbonising EIIs. Such an institution could primarily focus on high-level orchestration of existing activities as well as on the harmonisation of standards, demand-side policies, enhancing the provision of means of implementation and addressing competitiveness and carbon leakage. Such a new institution can build on the G7 Climate Club proposal but should go beyond that towards more inclusivity and an initial focus on ‘softer’ governance activities. The provision of finance for the development and diffusion of breakthrough technologies, access to lead markets as well as the ability to drive the global transition of EIIs can comprise the key incentives for countries to join. Given their already strong involvement in the sectoral governance landscape the key (emerging) EII producers India, South Africa, Indonesia and Brazil could potentially be convinced to join the creation of the new institution, next to the G7 members.

Finally, it is to be noted that the finding and recommendations presented in this paper are subject to several limitations. The empirical analysis only provides a snapshot of global activities relevant to the decarbonisation of EIIs. Future research should therefore continue to observe the development of the sectoral landscape but could also seek to uncover the underlying political dynamics of international cooperation on EIIs. Additionally, while differences across the specific industries were considered in the analysis, the space available did not allow for an in-depth discussion thereof. Nonetheless, as indicated in our analysis, significant differences regarding decarbonisation barriers and the supply of global governance exist across the different EIIs. Further research should focus on the specific challenges faced by the steel, cement, basic chemicals and aluminium industries, but also other EIIs not considered here.

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Annex 1 – Inventory of International Institutions Relevant to the Decarbonisation of EIIs

This Annex contains the inventory of international institutions that were identified as relevant to the decarbonisation of energy intensive industries (EIIs). The inventory includes include formal international and transnational institutions and initiatives, given that they meet certain conditions:

- Are active at international level and realise the common purpose of decarbonising EIIs.
- Contribute actively to at least one of the six governance functions.
- Have dedicated resources, rules governing membership, and are of a lasting nature.

The analysis is based on comprehensive desk research conducted by the authors between February and September 2022. The work of Oberthür et al. (2021b) and Khandekar et al. (2018) was taken as a starting point and triangulated with other existing analyses and secondary literature (IEA, 2022a; Agora Industry, 2022; Future of Climate Cooperation, 2022). Interim results were discussed with relevant stakeholders at two occasions under the NDC ASPECTS Project.[2]

** Indicates announced, planned or future activities that have not yet been implemented.*

Institution	Membership	Sectoral Focus
Intergovernmental Institutions		
UN Framework Convention on Climate Change (UNFCCC) & Paris Agreement (PA)	Universal	Cross-cutting
UN Industrial Development Organization (UNIDO)	Near universal	Cross-cutting
UN Environment (UNEP)	Near universal	Cross-cutting
World Bank Group (WBG) & Multilateral development Banks (MDBs)	Near universal / regional	Cross-cutting
Organisation for Economic Co-operation and Development (OECD)	38 countries, mainly industrialised	Cross-cutting & Steel
International Energy Agency (IEA)	Most OECD countries (31 countries)	Cross-cutting & all EIIs
World Trade Organization (WTO)	Near universal	Cross-cutting
G7, *incl. G7 Industrial Decarbonisation Agenda (IDA)*	CA, FR, DE, IT, JP, UK, US (+EU)	Cross-cutting
G20	AR, AU, BR, CA, CN, FR, DE, IN, ID, IT, JP, KR, ME, RU, SA, ZA, TR, UK, US, EU	Cross-cutting
Intergovernmental Initiatives		
*G7 Climate Club (CC)	G7 countries + pot. others	Cross-cutting
Mission Innovation – Net Zero Industry Mission (MI)	Industry-mission[3]: AT, AU, CN, EU, FI, DE, UK.	Cross-cutting
Clean Energy Ministerial (CEM)	29 countries accounting for 90% of global clean energy investments, incl., among others, AU, BR, CA, CL, CN, EU, DE, IN, ID, JP, NO, RU, SA, ZA, KR, ES, SE, UAE, UK, US	Cross-cutting
Industrial Deep Decarbonisation Initiative (IDDI)	UK, IN, DE, CA, UEA, US, SA	Steel & Cement
Breakthrough Agenda (BA)	Endorsed by 30 countries incl. AU, BE, CA, EU, FR, DE, IN, JP, NO, NA, KR, SE, TR, UK, US	Steel
EU-US Carbon-based Sectoral Agreement (CBSA) on Steel and Aluminium Trade	EU, US	Steel & Aluminium

[2] See Khanderkar, G,. Obergassel, W., Xexakis, G. (2022). *First Sectoral Conversation on Industry on 1/2 December 2021*. NDC Aspects. http://www.ndc-aspects.eu/blog/first-sectoral-conversation-industry-12-december-2021

[3] Members of Mission Innovation are AU, AT, BR, CA, CL, CN, DK, FI, FR, DE, IN, IT, JP, MO, NL, NO, KR, SA, SE, UAE, UK, US, EU.

Institution	Membership	Sectoral Focus
Hybrid Initiatives incl. state and non-state actors		
Leadership Group for Industry Transition (LeadIT)	AR, AU, AT, DK, ET, FI, FR, DE, IN, IE, JP, LU, NL, KR, ZA, SE, UK, US + private companies	Cross-cutting
First Movers Coalition (FMC)	55+ companies, incl. EII purchasers; US & WEF	Steel, Cement, *Chemicals, *Aluminium
Transnational Institutions		
Global Cement and Concrete Association (GCCA)	Companies accounting for 80% of global concrete industry outside China	Cement
Concrete Sustainability Council (CSC)	International association initiated by WBCSD. Supported by GCCA.	Cement
World Cement Association (WCA)	Various cement producers, also represent companies across wider value chain, including specialist engineering firms, equipment suppliers and technology providers.	Cement
International Council of Chemicals Association (ICCA)	Companies accounting for 90% of global chemicals sales	Chemicals
International Aluminium Institute (IAI)	Companies, accounting for 60% of global bauxite, alumina, aluminium production	Aluminium
World Steel Association (WSA)	Companies accounting for 85% of global steel production	Steel
ResponsibleSteel (RS)	Non-profit; business & CSO members	Steel
Energy Transition Commission (ETC)	Global coalition of energy landscape leaders	Steel, Cement & Chemicals
Mission Possible Partnership (MPP) *Incl. sector specific initiatives.*	Alliance of corporate 'climate leaders', incl. nearly 300 corporate partners. Led by ETC, RMI, We Mean Business Coalition, WEF	Steel, Cement & Chemicals
World Economic Forum (WEF)	Non-profit on public-private cooperation	Cross-cutting
International Standardisation Organisation (ISO)	composed of representatives from national standards organizations of member countries	Cross-cutting, Steel & *Cement
Transnational Initiatives		
Low-Carbon Emitting Technology Initiative (LCET)	10+ chemical companies & WEF, MPP	Chemicals
*Global Low Carbon Metallurgical Innovation (GLCMI) Alliance	60+ companies from 15 countries, research institutions, led by Baowu Steel (China)	Steel
SteelZero *by the Climate Group*	private company members, Initiative by Climate Group	Steel
ConcreteZero *by the Climate Group*	private company members, Initiative by Climate Group	Cement
Breakthrough Energy (BE)	Network of private funds, philanthropies, non-profits	Cross-cutting
Science Based Targets initiative (SBTi)	partnership between CDP, the United Nations Global Compact, WRI and WWF	Steel, Cement, Chemicals, Aluminium

**Initiatives have to date been announced but not yet implemented*

Annex 2 – Supply of Global Governance by International institution

This Annex contains the detailed analysis of the global governance relevant to the decarbonisation of energy intensive industries (EIIs). For each of identified international institutions it lists relevant contributions to the six governance functions, if applicable. The analysis is based on comprehensive desk research conducted by the authors between February and September 2022. The data was compiled from institution's websites and relevant outputs such as reports, statements, or treaties. The work of Oberthür et al. (2021b) and Khandekar et al. (2018) was taken as a starting point. The empirical data was complemented and triangulated with other existing analyses and secondary literature (IEA, 2022a; Agora Industry, 2022; Future of Climate Cooperation, 2022) and discussed with relevant stakeholders at two occasions under the NDC ASPECTS Project.[4]

* Indicates announced, planned or future activities that have not yet been implemented.

Institution	Function	Supply of Governance
UN Framework Convention on Climate Change (UNFCCC) & Paris Agreement (PA)	Signal	〉 PA objectives, incl. 2°C/1.5°C target, phase out of net GHG emissions by mid-century, and alignment of financial flows with PA objectives, provide general guidance. 〉 The Climate Action Pathway (CAP) for industry**,** developed under the MPGCA, sets out a sectoral vision/pathway for achieving carbon neutrality and SDGs by 2050, with specific focus on EIIs. Includes recommended actions for 2021, 2025, 2030 and 2040. 〉 *2030 Breakthroughs*, derived from CAP, provide sector specific goals for aluminium, CCUS, cement and concrete, chemicals, plastics, steel, green hydrogen and CCUS networks serving heavy industry for private actors. Part of *Race to Zero.*
	Rules	〉 Parties are required to regularly submit/update national medium-term climate action plans (NDCs) and long-term strategies (LTS). Sector specific targets are not required and therefore often not included in NDCs. 〉 2021 Glasgow Climate Action Pact calls upon parties to accelerate efforts towards the phasedown of unabated coal power and phase out of inefficient fossil fuel subsidies.
	Transparency	〉 *UNFCCC/PA enhanced transparency system* requires Parties to provide transparency on national emissions, measures taken, and their impacts in form of national emission inventories, national communications, and international reviews. The emission inventories include industrial emissions as such, but not for specific EIIs (2018;2021) 〉 *Global Stocktake (GST)* provides for a 5-yearly global review of climate action and progress towards PA and can catalyse more ambitious climate action across the entire global climate regime, but does not have strong sectoral focus to date (2018)
	Means	〉 Commitment of industrialised countries to provide international climate finance. 〉 Finance for projects and programmes on decarbonisation of EIIs in developing countries, through *Green Climate Fund* and *Global Environmental Facility.* 〉 Technology diffusion through the UNFCCC Technology Mechanism operated by *Climate Technology Centre and Network (CTCN)*, with projects steel and cement.
	Knowledge	〉 *Global Stocktake (GST)* reviews progress towards PA and can highlight best practices and remaining gaps and barriers. 〉 Technology Executive Committee provides relevant analysis on policy options and technologies for a variety of sectors including energy efficiency and carbon capture. 〉 Climate Action Pathway for industry offers policy guidance and showcases particularly successful initiatives by non-state and subnational actors.
	Orchestration	〉 *Race to Zero* rallies non-state actors to take rigorous and immediate action to halve global emissions by 2030, incl. specific membership requirements.
UN Industrial Development Organization (UNIDO)	Means	〉 Financing for limited project support on resource and energy efficiency and cleaner industrial processes (Oberthür et al., 2021b). 〉 Technology development, transfer, demonstration, and upscaling in industry sector, including for EIIs (Oberthür et al., 2021b). 〉 Capacity building on industrial energy efficiency and renewable energy application 〉 *Global Partnership for Hydrogen in industry* provides technical cooperation to promote the industrial application and up take of green hydrogen, through design and implementation of national industrial green hydrogen roadmaps and pilot projects.

[4] See Khanderkar, G,. Obergassel, W., Xexakis, G. (2022). *First Sectoral Conversation on Industry on 1/2 December 2021*. NDC Aspects. http://www.ndc-aspects.eu/blog/first-sectoral-conversation-industry-12-december-2021

Institution	Function	Supply of Governance
	Knowledge	〉 Data, analysis, technical guidelines and reports on low-carbon strategies in industry 〉 General knowledge sharing platform for members, incl. *Vienna Energy Forum* or *Global Partnership for Hydrogen in Industry*.
	Orchestration	〉 *Industrial decarbonization accelerator,* network of international initiatives working to accelerate shift of industrial organizations away from fossil-fuels, focusing on energy efficiency, uptake of renewables and alternative fuels, and heavy industry (see IDDI). 〉 Facilitation of country-to-country collaboration, including in a south-south context.
UN Environment (UNEP)	Means	〉 Financing of research on low-carbon strategies in EIIs (2021) 〉 Capacity building on developing laws, best practices and case studies for industrial efficiency with policy makers and stakeholders. 〉 *Climate Technology Centre & Network (CTCN)* facilitates transfer of climate technologies to developing countries through technical assistance, including projects on EIIs (e.g. cement) or energy efficiency.
	Knowledge	〉 Research, analysis and data on low-carbon strategies in EIIs. 〉 CTCN creates access to information and knowledge on climate technologies and fosters stakeholder collaboration
World Bank (WB) & MDBs	Rules	〉 *World Bank* guidelines for emission levels for provision of WBG assistance (2018) 〉 *European Investment Bank Group* aims to align financing activities with the principles and goals of PA by the end of 2020.
	Means	〉 *Climate Investment Funds (CIF)*[5] *Industry Decarbonisation program* aims to 'transform the carbon-emissions pathway of EII-sectors in developing and emerging countries' across multiple levels (industrial facility, technology, corporate, sectoral, and national). 〉 *CIF Clean Technology Fund (CTF)* provides large-scale finance for clean technology projects in low- and middle-income countries, incl. on industrial energy efficiency'. 〉 *World Bank* financed numerous projects targeting EIIs in developing countries, e.g. on energy efficiency, heat recovery, waste reduction. 〉 *EIB* finances technology development projects on EIIs. 〉 *World Bank* provides capacity building (2018) 〉 *World Bank & other MDBs* have extensively funded fossil fuel projects globally.
	Knowledge	〉 *World Bank* provides relevant data, analysis and best practices. 〉 *World Bank* provides Stakeholder dialogues 〉 *World Bank* issued technical Environmental, Health, and Safety (EHS) guidelines for the energy intensive sector.
Organisation for Economic Co-operation and Development (OECD)	Rules	〉 *OECD steel committee* provides forum for members to address global challenges facing the steel industry. However, with little focus on decarbonisation so far.
	Means	〉 Clean Energy Finance and Investment Mobilisation programme helps emerging economies strengthening their domestic enabling conditions to attract finance and investment in clean technologies, including for industry.
	Knowledge	〉 Analysis on decarbonisation of industry. 〉 Steel Committee provides data on Steel Market Developments, steelmaking capacity, and environmental performance, incl. Steel – Energy Efficiency Database.
International Energy Agency (IEA)	Rules	〉 Development of standards, definitions and benchmarks for near zero emission steel and cement on behalf of the G7 (IEA, 2022a).
	Means	〉 *Industrial Energy-Related Technologies and Systems Technology Collaboration Programme (IETS TCP),* fosters international co-operation for accelerated research and technology development, incl. for EIIs such as steel. 〉 IEA implementing agreements have provided framework for sharing research on breakthrough technologies, building pilot plants, and carrying out deployment or demonstration programmes along any technology-related activity in EIIs.

[5] Multilateral climate finance partnership that channels finance through six MDBs. The CIF implementing partners are the World Bank Group, including the International Finance Corporation, the African Development Bank, the Asian Development Bank, the European Development Bank, and the Inter-American Development Bank.

Institution	Function	Supply of Governance
		〉 Works with governments to develop effective, realistic, and well-integrated low-carbon climate and energy policies and strategies in the energy intensive sector (2018)
	Knowledge	〉 Analysis and data on technology development, incl. Industry-specific analysis on specific reports on aluminium, cement, chemicals, iron and steel, hydrogen etc. 〉 Analysis of policy options for mitigating EIIs, incl. on international cooperation. 〉 Analysis, data and modelling on global energy transition, incl. energy policy database and global roadmap to net zero emissions by 2050. 〉 Knowledge exchange and stakeholder collaboration, e.g. through workshops with EII stakeholders or IEA implementing agreements
World Trade Organization (WTO)	Rules	〉 WTO rules constrain countries to apply policy measures addressing carbon leakage.
G20	Rules	〉 Pledged to phase out of (inefficient) fossil fuel subsidies at 2021 leaders summit. 〉 Agreement on anti-dumping measures to cut overcapacity in steel sector in 2017
G7 *Incl. G7 Industrial Decarbonisation Alliance (IDA)*	Signal	〉 Commitment to reach net-zero emissions by 2050, half collective emissions by 2030, decarbonise power sectors by 2035, and align financial flows with goals of PA at 2022 leaders summit. 〉 Development of industrial transition plans and policies, including clear objective and joint action under *IDA*.
	Rules	〉 Pledged to phase out new direct government support for international fossil fuel energy in 2021 and to eliminate inefficient fossil-fuel subsidies by 2025 in 2022. 〉 *Development of Demand-pull policies for near zero emissions materials production with guaranteed long-term support under *IDA* 〉 *standards & definitions for near zero emissions materials production under *IDA* (see IEA, 2022a). 〉 Agreed to establish *climate club* by end of 2022 to support implementation of PA 'by accelerating climate action and increasing ambition, with a particular focus on the industry sector, thereby addressing risks of carbon leakage for emission intensive goods.' Based on three pillars [see also full assessment below]: - (1) advancing climate mitigation policies - (2) transforming industries - (3) boosting international ambition
	Means	〉 *Finance for near zero emission demonstration projects for industrial production technologies under *IDA*. 〉 *Finance mechanism for technology deployment and associated infrastructure to support transition in emerging and developing economies under *IDA*, incl. finance strategies to contribute to phase out financing for high-emission technologies, contribution to international finance mechanisms, and help coordinate work on industry. 〉 Support for decarbonising energy systems under *Clean and Just Energy Transition Partnerships (JETP)*. JETP in place with SA. JETP announced with ID, ID, SN, VN. 〉 *Partnership for Global Infrastructure and Investment* in 2022, with aim to mobilize $600 billion by 2027 in global infrastructure investments in low- and middle-income countries, incl. for 'tackling the climate crisis and bolstering global energy security'. 〉 *Hydrogen Action Pact (G7-HAP)* to strengthen joint action in field of low-carbon/renewable hydrogen and streamline implementation of existing multilateral activities. Launched in 2022.
	Knowledge	〉 Best practices and policy toolbox for industry transition towards near Zero Emission Material Production under IDA, developed by IEA (see IEA, 2022).
	Orchestration	〉 Aim to review and advance international industry decarbonisation collaboration under IDA, incl. with G7-CC, CEM, IDDI, FMC, LeadIT, MI.
***G7 Climate Club**	Rules	〉 *Efforts on industrial transition, incl. expanding markets for green industrial products 〉 *Countering carbon leakage at the international level. 〉 *On general level, making policies and outcomes consistent with ambition and work towards common assessment of effectiveness and impact of mitigation policies.
	Transparency	〉 *Strengthening emissions measurement and reporting mechanisms

Institution	Function	Supply of Governance
	Means	〉 *JETPs to leverage support and assistance to developing countries for decarbonising energy and industrial sectors, transparency, including through financial, technical capacity support and technology transfer development and deployment
Mission Innovation *incl. Net Zero Industry Mission*	Signal	〉 Joint roadmap and mission action plan 〉 Development of roadmaps for infrastructure transition enabling decarbonisation of industry, incl. clean hydrogen, green electricity and CO2 transport and storage. 〉 **National Innovation Pathways** to outline how members will enhance ambition to pioneer clean energy technologies.
	Rules	〉 Elaboration on definitions, methodologies and reporting guidelines to assess net-zero industrial production.//just sharing practise 〉 Develop and strengthen policy framework through sharing of good practices on R&I policy, regulatory frameworks or market incentives.
	Transparency	〉 Sharing of data and progress reviews
	Means	〉 *R&D on breakthrough technologies, incl. portfolio of +50 large-scale demonstration projects in EIIs and mobilizing private finance, including public-private partnerships. 〉 *Demonstration initiative, portfolio to showcase net-zero emissions EII solutions in large scale demonstration projects, in collaboration with private sector. Dedicated funding by members and co-leads (EUR 2 or 5 mio./y respectively). 〉 Creating enabling conditions for demonstration projects. E.g. funding Front-End Engineering Design (FEED), feasibility studies, sharing of good practices on good R&I policy practices, regulatory frameworks or market incentives. 〉 Focused on catalysing private sector investment in transformative clean energy technologies, including EIIs (2021)
	Knowledge	〉 Knowledge sharing with network and platforms to create alignment and coordinated effort on emission reductions. 〉 Innovation Platform analysing global innovation progress and facilitating knowledge-sharing and collaboration to support countries in planning ambitious clean energy transitions. 〉 Data, expertise, and analysis to support transition
	Orchestration	〉 After COP27 (2022), MI and CEM will host the *Breakthrough Agenda* [see below].
Clean Energy Ministerial (CEM)	Means	〉 Implementation vehicle that helps its members to achieve specific domestic clean energy objectives. 〉 International coordination on construction of green energy supply and carbon infrastructure through CEM CCUS Initiative & CEM CCUS Hydrogen 〉 Technology development through the CEM CCUS Initiative, cooperation with GCCA to scale up deployment of CCUS across cement industry. Focus on policy and technology development. 〉 *CEM ACTION FUND* channels funding into major international efforts that accelerate clean energy action, incl. support for public-private collaboration, also for industry.
	Knowledge	〉 Community for exchanging knowledge and insights, building networks and partnerships, and facilitating coordinated actions on clean energy. 〉 Analysis on possibilities of CCUS
	Orchestration	〉 Builds global action coalitions to achieve clean energy goals and advance their transition, including for EIIs (see IDDI) 〉 After COP27 (2022), CEM and MI will host *Breakthrough Agenda* (see below).
Industrial Deep Decarbonisation Initiative (IDDI)	Signal	〉 *Development of Global 2050 vision for decarbonisation of steel and cement industries with ambitious target informed by stakeholder input
	Rules	〉 Fostering private and public green procurement commitments for steel & cement 〉 *Green Public Procurement (GPP) Pledge* targeting (sub) national governments to incentivize low-carbon production and use of steel, cement and concrete. Members can sign up to different levels. - *Level 1:* Disclosure of the embodied carbon in cement/concrete and steel procured for public construction projects from 2025. - *Level 2:* conduct whole project life cycle assessments for all public construction projects by 2030. Net zero emissions in all public construction projects by 2050.

Institution	Function	Supply of Governance
		- *Level 3:* requires procurement of low emission cement/concrete and steel in public construction projects by 2030. - *Level 4*: Starting in 2030, require procurement of a share of cement and/or crude steel from near zero emission material production for signature projects. 〉 Development of minimum standards for low-carbon steel and cement products. GPPP will take IEA definition of near zero emissions cement & steel as a starting point
	Transparency	〉 *GPP:* Full life cycle assessment for all construction projects and disclosure of the embodied carbon in cement/concrete and steel procured for public construction projects. 〉 *Provision of certification service for low-carbon steel and cement. 〉 Development of standard environmental reporting mechanism for cement and steel industry, providing consistent communication framework for accountability within 3y.
	Means	〉 Capacity building to support countries to align public procurement with their purchasing pledge.
	Knowledge	〉 Data, research and tools for industry and governments to set targets, 〉 Establish industry wide definition of key sustainable productions, improve production processes and benchmark best practices 〉 Industrial deep decarbonisation training and knowledge sharing to ensure that all cement and steel manufacturers have access to the information required.
Breakthrough Agenda	Signal	〉 *Glasgow Breakthrough for steel:* leader-led 2030 decarbonisation vision for steel, i.e. 'near-zero emission steel is preferred choice in global markets, with efficient use and near-zero emission production established and growing in every region by 2030.' 〉 *Glasgow Breakthrough for hydrogen:* leader-led target for hydrogen, i.e. 'Affordable renewable and low carbon hydrogen is globally available by 2030.'
	Transparency	〉 Annual tracking, measuring and review of global progress, through annual Global Checkpoint Process. Includes annual leaders-gathering and State of Transition Report (see IEA, 2022b).
	Knowledge	〉 Breakthrough report assesses global progress and identifying opportunities for further international coordination gains.
	Orchestration	〉 Coordination of international collaboration incl. IDDI, SteelZero, FMC, LeadIT, MI, MPP-NZSI, ResponsibleSteel.
EU-US Carbon-based Sectoral Agreement on Steel and Aluminium Trade	Rules	〉 *Development of common rules to address overcapacity and steel dumping by 'restrict(ing) market access for non-participants that do not meet conditions of market orientation and that contribute to non-market excess capacity, through application of appropriate measures including trade defence instruments' 〉 *Restricting market access for steel that does not meet standards for low-carbon intensity for non-participants to address carbon leakage. 〉 *Development of common methodology for assessing embedded emissions of traded steel and aluminium.
	Transparency	〉 *Sharing of data
Leadership Group for Industry Transition (LeadIT)	Signal	〉 long-term decarbonisation commitment to accelerating transition of all industry sectors to PA aligned pathways, pursuing efforts to reach net-zero carbon emissions by 2050
	Means	〉 Actionable measures on innovation and finance. 〉 Capacity building and technical assistance on roadmap development (e.g. Roadmap Planner) and implementation. 〉 Fostering public-private collaboration
	Knowledge	〉 Analysis to improve collective understanding of opportunities and challenges in industry transitions, e.g. role of financial institutions in steel transition. 〉 Platform for knowledge exchange and networking, inc working groups and seminars. 〉 Interactive databases on industry transition roadmaps by members or Green Steel Tracker on announcements of low-carbon investment in steel industry.
	Orchestration	〉 Coordination on demand side standards and methods with IDDI, FMC, SteelZero, and Concrete Zero

Institution	Function	Supply of Governance
First Movers Coalition (FMC)	Rules	〉Purchasing commitment by aluminium purchasers: min. 10% of annual primary aluminium volumes procured by 2030 meets or exceeds the FMC definition for low-CO2 primary aluminium. Optionally, procurement of min. 50% secondary aluminium by 2030. 〉Purchasing commitment by steel purchasers: min. 10% of annual steel procurement volumes by 2030 meets or exceeds FMC definition for near-zero emissions steel. 〉Standards & definitions for near-zero emissions steel and aluminium as part of respective purchasing commitment. 〉*Purchasing commitments for Chemicals and Cement planned for 2022.
	Knowledge	〉Support activities to facilitate implementation of purchasing commitments, incl. best practice sharing sessions, creating templates, and provisions of frameworks to track progress.
	Orchestration	〉Facilitate collaboration of members with financial players, suppliers, and other value chain partners. 〉Coordination and collaboration with existing initiatives incl. NetZero Steel, Steel Zero, GCCA, MPP, ASI
Global Cement and Concrete Association (GCCA)	Signal	〉2050 net-zero roadmap for global cement and concrete sector published in 2021, incl. 2030 interim target, milestones, policy and investment needs. Incl. commitment of members to produce net zero concrete by 2050. 〉Development of national cement and concrete decarbonisation roadmaps under GCCA 2050 Net Zero Roadmap Accelerator Program, incl. focus on global south.
	Rules	〉Sustainability charter: full members must implement sustainability initiatives across five pillars: health & safety, climate change and energy, social responsibility, environment and nature, circular economy and set targets for performance for each.
	Transparency	〉Monitoring and reporting requirements for members under sustainability guidelines. Full members need to have their data verified and reported publicly. 〉Publication of data on industry's sustainability commitments, including GHG emission.
	Means	〉Facilitation of cooperation on technology innovation, development, and financing, (through 'Innovandi'), incl. pre-competitive research projects on mitigation technologies; and the channelling of investments into promising start-up technologies through formal working partnerships (consortia) with its members (Innovandi Open Challenge). 〉Capacity building for development of national cement and concrete roadmaps through the GCCA 2050 Net Zero Roadmap Accelerator Program, with aim to accelerate local implementations of global roadmap, identify local barriers to decarbonisation in target countries and recommend key actions.
	Knowledge	〉*Innovandi Global Cement and Concrete Research Network (GGCRN)* provides global collaboration on cement and concrete innovation with actionable research since 2019. 〉Sustainability related guidelines and handbooks, such verified Environmental Product Declaration Tool (GCCA EPD Tool). 〉Showcases best practices and case studies on sustainability action from members.
	Orchestration	〉Collaboration with OECD and High-level climate champions on Roadmap Accelerator Programme. 〉Collaboration with LeadIT, CEM, MPP on cement initiatives
Concrete Sustainability Council (CSC)	Transparency	〉Global certification system for responsibly sourced concrete, covering complete supply chain (producers, aggregate suppliers and concrete manufacturers), contains Energy & Climate criteria. Does not contain benchmark for climate criteria.
World Cement Organisation (WCO)	Transparency	〉PEGASUS programme helps to identify gap between corporate plants and world-class best practice through gap analysis, plant audits and dialogue with experts. Includes benchmarking on energy and CO2 (among other topics).
	Knowledge	〉Climate Partnerships with NGOs and thinktanks to allow knowledge sharing and foster new partnerships, collaborations and ideas between cement industry, other hard-to-abate sectors and the wider climate movement.
International Council of Chemicals Association (ICCA)	Transparency	〉Guidelines for assessing and reporting avoided GHG emissions
	Means	〉Capacity building to improve performance in GHG mitigation by helping to strengthen skills, processes and resources of companies.

Institution	Function	Supply of Governance
	Knowledge	〉 Guidelines for assessing and reporting avoided GHG emissions 〉 Reports and case studies on pathways to lower GHG emissions using chemistry 〉 Stakeholder collaboration and knowledge exchange through collaboration between industry, governments, stakeholders and communities and global and regional dialogue
International Aluminium Institute (IAI)	Signal	〉 Aluminium Sector Greenhouse Gas Pathway to 2050 in line with IEA beyond 2-degree scenario.
	Knowledge	〉 Analysis on pathways towards alignment with PA targets and other relevant topics. 〉 Bests practices for Calculation of Primary Aluminium and Precursor Product Carbon Footprints. 〉 Data and outlooks on GHG emissions.
World Steel Association (WSA)	Rules	〉 Voluntary Sustainability Charter incl. 9 principles and 20 criteria covering areas of environment, social, governance and economics (ESGE), incl. Climate Action. Members must meet 20 criteria to sign charter.
	Transparency	〉 CO2 data collection benchmarking system methodology to report on overall emissions intensity for steel production of at a site. 〉 Collection of emission data through worldsteel *Climate Action data collection programme* with aim to share best practices within industry. Data is kept confidential and only average published.
	Knowledge	〉 Analysis, report, best practices, policy papers on steel-decarbonisation technologies 〉 Methodology and roadmaps for CO2 reduction across steel production value chain.
International Standardisation Organisation (ISO)	Rules	〉 Calculation methodology for CO2 emission intensity from iron and steel production (ISO 14404 Series), incl. route specific guidance.[6] Covers direct and indirect emissions. Based on worldsteel measurement standards. 〉 Life cycle inventory calculation methodology for steel products (ISO 20915:2018) specifies guidelines and requirements for conducting life cycle inventory (LCI) studies of steel products reflecting steel's capacity for closed-loop recycling. 〉 Development of standards overseen by Technical committee on steel. 〉 *Standard for cement production is under development (ISO 19694-3) (IEA, 2022b).
ResponsibleSteel (RS)	Rules	〉 Standard for responsible steel manufacturing covering environmental, social and governance issues. 〉 Compliance rules and reporting requirements for RS members
	Transparency	〉 Certification of RS-Standard, including third party audits. 〉 Certification guidelines, methodology, measurements and reporting
	Means	〉 Capacity building and training for certification auditing service
	Knowledge	〉 Guidelines on certification, measurements and reporting 〉 Stakeholder collaboration and knowledge exchange, e.g. Responsible Steel Forum 〉 Analysis on steel decarbonisation in cooperation with stakeholders.
Energy Transition Commission (ETC)	Means	〉 Works with industry leaders to accelerate innovation, inform industrial policy, create demand and boost financing of the transition of chemicals, cement, steel and aluminium value chains. In cooperation with MPP.
	Knowledge	〉 Analysis, data and reports, including sectoral analyses, roadmaps and pathways
	Orchestration	〉 Cooperation with GCCA on cement to convene a group of high-ambition business leaders committed to driving sector transition. In context of MPP. 〉 Drives work of MPP Net-Zero Steel Initiative 〉 Works with LCET on chemicals decarbonisation. In context of MPP.
	Signal	〉 Development of industry-backed net zero roadmaps for hard-to-abate sectors, incl. cement, steel, aluminium, and chemicals (through LCET).

[6] Series includes route specific guidance for Steel Plant with BF (ISO 14404-1:2013), Steel plant with EAF (ISO 14404-2:2013), Steel plant with EAF and coal-based or gas-based DRI facility (ISO 14404-3:2017), guidance for using series (ISO 14404-4:2020).

Institution	Function	Supply of Governance
Mission Possible Partnership (MPP) *Incl. sector specific partnerships*		〉 Net-Zero steel strategy outlines shared decarbonisation vision, milestones and detailed reference points. Backed by industry and builds on climate targets by steel producers accounting for >20% of global production. Part of *Net-Zero Steel Initiative.* 〉 Aluminium Transition Strategy outlines shared decarbonisation vision, milestones and details industry, policy, and finance action required for 1.5C-aligned pathway. Endorsed by major global aluminium producers. 〉 Ammonia Transition strategy published in 2022, outlining decarbonisation challenges and solutions, potential pathways, and high-level actions needed form policy, industry and finance. Strategy was backed by number of chemical companies.
	Rules	〉 Work towards alignment of definitions of low carbon product labelling and certification 〉 Aims to foster corporate 'commitments to action that tie concrete actions to the net-zero roadmap milestones, therefore embedding the roadmap in corporate strategies. Currently for example through Net-Zero Steel Initiative.
	Means	〉 Mobilising finance & investment, incl. through engagement with financial institutions, among others, to adopt collective lending and investment policies, as well as facilitation of capacity building on that matter. 〉 Efforts to scale demand for low-carbon products and shift global markets and policies, including generation of corporate commitments, matchmaking, and others
	Knowledge	〉 Sector specific analysis and reports, including on policy needs and options as well as technological pathways. 〉 Sector transition tools offer 'model materials and analytics to promote transparency and collaboration as well as to facilitate regular refinement as data and insights evolve' 〉 Facilitates knowledge sharing and stakeholder collaboration 〉 Facilities industry engagement with policy makers and financial institutions.
	Orchestration	〉 Cooperation with other institutions through sector specific initiatives, e.g. ETC. 〉 Orchestration of demand campaigns to promote involvement from across value chains.
World Economic Forum (WEF)	Means	〉 *Transitioning Industrial Clusters towards Net Zero* initiative offers structured approach to financing, policy, technology and partnerships to other clusters to accelerate alignment on net zero targets. Aims for 100 industrial clusters to be signed up by 2024.
	Knowledge	〉 Analysis, reports, data and best practices relevant to the decarbonisation of EIIs. E.g. Net Zero Industries Tracker 2022. 〉 General stakeholder collaboration and knowledge exchange. 〉 Hosts high-level industry communities on chemistry and advanced materials and metals and mining
	Orchestration	〉 Hosts First Movers Coalition (see above). 〉 Cooperation with and involvement in number of other initiatives.
Low-Carbon Emitting Technology Initiative (LCET)	Signal	〉 Development of 'implementable, industry-driven roadmap for net-zero emissions by 2050 in the chemical sector.'
	Means	〉 Technology Implementation through fostering alliances for collaborative implementation of prioritised technologies, incl. through joint technology development and upscaling, sharing of early-stage risks, and co-investing into large projects.
	Knowledge	〉 Aims to increase understanding of low-carbon technology pathways and investment needs for the industry transition. 〉 Identification of policy priorities, supportive regulatory frameworks and public funding sources for pilot projects as well as optimal financing structure for potential pilot projects that deploy and scale low-carbon technologies. 〉 Policy dialogues with policy stakeholders in key regions to strengthen public private collaborations and strengthen collaboration between the chemical sector and financial institutions. 〉 Expert community collaboration in several working groups across technology, sustainability, finance, policy, and legal functions.

Institution	Function	Supply of Governance
SteelZero *By Climate Group*	Rules	〉Procurement commitment by steel purchasers: 'public commitment to procure, specify or stock 100% net zero steel by 2050 and an interim commitment to procure, specify or stock 50% of its steel requirement by 2030. 〉Standard & definition for near zero emission steel.
	Transparency	〉Members required to annually report progress towards commitments. Information includes summaries of the quantity and embodied carbon of steel produced.
	Means	〉Capacity building through Industry Transition Platform: works with governments from highly-industrialised regions to develop strategies to cut industry emissions while supporting growth, job creation and prosperity. However, not specific to EIIs.
	Knowledge	〉Working groups/stakeholder platforms to assist in developing company roadmaps, sharing of best practices, and address barriers facing steel supply chain.
ConcreteZero *By Climate Group*	Rules	〉Leadership commitments by concrete purchasers: 'public commitment to transition to 100% net zero concrete by 2050.' There are further minimum requirements for commitment rules. 〉Standard & definition for near zero emission concrete.
	Transparency	〉Members required to quarterly report volume and carbon intensity of concrete consumption. Specific rules tbd.
	Knowledge	〉Working groups to collaborate, share knowledge and best practices, and showcase leadership.
	Orchestration	〉Coordination with wide array of institutions, incl. Concrete for Climate Action, Concrete Action for Climate, Concrete Sustainability Standard, GCCA, IEA, MPP, Net Zero Carbon Buildings Commitment (WorldGBC), IDDI,World Cement Association
Global Low Carbon Metallurgical Innovation (GLCMI) Alliance	Means	〉Collaboration on development of low-carbon metallurgical technology among members (steel companies across the world). 〉Innovation financing to support research and development of low-carbon metallurgy amounting to at least 35 million yuan annually, provided by Baowu Steel.
	Knowledge	〉Knowledge and information exchange
Breakthrough Energy (BE)	Means	〉Mobilises private capital for early-stage breakthrough innovations (patient capital)[7] and to scale clean energy solutions for EIIs, incl. projects on cement, chemicals (ammonia), steel. 〉Public private partnerships with aim to accelerating deployment of clean technologies, including with the European Commission, US, UK, and CA. Focus on Direct air capture, green hydrogen, long-duration energy storage, sustainable aviation fuel.
	Orchestration	〉Collaboration through private public partnerships with EU, UK, US, CA 〉Helping to advance MI around the world through policy, partnerships, and targeted investment in potentially transformative tools and technologies.
Science Based Targets initiative (SBTi)	Knowledge	〉Develops science-based target setting methodologies, tools and guidance for companies and other stakeholders to help understand and implement climate ambition required to meet the 1.5°C goal. Ongoing efforts exists for steel (with MPP), aluminium (with IAI), cement, as well as for chemicals.

* Indicates announced, planned or future activities that have not yet been implemented.

[7] Breakthrough Energy Fellowship Programme. Include projects on cement (CHEMENT, FURNO), ammonia (LIQUIUM), steel (METPEEL). See https://www.breakthroughenergy.org/fellows

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