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Sectoral Analysis of Energy-Intensive Industries

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Note: This version includes an updated annex to incorporate an export review of the Russia case study.

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Executive Summary

Achieving the decarbonisation of energy-intensive industries (EIIs) by mid-century is technically possible and essential to achieving the aims of the Paris Agreement. However, decarbonising EIIs, such as steel, cement, chemicals, and aluminium, faces significant economic, political, and structural barriers across all levels of governance. To address these and accelerate industrial decarbonisation, far-reaching and comprehensive public policies and support are needed.

This study systematically analyses national sectoral decarbonisation barriers, enablers and policies for 13 major EII producing countries to assess if their respective national policy frameworks are fit for advancing the decarbonisation of EIIs in line with Paris-compatible pathways. The analysis is based on case studies that systematically map national sectoral mitigation barriers, enablers and policies conducted or reviewed by national or sectoral experts. The countries studied include China, the European Union (EU), India, Iran, Japan, Morocco, Nigeria, Norway, Russia, Saudi Arabia, South Africa, Turkey, and the United States (US).

Major barriers to the deep decarbonisation of EIIs continue to be economic challenges (e.g. high investment costs, long investment cycles), lack of targeted policy and international coherence, the limited commercial availability of deep decarbonisation technologies and lack of clean energy and feedstocks. Common enablers are ambitious national climate policies, the domestic potential for clean energy production, international cooperation, and the economic opportunities of industrial decarbonisation. However, our analysis shows that national decarbonisation barriers and enablers are highly context specific and differ significantly across income levels. Whereas decarbonisation in high-income industrialised countries is mainly hampered by the lack of breakthrough technologies and clean energy supply, low- and middle-income countries lack policies and political ambition, but also fiscal and governance capacity to proactive steer the sectoral transformation. At the same time, the latter tend to have high renewable energy potential offering significant opportunities for economic development through green EIIs, or long-lasting experience with state-led industrial policy. To address these barriers and exploit these opportunities comprehensive, timely, proactive and context-specific sectoral policies are needed.

To analyse national frameworks, we review relevant academic literature and indefinity key policy functions and levers that are needed to achieve the deep decarbonisation of EIIs. We then assess the extent to which these are exploited by domestic policies. Our findings show that no country has a sufficiently coherent and comprehensive policy framework in place that can achieve the sectoral transformations needed for the deep decarbonisation of EIIs. Existing policies instead mainly focus on incremental changes and limited emissions reductions, although some notable exceptions exist. Somewhat unsurprisingly, high-income countries, in particular the US, the EU and Norway, are starting to develop some transformative industrial climate policies, but also here crucial policy gaps remain. Overall, we find a particular lack of, and need to strengthen policies focused on demand reduction, material efficiency and circularity, the build-up of public capacity, and the enhancement of international cooperation.

Our findings show that more ambitious, proactive, and radical industrial climate policies are needed in a timely manner to put the sector on track to achieve a Paris-compatible pathway. This need for further political, private sector and academic discussion on the design and implementation of transformative industrial climate policies.

Contents

1 Introduction

The deep decarbonisation of energy-intensive industries (EIIs) is advancing but remains off-track to reach a Paris Agreement-compatible pathway (IEA, 2022b). EIIs compromise basic materials producing industries such as iron and steel, cement and concrete, basic chemicals, aluminium and non-ferrous metals, glass, ceramics and pulp and paper. In 2019 these industries were responsible for around 17-20% of global direct greenhouse gas (GHG) emissions (Bashmakov et al., 2022). Staying within a Paris Agreement compatible pathway, however, requires reducing global EII emissions to near zero by mid-century or as soon as possible thereafter (Bashmakov et al., 2022; IEA, 2021).

While technologically possible, the deep decarbonisation of EIIs faces significant economic, political and structural barriers and challenges (Bashmakov et al., 2022; Löfgren & Rootzén, 2021; van Sluisveld et al., 2021). This includes challenges specific to EIIs such as the strong reliance on fossil fuels as energy inputs and feedstocks, the limited commercial availability of deep decarbonisation technologies, as well as long asset lifetimes and high capital investment requirements (IEA, 2022a, 2022b). The high trade intensity and strong international competition inherent to many basic materials markets such as steel, aluminium or basic chemicals constrain the industry's ability to invest in the development and implementation of alternative production routes (Åhman et al., 2017). The adoption thereof furthermore requires abundant low or zero-emission energy supply, alternative feedstocks and infrastructure for the transport and storage of CO2, all of which remain scarce and are expensive. At the same time, demand for basic materials is expected to continue to grow, driven by economic growth and development in emerging economies and the low-carbon transformation of other sectors (Bashmakiov et al., 2022). The core challenge for decarbonising EIIs is therefore to meet growing demand while rapidly decarbonising production in light of the above-mentioned barriers and a relatively short time.

Possible policy options and mitigation pathways to address persisting barriers and unlock the sectoral transformations needed for the deep decarbonisation of EIIs have been explored extensively in academic literature and analysis (see Bashmakov et al., 2022). These analyses show that achieving near-zero emissions EIIs by mid-century is technologically possible, but conditional on further technological advancement and substantial financial support and transformative public policies (Nurdiawati & Urban, 2021; Rissman et al., 2020; van Sluisveld et al., 2021). The specific policy mixes required to unlock the sectoral transformation have been discussed extensively in the literature (Bataille, 2020; Bataille et al., 2018, 2021; Nilsson et al. (2021). Rissman et al., 2020; Sovacool et al., 2023), including the potential of, and need for, international cooperation for the decarbonisation of EIIs (Åhman et al., 2017, 2022; Oberthür et al., 2021; Otto & Oberthür, 2022, 2023). Additionally, the general implementation of climate policies, including for the industry sector (Boehm et al., 2022) and amongst major emitters (Nascimento et al., 2022) has been assessed. Analysis of EII-specific decarbonisation barriers, opportunities and policies at the national level remains lacking, however.

Against this backdrop, this study systematically analyses national decarbonisation barriers, enablers and policies for 13 major EII producing countries to assess if their respective national policy frameworks are fit for advancing the decarbonisation of EIIs in line with Paris-compatible pathways. We find that none of the countries studied has a sufficiently coherent and comprehensive policy framework in place to achieve the sectoral transformations needed for the deep decarbonisation of EIIs. Existing industrial climate policies, with few exceptions, instead focus on incremental changes and limited emissions reductions and fail to sufficiently address decarbonisation barriers or exploit opportunities. Accordingly, we argue that more ambitious, proactive, and radical industrial climate policies are needed in a timely manner to put the sector on track to achieve a Paris-compatible pathway. This should include in particular policies focused on accelerating the development of breakthrough technologies, fostering demand reduction, material efficiency and circularity strategies, the build-up of public capacity to steer the industrial transformation as well as the opportunities for international cooperation, as these remain largely underexploited.

Overall, our findings highlight the need to advance political, private sector and academic discussion on the design and implementation of transformative industrial climate policies. Our study contributes to this discussion in several ways. First of all, we provide a systematic mapping of national industrial climate policies of 13 major EII producing countries that allows us to identify gaps in policy mixes at the global and country-specific level. This allows us to take stock of the overall progress of sectoral climate policies and identify specific areas where more political action and academic analysis are needed, but also to highlight good practice examples. Second, the systematic analysis of national sector-specific decarbonisation barriers and enablers allows us to identify challenges where more political action is needed, but also to highlight opportunities industrial decarbonisation can bring along. The mappings and our analysis can inform policymakers, industry experts and academics in the design of industrial climate policies and mitigation pathways at the global and national level.

The analysis is based on 13 country studies of national decarbonisation barriers, enablers and policies that were conducted between June 2022 and June 2023 and reviewed by national experts as well as the review of relevant academic literature. The countries studied include China, the European Union (EU), India, Iran, Japan, Morocco, Nigeria, Norway, Russia, Saudi Arabia, South Africa, Turkey, and the United States (US). This paper focuses specifically on the iron and steel, cement and concrete, chemicals and aluminium and non-ferrous metals industries as they accounted for up to 50% of direct industrial emissions in 2019 (Bashmakov et al., 2022).[1] The analysis of the mapping of national decarbonisation barriers and enablers and the assessment of national industrial climate policy frameworks was presented to and discussed with industrial policy experts at an NDC ASPECTS workshop in May 2023.

The study is structured into several parts. Section 2 outlines the methodology of this paper and explains the country section. Section 3 reviews the main strategies to mitigate GHG emissions in EIIs. Section 4 summarises the findings on national decarbonisation barriers and enablers. Section 5 briefly reviews the interactions of industrial mitigation strategies with the Sustainable Development Goals (SDGs). Section 6 first reviews relevant academic literature and analysis to identify key policies to achieve the deep decarbonisation of EIIs. Based on the country studies it is then assessed to what extent these policies are exploited by existing national industrial climate policies and some general observations are provided. The paper is then concluded.

[1] The iron and steel industry accounted for iron and steel for 20%, the cement and concrete industry for 14-17%, the chemicals industry for 10% and the aluminium and non-ferrous metals industry for 3.1% of industrial emissions in 2019. See Bashmakov et al., 2022.

2 Methodology

This study aims to systematically assess and compare national mitigation barriers and enablers as well as policies and measures relevant to the decarbonisation of EIIs. To this end, a cross-country comparison of 13 current or future major EII-producing countries was conducted. This includes China, the European Union (EU)[2], India, Iran, Japan, Morocco, Nigeria, Norway, , Russia, Saudi Arabia, South Africa, Turkey, and the United States (US).

The country selection is based on the respective relevance of global basic materials production and emissions while taking into account geographical and economic diversity. Table 1 shows the country selection and the respective relevance for global steel, cement, aluminium, and chemicals production. The World Bank country classification by income level was used to group countries into different income levels (see World Bank, 2022).

For each country, we identified national mitigation barriers and enablers as well as relevant policies. These case studies were conducted from June 2022 to June 2023 based on existing relevant literature, official government documents (e.g. reporting under the UNFCCC), grey literature as well as specialised news reporting. The case studies were either conducted or reviewed by national or sectoral experts to ensure a high validity and reliability of results.

The full case studies can be found in Annex 1. They contain background information on the structure, emissions profile, and economic relevance of domestic EIIs. Furthermore, they include a detailed mapping of national decarbonisation barriers and enablers as well as national industrial climate policies and an assessment thereof.

Table 1: Country Selection

Country	Domestic production of selected basic materials			
	Steel 2022 production in million tonnes (global share in %)	**Cement** 2019 production in million tonnes (global rank)	**Aluminium** 2020 production in thousand tonnes (rank)	**Chemicals** 2021 sales in EUR (global share in %)
High-income countries				
European Union	136.3 Mt (7.2 %)	177.1 Mt (3rd)	2,100 (6th)	594 Bn (15 %)
United States	80.5 Mt (4.3 %)	89 Mt (5th)	1,010 (10th)	437 Bn (11 %)
Japan	89.2 Mt (4.7 %)	53.5 Mt	No data (9th)	190 Bn (5 %)
Norway	*No data*	1.76 Mt	1,300	*No data*
Saudi Arabia	9.1 Mt (0.4 %)	42.3 Mt	740	58 Bn (1 %)
Upper-middle income countries				
Russia	71.5 Mt (3,8%)	55.9 Mt (9th)	3,600 (2nd)	58 Bn (1 %)
China	1018.0 Mt (54 %)	2280.0 Mt (1st)	37,080 (1st)	1,729 Bn (43 %)
Turkey	35.1 Mt (1.9 %)	57 Mt (8th)	80	*No data*
South Africa	4.4 Mt (0.2 %)	12.4 Mt	717	*No data*
Lower-middle income countries				
India	125.3 Mt (6.6 %)	338 Mt (2nd)	3,500 (3rd)	104 Bn (3 %)
Morocco	*No data*	13.7 Mt	*No data*	*No data*
Nigeria	*No data*	22.6 Mt	*No data*	*No data*
Iran	30.6 Mt (1.6 %)	60 Mt (7th)	450	*No data*

Data: World Steel Association, 2023; U.S Geological Survey, 2021, 2023; CEFIC, 2023.

[2] For the purpose of this study the European Union is considered as one jurisdiction.

To allow for systematic comparison across the different countries studied and the analysis of other sectors conducted as part of the NDC ASPECTS project a common typology of mitigation barriers and enablers was applied. We thereby distinguish between six categories:

(1) **Structural context** captures societal, geographical and environmental conditions that are outside the socio-technical system in question but influence or constrain the options, preferences and behaviour of relevant actors.

(2) **Paradigms & discourses** capture explicit and implicit informal rules, cognitive schemes, routines, values and norms affecting the way actors view and respond to issues.

(3) **Polity** captures the general setup and political system and bureaucratic institutions in general.

(4) **Politics** captures the composition, relationships, power structures and vested interests of the actors involved in maintaining and changing the system.

(5) **Policy** captures formalised (i.e. codified and explicit) rules and principles that guide behaviour such as policies, standards, formal contracts, roadmaps, commitments and formalised governance mechanisms.

(6) **Economics** captures conditions, restrictions and incentives affecting the ability of economic actors to adopt more climate-friendly solutions.

The analysis of national policy frameworks is based on a comprehensive mapping of relevant national policies and measures, that was undertaken as part of the country studies. This policy mapping focused explicitly on public policies and measures that are relevant to the decarbonisation of EIIs, hereinafter referred to as industrial climate policies. This includes policies directly aimed at mitigating emissions as well as policies that can contribute to sectoral decarbonisation in a broader sense, such as financing, research and innovation support or information requirements (see Section 6 for further information). In the mapping we included governance and planning instruments, economic instruments, regulatory instruments, informational (i.e. 'soft') instruments as well as voluntary agreements with industry. This ensures a broad consideration of instruments and allow for better comparison across countries and the analysis of other sectors conducted as part of the NDC ASPECTS project.[3]

[3] See http://www.ndc-aspects.eu

3 Main mitigation strategies for energy-intensive industries

Achieving near-zero emissions EIIs by mid-century is possible but requires a fundamental transformation of production processes and the further development of breakthrough technologies (Nurdiawati & Urban, 2021; van Sluisveld et al., 2021). Several strategies exist to reduce emissions from basic materials production, including demand reduction strategies, material efficiency, energy efficiency, electrification and fuel switching, circular economy measures, and the application of carbon capture, utilisation and storage. To decarbonise EIIs by mid-century a mix of these strategies will be required, tailored to specific country and industry contexts (see Bashmakov et al., 2022; IEA, 2022a, 2022b).

First, measures to reduce the overall demand for primary basic materials can significantly reduce sectoral emissions. Demand growth has been the main driver behind the increase in sectoral emissions in the past as the demand for basic materials has increased 3 to 5 fold over the last 25 years due to economic and population growth. At the same time, demand for basic materials is expected to increase further, driven by economic growth in emerging economies as well as material needs for the low-carbon transformation in other sectors. Demand for emission-intensive primary production can be reduced through increased material efficiency and behavioural changes leading to lower demand for final consumer products, (Bashmakov et al., 2022: IEA, 2022b).

Material efficiency improvements aim at delivering goods and services with fewer materials. Potential for ME improvements continues to exist at every stage of EII value chains. Several material efficiency options such as light weighting of products, reusing of product components, and improving manufacturing yields thereby result in immediate (short-term) emission savings. Other options, such as changes in product design or reuse, only lead to emissions saving in the longer term (delayed), but can nonetheless be substantial (IEA, 2022b).

Next to reducing overall demand for basic materials, it will be necessary to also decarbonise their production (supply side) through measures such as energy efficiency improvements, electrification and fuel switching as well as carbon capture utilisation and storage (CCUS). Energy efficiency improvements reduce energy supply and storage needs, thereby avoiding indirect emissions. While the potential of energy efficiency improvements has already been exploited to a large extent in industrialised countries, it remains an important short-term mitigation strategy to reduce emissions in emerging and developing countries. Energy efficiency improvements further reduce costs and the demand for low-carbon energy supply (Bashmakov et al., 2022).

Electrification and fuel-switching strategies aim at shifting EII production away from reliance on fossil fuels as energy carriers and feedstocks Bashmakov et al., 2022). First, fossil fuels as energy carriers can be replaced by low- or zero-emission electricity, hydrogen or ammonia. However, due to the high heat requirements of EII production processes the potential for direct electrification is relatively limited, in particular for cement and, at least for the time being, primary steel, whereas aluminium production is already electrified to a large extent. For steel production the use of fossil fuels as energy carriers (and feedstocks) can be replaced by green hydrogen (Agora Industry & Wuppertal Institute, 2023). In contrast, electrification of basic chemicals production is considered an important option through the electrification of naphtha stream crackers (expected to be available at large scale by 2030-2035) next to the use of green hydrogen and ammonia (Bauer et al., 2023; Chung et al., 2023; Mallapragada et al., 2023).

Second, the reliance on fossil fuels as feedstocks can be reduced using biofuels, biogenic (including solid biomass) and captured carbon as well as green hydrogen and ammonia. Furthermore, circular economy measures, including recycling and better waste management, can reduce the amount of primary production needed to saturate demand for basic materials (Agora Industry, 2022). Secondary production with recycled materials only requires a fraction of energy compared to primary production and is already commonly used in steel, aluminium and copper production. The Increase of secondary production for these materials is, however, hampered by the limited supply of secondary raw materials and quality (i.e. purity) of scrap (Bashmakov et al., 2022). The potential for an increase in circularity and recycling for cement and chemicals continues to be limited, due to technological barriers, economic barriers (too costly to recycle) and underdeveloped value chains for recycled concrete and plastics (Chung et al., 2023; Wyns et al., 2019).

Finally, carbon capture utilisation, and storage (CCUS) can be used to capture remaining and process emissions (Bashmakov et al, 2022; McLaughlin et al., 2023). The mitigation potential of CCUS, however, depends on the process, and in some cases needs to be combined with the use of sustainably sourced biofuels and feedstocks or carbon offsets (i.e. carbon dioxide removal). While CCUS is already being used at an industrial scale – mainly for enhanced oil recovery, however – its widespread application in industry is contingent on the development of gathering and transport networks as well as permanent storage locations for captured CO2. Given the high amount of process emissions, CCS will be an essential strategy to decarbonise cement production in particular (Griffiths et al., 2023).

Essentially, all of the above-mentioned mitigation strategies will need to be pursued in parallel to deep decarbonise EIIs by mid-century. The specific mitigation potential of each strategy thereby differs strongly across the industrial sub-sectors and regional context (for industry-specific considerations see Agora Industry & Wuppertal Institute, 2023; Chung et al, 2023; Griffiths et al., 2023; Janipour et al., 2022; McLaughin et al., 2023; Woodall et al., 2022). Additionally, their application requires further technological progress, far-reaching policy measures, and infrastructure development. Table 2 summarises the main mitigation strategies and options for the specific industrial sub-sectors respectively and further outlines the technology-specific mitigation potential, Technology Readiness Level (TRL), and year of expected commercialisation.

As shown in Table 2 many of the technologies required to decarbonise these industries will only reach market maturity around 2030 and can be deployed at large scale only thereafter (Bashmakov et al., 2022; IEA, 2022b). Accordingly, and given the high complexity and long-lasting lifetime of EII installations, the transformation of EIIs will require time and a sequential approach. In the short to medium term (until 2035) energy and material efficiency improvements, circular economy measures and direct electrification can reduce emissions, while more transformative technologies reach market maturity. Once these technologies are mature, the focus needs to shift to ensure their widespread deployment and the structural changes required to reach near-zero emissions in the sector by mid-century (Rissman et al., 2020).

Implementing these mitigation strategies entails a significant transformation of the sectoral system, away from marginal and incremental changes to production processes and towards transformative change, at an unprecedented scale and speed (Bashmakov et al., 2022; IEA, 2022a, 2022b). While technologically possible, however, the transformation of EIIs continues to be significantly constrained by structural, economic, institutional, and political barriers. The exploration of which we turn to in the next section.

Table 2: Potential of deep decarbonisation technologies for EIIs

Process	Potential GHG reduction	TRL(1)	Cost per tonne CO2-eq	Technology Availability(2)
Iron and Steel				
Electric Arc Furnace (EAF) (depends on electricity intensity & pre-heating fuel)	Up to 99%			Today
Material efficiency	Up to 40% (through demand reduction	9	Subject to supply chain building codes and education	Today
More recycling; depends on available stock, recycling network, quality of scrap, availability of DRI for dilution	Highly regional, growing with time	9	Subject to logistical, transport, sorting and recycling equipment costs	Today
Blast Furnace-Basic Oxygen Furnace (BF-BOF) with top gas recirculation and CCU/S	60%	6-7	USD 70-130 t	2025-2030
Syngas (H2 & CO) DRI EAF with concentrated flow CCU/S	> 90%	9	> USD40 t	Today
Hisarna smelting with concentrated CO2 capture	80-90%	7	USD40-70 t	2025
Hydrogen Direct Reduced Iron (DRI) EAF	Up to 99%	7	USD39-79 t	2025, Today already (FF H2 with CCS)
Aqueous (e.g., SIDERWIN) or Molten Oxide (e.g., Boston Metals) Electrolysis (MOE)	Up to 99%	3-5	Unknown	2035-2040
Cement and Concrete				
Building design to minimise concrete	Up to 24%	9	Low, education, design and logistics related	2025
Alternative lower-GHG fuels, e.g., waste (biofuels and hydrogen)	40%	9	Dep. on the cost of alternative fuels	Today
CCUS for process heating & CaCO3 calcination CO2 (e.g., LEILAC, possible to retrofit)	99% calc., ≤90% heat	5-7	≤USD40t calc. ≤USD120t heat	2025
Clinker substitution (e.g., limestone + calcined clays)	40-50%	9	Near zero, education, logistics, building code revisions	Today
Use of multi-sized and well-dispersed aggregates	Up to 75%	9	Near zero	Today
Alternative (Magnesium or ultramafic) cements	Negative	1-4	Unknown	2040
Chemicals				
Catalysis of ammonia from low-/zero-GHG hydrogen H2	≤99%	9	Cost of H2	Today
Electrocatalysis: CH4, CH3OH, C2H5OH, CO, olefins	Up to 99%	3	Cost: elec., H2, COx	2030
Catalysis of olefins from (m)ethanol, H2 and COx directly	9%	9, 3	Cost: H2, COx	Before 2030
End-use plastics, mainly CCUS and recycling	94%	5-6	USD150–240 t	2030 (unknown)
Aluminium and other non-ferrous metals				
Inert electrodes and green electricity	100%	6-7	Relatively low	2024
Hydro/electrolytic smelting (with CO2 CCUS if necessary)	Up to 99%	3-9	Ore-specific	Before 2030

Source: Bashmakov et al., 2022, p. 1197.
Notes: (1) NASA Technology Readiness Levels (TRLs). (2) Year of technology availability assuming policy drivers.

4 Main decarbonisation barriers and enablers

This section explores the main mitigation barriers and challenges as well as enablers and drivers to the decarbonisation of EIIs following the typology introduced in Section 2. The subsequent analysis is based on the synthesis of existing literature (e.g. Chiappinelli et al., 2021; Nurdiawati & Urban, 2021; Wesseling et al., 2017), as well as the 13 case studies conducted for this paper (see Annex 1). Table 2 summarises the main barriers and enablers identified in the country studies, while this Section synthesises and contextualises the main observations across the six categories of the typology.

4.1 Structural context

The structural context captures societal, geographical and environmental conditions that influence or constrain the options, preferences and behaviour of relevant actors. The structural thus determines important conditions that can constrain or enable the domestic decarbonisation of EIIs, such as the structure of the economy and availability of public resources, existing clean energy supply and supporting infrastructure as well as expected demand growth for basic materials.

Regarding the structure of the economy, we find that macroeconomic instability (e.g. Turkey, Russia, Iran), domestic industrial decline (e.g. South Africa, Russia, Nigeria), or a strong economic reliance on fossil fuel revenues (e.g. Saudi Arabia, Nigeria, Russia, Iran, Norway) can be important barriers to the decarbonisation of EIIs. These factors constrain the ability of and incentive for national governments to implement ambitious sectoral decarbonisation efforts [ref]. Similarly, many of the policy instruments required to advance the decarbonisation of EIIs require substantial public financial resources, for example for infrastructure development, research and innovation or production subsidies. However, the availability to finance, implement and administer such measures is often limited in emerging and developing countries (Sovacool et al., 2023).

Second, the availability of abundant and low-cost clean energy supply (i.e. green hydrogen, biomass, electricity) and supporting infrastructure (i.e. electricity grids, infrastructure for the transport and storage of CO2 and hydrogen) is an essential precondition to enable the adoption of several near-zero emission production technologies (IEA, 2022a, 2022b). However, the case studies show that the availability of both remains a major barrier in almost all the countries studied, at least for the time being. Nonetheless, almost all countries have a high potential for a zero-emission energy supply, that can become a necessary enabler once exploited (IEA, 2021). Additionally, several large EII producers, including the EU, the US, Norway, Saudi Arabia, India and Russia have a high potential for the application of CCS, both in terms of (potential) available storage sites and a high clustering of EII production sites (IEA, 2020).

Finally, the strong growth in global demand observed over the past decades 25 years and is expected to continue, driven by population and economic growth as well as the low-carbon transformation in other sectors. While the basic materials stock may eventually saturate in some industrialised economies, future demand growth will be particularly strong in emerging and developing economies (Bashmakov et al., 2022; IEA, 2022a). Decarbonising EIIs while satisfying the growing demand for basic materials, therefore, presents a major challenge at the global and country-specific leve. Accordingly, demand reduction strategies such as material efficiency or behavioural change can serve as an important enabler in that they reduce the overall demand for primary production as discussed above.

4.2 Paradigms and discourses

The emerging paradigm of green growth and the 'race to clean technology' is increasingly becoming an important driver of policy change in several, mainly industrialised countries. This can be observed in the US with the Inflation Reduction Act (IRA) and the EU through the publication of the Green Deal Industrial Plan (see European Commission, 2023), but also in Norway, Japan, China and to a lesser extent in India and Saudi Arabia. Furthermore, the development of EIIs, in terms of conventional as well as low-carbon production, is increasingly seen as an opportunity to drive economic diversification and development, in particular in, but not exclusive to, emerging and developing economies. For example, both Saudi Arabia as well as Norway acknowledge the potential of clean basic materials production to diversify their economy away from reliance on fossil fuel revenues (Kingdom of Saudi Arabia, 2022; Ministry of Trade, Industry and Fisheries, 2022), whereas clean metals production offers potential economic opportunities for South Africa (see Trollip et al., 2022). These paradigms are important because they shift the narrative from the decarbonisation of EIIs as being harmful to economic development towards a positive narrative of sustainable (and climate-friendly) economic development. This, in turn, changes policy perceptions and can trigger policy ambition and implementation.

At the same time, however, several paradigms continue to exist that pose barriers to decarbonisation. This encompasses paradigms of traditional industrial policy focused on maintaining competitiveness and innovation and fostering economic development, with little regard to climate objectives (Nilsson et al., 2021). These can be observed in most countries studied, although it seems to be shifting in several places as discussed above. Industrialised economies like the EU and the US have historically exhibited a general aversion towards strong industrial policies, which has slowed down the development of pro-active industrial climate policies over the last decades.

4.3 Polity

Polity captures the general setup and political system and bureaucratic institutions. Sufficient public sectoral capacity and expertise is an essential necessary condition to govern the complexities of the transformation of EIIs and ensure a stable and predicative investment climate (Bashmakov et al., 2022; Nilsson et al., 2021). The absence thereof, however, can be an important barrier to decarbonisation, which is the case for most of the developing countries observed, including South Africa, Morocco, Nigeria and Iran. Similarly, general political instability or prevalent corruption limits public sector capacity and undermines the investment climate and therefore poses a barrier to EII decarbonisation as well.

A challenge particular to EIIs is a mismatch between the globalised nature of EIIs and the international climate policy regime. Whereas the Paris Agreement foresees the implementation of climate action as a predominantly national responsibility, most EII producers are large multinational conglomerates operating in multiple countries (Khandekar et al., 2018). This constrains the effectiveness of national policies and poses the risk of potential carbon leakage, i.e. the relocation of industries to jurisdictions with less stringent climate policies (Åhman et al., 2022; Oberthür et al., 2021).

Similarly, within several countries competencies regarding industrial policy are dispersed across different levels of governance (e.g. US and EU), which can complicate and delay policymaking significantly. For example, in the EU Single Market rules constrain the ability of member states to provide direct subsidies (i.e. state aid) to industrial actors (Traversa & Sabbadini, 2022). Finally, institutional or regulatory barriers such as long permitting procedures or complex rules and procedures can slow down the deployment of new technologies, posing a barrier to EII decarbonisation in particular in industrialised countries such as the EU (Löfgren & Rootzén, 2021).

4.4 Politics

Politics captures the composition, relationships, power structures and vested interests of the actors involved in maintaining and changing the system. Regarding domestic politics, the public salience of climate change concerns in political debates and public support for climate action is an important enabler for policy change, also regarding the decarbonisation of EIIs. While this seems to be the case in most industrialised countries, climate change concerns tend to continue to be mainly absent in political debates elsewhere, including Saudi Arabia, Russia, Iran and Nigeria. Similarly, protectionism of strategic industries and related jobs continues to play an important role in domestic politics, often side-lining political calls for more stringent industrial climate policy. EIIs are often of high economic and strategic relevance for specific regions and have thus often been exempted from stringent environmental or climate legislation to avoid carbon leakage or a loss of economic competitiveness (Wesseling et al., 2017). In addition to that (and as a result thereof), vested interest and industrial lobbying against stringent decarbonisation policies continue to be an important barrier (Wesseling et al., 2017). This seems to be particularly the case in Russia, Saudi Arabia, Japan, Russia, Iran, and to a lesser extent in the EU, US and Morocco. Next to industrial lobbying, this also increasingly concerns broader discussions on the potential of negative implications of industrial decarbonisation, often captured in just transition debates. The sectoral transformation may lead to the relocation of EIIs and global value chains to regions with abundant renewable energy or CO2 storage potential (Samadi et al., 2021). While this offers economic opportunities for regions with such conditions, it also risks deindustrialisation and economic decline in other regions with potentially far-reaching socio-economic and political implications (Bataille et al., 2021; Swennenhuis et al., 2022).

At the same time, the opportunities associated with industrial decarbonisation are increasingly gaining traction in domestic politics, in particular in the US, the EU, Norway and China but also other emerging economies (see also above discussion on economic diversification paradigm). For example, the opportunities for high-quality job creation through industrial transformation are a strong focus of the IRA in the US and are also increasingly salient in the EU (Krebs, 2023). However, in the US and the EU the political aim of reaping the economic benefits of clean technology leadership and a focus on domestic sectoral transformation has led to an uprise of protectionist industrial policies (Kaufman et al., 2023). Finally, private sector support and action for industrial decarbonisation is becoming an important enabler in industrialised economies.

International politics can serve as a driver as well as a barrier to decarbonisation. International climate politics and the adoption of the Paris Agreement are important enablers as such in that they drive the development of domestic climate ambition and highlight the need for the sector to achieve near-zero emissions by around mid-century. Furthermore, international cooperation focused on industrial decarbonisation is an important enabler for the transformation of EIIs as such and a key lever to address several other barriers, both at the global and national level (Oberthür et al., 2021). For example, the engagement of national governments in international cooperation initiatives such as the Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (CEM-IDDI) or the Leadership Group for Industry Transition (LeadIT) can drive or support domestic efforts. Several of the countries studied are actively involved in such initiatives, including the EU, the US, India, Japan, South Africa, Turkey, Morocco, and Saudi Arabia (see Otto & Oberthür, 2022). Furthermore, policies adopted in one jurisdiction can serve as a driver or challenge to the decarbonisation of EIIs in another jurisdiction. For example, the adoption of the EU's Carbon Border Adjustment Mechanism (CBAM) is likely to have a strong impact on countries exporting a high share of their basic materials production to the EU's internal market, such as Turkey or Morocco, potentially impacting domestic politics, (Magacho et al., 2023; Pauw et al., 2022). While measures to address carbon leakage are an essential tool to mitigate EII emissions, their unilateral adoption can trigger trade conflicts (Kaufman et al., 2023; Moens & Mathiesen, 2023).

4.5 Policy

Policies, formalised rules and principles are essential to drive and enable the transformation of EIIs in that they guide and constrain the behaviour and decisions of relevant actors, such as EII producers and consumers of basic materials (Bashmakov et al., 2022; IEA, 2022a, 2022b). Our analysis of national policies presented Section 6 shows that policies are increasingly becoming an enabler (and necessary condition) for industrial transformation in many countries. However, while most countries have announced medium and long-term mitigation targets, only the EU, US, and Norway, have effective policies in place that could enable the deep decarbonisation of EIIs by mid-century. The policies and measures in place here are key enablers to advance the domestic decarbonisation of these countries and might have positive spillover effects to other countries, for example through accelerating the development of breakthrough technologies.

However, from a global perspective existing policies and measures remain insufficient to trigger the sectoral transformations at the speed and scale needed to reach near-zero emissions by mid-century (see IEA, 2022b; Boehm et al., 2022). While our analysis of national policies shows that all countries studied have policies in place that (in)directly contribute to decreasing emissions from EII production, their impact is limited and cannot enable the sectoral transformation needed. Instead, existing policies tend to focus on incremental changes, such as industrial energy efficiency or strongly rely on the application of CCS, focus on the latter being particularly strong in oil-producing countries such as Saudi Arabia and Norway (see Shehri et al., 2022; Ministry of Trade, Industry and Fishers). While CCS will be essential to achieve industrial decarbonisation, a strong reliance thereon carries the risk of fossil fuel lock-in and comes with significant challenges and risks (Bashmakov et al, 2022).

Finally, even where ambitious domestic climate policies are in place, EIIs continue to be largely exempted from their impacts to avoid carbon leakage (Wesseling et al., 2017), as is the case in the EU and Norway. In general, rather than driving decarbonisation, industrial policies tend to continue to focus primarily on driving economic growth and free trade, although this is slowly changing as already discussed above (Nilsson et al., 2021). Therefore, in most countries analysed, the absence of targeted policies for EII decarbonisation continues to be an essential barrier rather than a driver.

4.6 Economics

Economics captures conditions, restrictions and incentives affecting the ability of economic actors to adopt more climate-friendly solutions. Most importantly, the lack of commercial availability of near-zero emission technologies for basic materials production continues to be a major barrier to the decarbonisation of EIIs globally (Bashmakov et al., 2022; IEA, 2022b). Deep decarbonisation technologies exist in principle, but they remain in the demonstration or pilot phase and large-scale deployment is not expected until 2030, as shown in Table 2 (Bashmakov et al., 2022; Chiappinelli et al., 2021; Nurdiawati & Urban, 2021). Next to accelerating the development of such technologies, sufficient engineering capacity for their implementation can become a major barrier as well. Currently, demonstration and pilot plants exist mainly in Europe and the US, and function as important decarbonisations driver there. However, such technologies will be needed in particular in emerging and developing countries with future growth in basic material demand (Hermwille et al., 2022). Ensuring the transfer of these technologies beyond industrial countries is therefore a major challenge (Sovacool et al., 2023)

The adoption of deep decarbonisation technologies is hampered by long asset lifetimes and high capital investment needs (Löfgren & Rootzén, 2021; IEA, 2022a, 2022b; Nurdiawati & Urban, 2021). EII production plants have lifecycles of up to 40 years, with major refurbishment occurring usually every 10-20 years. Hence, windows of opportunity to implement new technologies are rather limited. At the same time, a significant share of EII production sites is reaching the end of its lifetime and needs to be replaced until. If these opportunities are not used to implement near-zero emission technologies, there is a strong risk to lock in fossil-fuel-based production routes for several decades (Agora Industry et al., 2021; Bashmakov et al., 2022; IEA, 2022a). This underscores to need to speed up the development and commercialisation of deep decarbonisation technologies mentioned above, to ensure their broad availability by 2030 (IEA, 2022b). Additionally, building EII production plants requires high capital investments, with low or near-zero emission production routes being more costly than conventional options. While Bashmakov et al. (2022) highlight that pathways to near-zero emissions industry could be realised with limited additional costs (pp. 72-73), transforming EIIs globally will require vast amounts of public and private investments (IEA, 2022b). This constitutes a crucial barrier, especially for emerging and developing countries.

Closely related, most near-zero emission technologies have higher operational costs vis-à-vis conventional production routes. Although the difference is likely to diminish in the future (and may already become locally competitive in the medium term under ambitious policies, e.g. in the US under IRA incentives), low-emission steel can be 20-40%, cement 70-115%, and basic chemicals 15-60% more expensive than if conventionally produced (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, making the availability of cheap and abundant renewable energy an important decarbonisation enabler (as observed in Norway). Additionally, basic materials are usually highly globally traded, subject to strong international competition with little product differentiation, resulting in limited profit margins (Åhman et al., 2017).

Taken together, the high operational costs, high capital investments and strong international competition significantly limit the business case for low-emission basic materials production and increase the economic risks for investments in breakthrough technologies (Bashmakov et al., 2022; Löfgren & Rootzén, 2021). In the absence of sufficient public support or incentives, this presents a major barrier to the implementation of breakthrough technologies by EII producers globally. Accordingly, explicit demand for near-zero emissions basic materials can be a key enabler for EII producers to implement decarbonisation strategies. Historically, major consumers of basic materials such as car manufacturers were not willing to pay the price premium for ‘greener’ materials (Chiappinelli et al., 2021; Wesseling et al., 2017). This seems to be changing, however, with many major basic materials customers committing to purchasing clean(er) basic materials, both private and public (e.g. First Movers Coalition, 2023). At the same time, the creation of distinguishable markets for green basic materials is a challenge in itself.

Table 3: Summary of decarbonisation barriers and enablers

	Barriers & Challenges	Enablers & Drivers
Structural Context	▪ Growing basic materials demand *CN, IN, SA, MO, NG, IR, TR; limited US, EU, others* ▪ Lack of fiscal means and governance capacity *ZA, NG, IR, MO* ▪ Limited availability of low/zero-carbon energy supply & supporting infrastructure (CCS, energy grids) *All countries* ▪ Domestic industrial decline/weak industry *ZA, RU, TR, NG, IR*	➢ Rich in natural resources and human capital *US, NO, CN, SA, IN, IR, NG* ➢ High fiscal and economic resources *EU, US, NO, JP, CN, SA* ➢ High potential for CCS (storage sites & clustering) *EU, NO, US, SA, IN, to a lesser extent RU* ➢ High potential for zero-emission energy supply *US, NO, CN, ZA, SA, RU, MO, NG, IR, IN*
Paradigms	▪ Priority of economic development over decarbonisation *JP, CN, SA, ZA, MO, NG to a lesser extent US* ▪ Traditional industrial policy *in particular EU, US, CN*	➢ Green Growth *EU, NO, US, CN* ➢ Clean technology leadership *US, EU, CN* ➢ Green EIIs for economic diversification/development *ZA, SA, NO, CN, IN, TR; limited MO, NG*
Polity	▪ Limited public sector capacity: *ZA, MO, NG, IR* ▪ Political instability, corruption *MO, NG, TR, RU, IR* ▪ Dispersed competencies regarding industrial policy *EU, US*	➢ Public sector capacity and expertise *EU, NO, JP, US* ➢ Stable investment climate
Politics	▪ Absence of climate action concerns *SA, RU, TR, NG, IR* ▪ Protectionism of strategic industries, trade conflicts *EU, US, CN* ▪ Vested interests & industrial lobbying *JP, ZA, SA, RU, IR; limited in EU, US, MO* ▪ Just transition concerns ▪ International isolation/sanctions *RU, IR*	➢ Salience of & public support for climate policy *EU, NO* ➢ Private sector ambition and action *EU, NO, ZA, US* ➢ International cooperation (on industry decarbonisation) *US, EU, SA, ZA, NO, IN, TR, MO* ➢ International climate politics, incl. CBAM *EU, US, TR, MO*
Policies	▪ Absence of EII decarbonisation policy *JP, SA, RU, TR, MO, IR* ▪ Policy exemptions for EIIs (e.g. carbon leakage) *NO & EU (until 2034)* ▪ Emphasis on innovation, energy efficiency, CCS over deep decarbonisation *JP, US, SA, IR, MO, to a lesser extent NG* ▪ Counterproductive policies (e.g. fossil fuel subsidies) *US, EU, JP, CN, NO, SA, MO, IR, NG*	➢ Medium & Long-term mitigation targets *EII specific: EU, NO, CN;* *Economy-wide: all countries except IR* ➢ Industrial decarbonisation policies & funding *CN, EU, JP, NO, US, IN; limited JP, TR, SA* ➢ Policies for energy supply and infrastructure *EU, JP, US, NO, CN, SA, TR, MO*
Economics	▪ Ltd. availability of breakthrough technologies *Global; in particular EU, US, NO* ▪ Long investment cycles & investment costs ▪ Higher operational costs *Global; in particular EU, US, NO, JP, CN, IN* ▪ International competition and trade pressures *ZA, EU* ▪ Technology engineering and production capacity ▪ Cheap fossil-fuel supply for EIIs (e.g. gas): *RU, SA, NO, NG, IR, IN, ZA, CN*	➢ Public support for investments *EU, NO, US* ➢ Development of breakthrough technologies *NO, EU, US; CCS in NO, SA* ➢ Private/public demand for NZE basic materials *emerging in US, EU, NO* ➢ Low-cost zero emissions energy supply ➢ Potential for EE improvements *CN, IN, RU, TR, ZA, MO, NG, IR* ➢ High intellectual capital

The analysis is based on the case studies, available in Annex 1.

4.7 Reflections

The above-presented analysis and the summary of national decarbonisation barriers and enablers presented in Table 3 show that decarbonisation barriers and enablers differ significantly across the countries studied. This underlines the argument that industrial decarbonisation pathways need to take into account country-specific contexts and local and regional decarbonisation barriers. At the same time, we can identify several mitigation barriers and enablers that are strongly present at the global level and that need to be addressed or exploited to put the sectoral transformation on track to reach near-zero emissions by mid-century.

Major global barriers remain the continued limited commercial availability of deep decarbonisation technologies and potential bottlenecks in their production, limited availability of abundant and cheap clean energy supply and lack of supporting infrastructure. Closely related, due to high investment and operation costs, limited demand and strong international competition, a clear business case to produce near-zero emissions basic materials remains lacking, limiting private sector incentives to adopt breakthrough technologies. Finally, as explored later in-depth, existing policies so far fail to trigger the sectoral transformation required for the deep decarbonisation of EIIs.

At the same time, we can identify several global enablers that are driving the decarbonisation of EIIs. This includes the increasing focus on the economic opportunities of industrial decarbonisation at the national and international level but has yet to materialise into concrete measures and actions. Recent national policy measures to accelerate the implementation of low-carbon production and the creation of lead markets, such as the IRA, can provide a push for global industrial decarbonisation if protectionist tendencies are addressed. International cooperation on industrial decarbonisation, focused on technology transfer, creating the right enabling environment, and addressing international competition and protectionism is another important enabler to advance the global sectoral transformation.

Furthermore, we observe strong differences across countries. The transition in high-income countries is mainly hampered by technology availability and lack of infrastructure, but most of these countries have existing industrial climate policies, ongoing pilot projects, sufficient governance capacity – albeit with limited expertise in state-led industrial policy – as well as strong economic and intellectual resources. However, recent protectionist tendencies of high-income countries risk undermining the global transition. Low- and middle-income countries often lack the political will, but also fiscal and governance capacity to proactively steer the sectoral transformation. At the same time, most low-income countries have high renewable energy or carbon storage potential, offering significant opportunities for economic development through green EIIs, and long-lasting experience with state-led industrial policy.

Finally, our analysis indicates that most existing decarbonisation barriers can be addressed and existing enablers exploited if the right policies are put in place. This highlights that achieving near-zero EIIs by mid-century is possible in principle, but requires comprehensive, timely, proactive and context-specific sectoral policies.

5 Interactions of industrial decarbonisation with the SGDs

The decarbonisation of EIIs can have positive as well as negative interactions, or co-benefits and trade-offs, for the achievement of the Sustainable Development Goals (SDGs) (Bashmakov et al., 2022: Denton et al, 2022; Roy et al., 2018). Table 4 highlights potential co-benefits and trade-offs across the six mitigation strategies outlined in Section 3 with the SDGs.

Potential co-benefits can serve as important enablers and drivers of the decarbonisation of EIIs, at the national and global level. First and foremost, the transformation of EIIs offers opportunities for economic development, with positive impacts on economic growth and job creation (SDG 8) and infrastructure development (SDGs 9 and 12). This potential exists in particular in countries with high potential for cheap clean energy or 'decarbonisation frontrunners' and early adopters of clean technologies (Bashmakov et al., 2022; Samadi et al., 2021). As shown in Section 4, most of the countries studied increasingly see the decarbonisation of EIIs as a specific opportunity to foster sustainable economic development and growth and diversification away from heavy economic reliance on fossil fuels. Second, mitigating EII emissions through electrification (with clean energy), fuel switching, or carbon capture can have direct positive impacts on air and water pollution supporting SDGs 3 and 6 and combatting climate change in general (SDG 13). Finally, energy efficiency measures can lower the energy consumption of EIIs, supporting local energy security and general access to energy (SDG 7), which can further foster economic growth (SDG 8). Similarly, material efficiency improvements and circular economy measures lead to less material use and waste (SDGs 12 and 6), while offering possibilities for the creation of new business models (SDG 8), while generally decreasing pressures and negative impacts on the natural environment.

Table 4: Interactions of mitigation strategies with the SDGs

Mitigation Strategies	Interactions with Sustainable Development Goals																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Demand reduction						+		o	+			+	+				
Material Efficiency						+		o	+			+	+				
Circular Economy			+			+	+	+			+	+	+	+	+		+
Energy Efficiency			+				+	+	+				+				
Electrification & fuel switching	o	o	+		+	-	o	+					+		-	-	
Carbon Capture and Utilisation or Storage			o			-	o	+	+		+		o		-		

Explanation:
+ co-benefits
- trade-offs
o both co-benefit and trade-off

Sustainable Development Goals
1 No poverty
2 Zero hunger
3 Good health and wellbeing
4 Quality education
5 Gender equality
6 Clean water and sanitation
7 Affordable and clean energy
8 Decent work and economic growth
9 Industry, innovation and infrastructure
10 Reduced inequalities
11 Sustainable cities and communities
12 Responsible consumption and production
13 Climate action
14 Life below water
15 Life on land
16 Peace, justice and strong institutions
17 Partnership for the goals

Source: based on Denton et al., 2022, Figure 17.1, p. 1762; Bashmakov et al., 2022; Roy et al., 2018.

Potential trade-offs of industrial decarbonisation with the achievement of the SDGs pose significant decarbonisation barriers that need to be addressed through adequate policies and measures. Whereas decarbonisation can offer economic opportunities as discussed above, it can also lead to regional economic decline (SDG 8), stranded assets (such as unused fossil–fuels, and production facilities) and job losses if affected regions fail or are unable to adapt their industries in time (Nilsson et al., 2021). Another core challenge is the high demand for zero- or low-emission energy, alternative feedstocks and water (for the production of green hydrogen) required to enable electrification and fuel switching as well as the application of CCS. This can potentially lead to pressures on local and regional energy and water systems, in particular in places with already limited access to energy, potentially having negative impacts on the achievement of SDG 7, 6 and 1 (Bashmakov et al., 2022; Woods et al., 2022). Closely related, an increase in the use of biomass as alternative fuel and feedstock in cement and chemicals production can lead to conflicts over the use of biomass, land, and deforestation with potential negative impacts on SDGs 2, 13, 15 and 16. Finally, the application of CCUS does not only require vast amounts of energy (SDG 8) but also carries the risk of CO2 leakage, with potential negative effects on climate mitigation efforts (SDG 13) and biodiversity (SDG 14 and 15).

Finally, the green industrial transformation also offers opportunities to strengthen gender equality within the sector (UNIDO, 2019). Historically, the benefits of industrialisation have not been equally enjoyed by men and women. While women are often precluded from well-paid jobs in manufacturing and technology development, they are over-represented in low-skill, low-tech sectors such as textiles, food processing or electronics and shoulder most of the domestic care work. This gender-biased division of labour is thereby particularly prevalent in EIIs. Green industrial policies, and in particular circular economy measures, can reduce gender inequality through high quality job creation for women, but can also reinforce existing gender hierarchical structures. At the same time, the inclusion of women in previously precluded industrial sector can support the sectoral transformation by making full use of the richer and more diverse skill set that come a long with a more inclusive workforce. Promoting gender equality requires pro-active efforts towards enabling women to participate in new sectors and roles, including EIIs and clean technology development (UNIDO, 2019).

6 Policies and Measures

This section analyses if the 13 countries studied have adequate policies in place to put their domestic EIIs on track to achieve near-zero emissions by around mid-century. To do so, we first synthesise the relevant literature on policies and measures needed to put EIIs on track for near-zero emissions by mid-century. Next, we assess the extent to which such policies and measures are reflected in national policy mixes and identify remaining gaps. Finally, the overall findings are discussed and general observations on how to improve policy frameworks are provided.

6.1 Policies for the deep decarbonisation of energy-intensive industries

Academic analysis and pathways modelling has extensively explored specific policies and measures to bring about these transformation changes (e.g. Bashmakov et al., 2022; Bataille, 2020; Bataille et al., 2018, 2021; IEA, 2022a, 2022b; Rissman et al., 2020; Wyns et al., 2019). Relevant policies and measures commonly include GHG pricing coupled with border adjustments or other economic signals for trade-exposed industries, robust government support for research, development and deployment, energy, material and emissions standards, recycling policies, sectoral technology roadmaps, market pull policies, support for new infrastructure, and inclusive and transparent governance processes (see Bashmakov et al., 2022, pp. 1211-1213). While this provides relevant guidance for industrial policy design, the far-reaching transformation of existing socio-technical systems, existing value chains, and economic structures needed to achieve the deep decarbonisation of EIIs, requires a comprehensive and interrelated mix of regional, national and international policies that focus on long term sectoral transitions (Bashmakov et al., 2022; Rissman et al., 2020).

To bring about these transformative changes in a structured and comprehensive manner, Nilsson et al. (2021) have proposed an industrial policy framework building on several pillars (or topics), each addressing key barriers to the decarbonisation of EIIs (see also Bashmakov et al., 2022). This includes:

(1) **policy commitment and pathways**, to provide directionality and certainty to relevant actions,
(2) **technology innovation and deployment**, to accelerate the development and commercialisation of breakthrough technology,
(3) **(re-)shaping** basic materials **markets** to increase the competitiveness of low-carbon options,
(4) **policy coherence and integration** with other sectors and international coherence, and,
(5) **public capacity and knowledge** to enable the proactive governance of the transition.

Each of these pillars fulfils certain policy functions, or levers, aimed at addressing specific decarbonisation barriers or amplifying enablers. Each policy function can thereby be achieved through different policy instruments, as discussed in more detail below and illustrated in Table 5.

The first pillar of *policy commitments and pathways* encompasses the provision of clarity and guidance on the direction and speed of the transformation and long-term finance through national policy. The former can be provided through economy-wide or sector-specific decarbonisation targets, visions, strategies, or roadmaps, that consider interdependencies with other sectors. Such planning instruments provide certainty to relevant actors, such as EII producers, and are important to enable investment decisions given the long asset lifetime and high investment needs inherent to the sector (see Bashmakov et al., 2022; Agora Industry et al., 2021). Clarity and guidance should be accompanied by stable, sufficient and long-term finance for investments in the decarbonisation of the economy and the development of the required supporting public infrastructure, such as energy grids or CO2 transport and storage facilities (Nilsson et al., 2021; IEA, 2022b).

Table 5: Policy functions to enable the deep decarbonisation of EIIs

Pillar	Policy Functions	Possible Policy Instruments and Measures
Policy Commitment & Pathways	**Clarity and guidance** on direction and speed of transformation.	- Mitigation targets, laws defining overall policy direction/ambition - Economy-wide decarbonisation plans/strategies highlighting sectoral interdependencies - Detailed EII sector-specific plans/roadmaps and mitigation targets
	Long-term finance to enable sustained investments and reduce investment risks.	- Long-run, low-cost finance mechanisms to enable investment and reduce risks - Funding for the development of infrastructure & energy supply - International financial support for emerging and developing economies
Innovation, Demonstration & Deployment	**Enhance public RD&D** for breakthrough technologies to reduce innovation costs and risks for industry.	- Public RD&D policies, incl. funding of basic research, pilot and demonstration plants - Support for innovation in business models & structures throughout value chains - Promoting stakeholder collaboration & knowledge exchange
	Accelerate early commercialisation, and deployment of breakthrough technologies to ensure availability by 2030.	- public support for commercialisation: pilot projects, demonstration projects, early commercialisation - Direct production subsidies - Carbon contracts for difference - Support for education and training, incl. re-skilling
(Re)-shaping markets	**Creation of demand** for low-emission basic materials through demand-pull policies.	- Public and private procurement (i.e. for steel & cement) - Green labelling - Subsidies, tax incentives, carbon contracts for difference - Standards and quota obligations - Reducing market entry barriers for new business models
	Reshaping existing markets to increase the competitiveness of low-emission basic materials.	- GHG pricing, taxes, and other financial incentives - Performance standards & codes, incl. emission intensity requirements - Phase out of fossil-fuel and other harmful subsidies. - Sunset clauses for specific production technologies, or retrofit ready requirements
	Transparency and information of basic materials and value chains.	- GHG content certifications & carbon footprint tracing - Labels for green materials, incl. definitions - Third party certification schemes
Policy coherence and integration	**Reducing demand** and **enhancing circularity**.	- Material efficiency requirements, incl. performance standards & codes - Circular economy measures incl. enhanced recycling - Extended producer responsibility - Downstream demand reduction policies, e.g. car-sharing, sufficiency
	Planning and construction of **low-emission energy supply** and relevant **infrastructure.**	- Public infrastructure planning, financing and construction - RE and hydrogen support policies - Energy efficiency in industry (to reduce industrial energy demand) - CO2 transport and storage infrastructure policies
	Ensure **international coherence** of national policies.	- International cooperation on technology development and transfer - Measures addressing international competition and carbon leakage - Common standards and rules, e.g. on labels
	Addressing **socio-economic implications** and phase-outs related to industrial decarbonization.	- Just transition policies, incl. transitional assistance policies - Structural policies: flexible labour markets, welfare policies - Governance of phase-outs - Workforce re-skilling
	Supportive and stable **regulatory environment**.	- Streamlining regulatory requirements - Enforcement mechanisms
Knowledge & Capacity	Sufficient **public managerial and bureaucratic capacity** to enable proactive governance of the transformation.	- Institutional capacity to understand challenges of transformation in government bodies - Active co-oversight of firms, sector associations and other actors - Facilitating stakeholder engagements
	Comprehensive **monitoring and evaluation** of progress and emission development.	- Systems for monitoring & evaluation - GHG inventories, including specific monitoring of industrial emissions - New indicators for industrial policy implementation (beyond GHG emissions)

Framework based on Nilsson et al., 2021 & Bashmakov et al., 2022. Policy Instruments and measures based on Bashmakov et al., 2021; Bataille, 2020; Bataille et al., 2021; IEA, 2022a, 2022b; Nurdiawati & Urban, 2021; Rissman et al., 2020; Wyns et al., 2019.

The second pillar focuses on the provision of public support for *innovation, demonstration and deployment* of the low-emission technologies outlined in Table 2. This includes public support for research, development & demonstration (RD&D) projects to advance the maturity of breakthrough technologies. Furthermore, this includes policies specifically aimed at accelerating the commercialising and large-scale deployment of promising technologies, such as direct production subsidies or tax incentives, but also an increase in the production capacity of such technologies and the re-skilling of the workforce. The timely exploitation of these functions is essential to accelerate the development and uptake of deep decarbonisation technologies by reducing innovation costs and risks for EIIs (Sovacool et al., 2023).

Third, it will be essential to *reshape national and global markets* for basic materials to enhance the competitiveness of near-zero emissions options compared to conventional production methods. Demand-pull policies, such as green public procurement, subsidies, tax incentives, standards or quota obligations, are essential to develop and upscale lead markets for green basic materials (IEA, 2022b). This pillar further entails the reshaping of existing markets through emissions pricing or the phase-out of unproductive subsidies. Informational policies, such as GHG content certifications, can enhance transparency and information and enable consumers to make more informed choices (Bashmakov et al., 2022).

The fourth pillar encompasses several functions relevant to ensure broader *policy coherence and integration* of EII decarbonisation vis-à-vis other sectors and policy domains (Bashmakov et al., 2022). First, this includes policies aimed at reducing or managing demand for primary production, including increases in material efficiency, circular economy measures, behavioural changes and better recycling (Agora Industry, 2022). Second, the build-up of a stable and low-cost clean energy supply (e.g. renewable electricity, green hydrogen) and the related infrastructure, such as CO2 transport and storage networks and transmission grids, needs to be planned, financed and developed to enable the adoption of new technologies (IEA, 2022b). Third, possible socio-economic implications related to the decarbonisation of EIIs, including possible phase-outs and stranded assets, need to be addressed to ensure a just transition (Swennenhuis et al., 2022). Finally, given the globalised nature of basic materials markets and many EII actors as well as high international competition, it will be important to ensure international coherence of national policies and decarbonisation visions to avoid carbon leakage and ensure a global transformation (Åhman et al., 2017, 2022; Oberthür et al., 2021).

Finally, the *knowledge and capacity* pillar encompasses sufficient public managerial and bureaucratic capacity to design, implement, monitor compliance and evaluate the policies mentioned above (Bashmakov et al., 2022). Given the complexity of the task at hand, public institutions must be able to proactively steer and govern the sectoral transformation in close cooperation with relevant stakeholders. This requires the build-up of public (and private) institutions tasked with overseeing the industrial transformation that are sufficiently funded and staffed. Public institutions must thereby in particular increase their capacity and expertise to implement complex measures such as green public procurement. Comprehensive monitoring and evaluation processes are essential to keep track of mitigation progress and ensure accountability.

6.2 Analysis of national industrial decarbonisation policy frameworks

To analyse if national policy frameworks are fit for purpose to trigger the needed sectoral transformations, we mapped existing policies for all 13 countries (as of June 2023). We then assessed to what extent existing policies exploit the policy functions introduced above on a low, medium, to high scale. This approach allows us to assess and directly compare the strengths and weaknesses of individual policy frameworks and identify areas where more policy action is needed more comprehensively, for several reasons. First, the policy functions directly correspond to the decarbonisation barrier and enablers identified above and therefore allow to assess if and how these are addressed or exploited in a given national context. Second, assessing if a specific policy function is exploited, rather than comparing specific policies directly, allows for a better cross-comparison of national policy frameworks, given the high diversity of political systems assessed. The assessment is summarised in Table 6. The country-specific assessments are provided as part of the Case Studies in Annex 1.

Overall, the analysis shows that while all countries studied have relevant industrial climate policies in place, these generally fall short of triggering the transformational changes needed for the deep decarbonisation of the sector. On the one hand, most countries have long-term mitigation targets and are developing EII-specific decarbonisation roadmaps. indicating political interest in accelerating industrial decarbonisation. On the other hand, existing policies, with few exceptions, do not go beyond incentivising incremental changes. Therefore, at large, existing industrial climate policy frameworks remain insufficient to trigger the sectoral transformations needed to put EIIs on a Paris Agreement-compatible pathway. At the same time, our analysis reveals strong differences across policy frameworks in terms of income level, country-specific context and policy functions.

First, we observe strong differences across existing industrial climate policies across the 13 countries. Somewhat unsurprisingly, the high-income industrialised countries EU, US and Norway have the most advanced policy frameworks, exploiting the different policy functions to the largest extent. In these countries strong policies are in place to trigger a transformation of EIIs, albeit policy approaches differ significantly. While the US focuses primarily on economic incentives for the development and uptake of new deep decarbonisation technologies, the EU and Norway have a more regulatory approach to the decarbonisation of EIIs mainly driven by the EU Emissions Trading System (ETS) and the Modernisation Fund focused on enhancing innovation. China and India have comprehensive and proactive industrial decarbonisation policies in place. Both have long-term sectoral decarbonisation visions and industrial energy efficiency policies, are implementing (China) or considering (India) carbon markets and China intends to peak EII emissions before 2030. These policies can lead to considerable domestic emissions savings, which is essential given their relevance to global EII emissions, but it is unlikely that they will lead to deep sectoral decarbonisation.

In contrast, industrial climate policies in most other middle-income countries focus on incremental changes such as increasing energy efficiency, renewables uptake or improving emissions monitoring. These policies can lead to relevant mitigation achievements but are insufficient for deep sectoral decarbonisation. Here, the development and implementation of more ambitious policies seem to be particularly challenged by powerful political forces resting the transformation, but also a lack of public fiscal and governance capacity. This stark difference in industrial climate policy framework and the lack of transformative climate policies in most middle-income countries risks undermining the global transformation of the sector. Especially when considering that the majority of EII emissions growth is expected to occur in these countries (see Sovacool et al., 2023).

Table 6: Assessment of national policy frameworks against the policy functions

Pillar	Policy Function	High income					Upper-middle income				Lower-middle income			
		US	EU	NO	JP	SA	CN	RU	TR	ZA	IN	MO	NG	IR
Policy Commitment & Pathways design	Clarity & guidance	o	+	+	o	o	o	o	o	o	o	o	o	-
	Long term finance	+	+	+	+	o	+	-	-	o	o	o	-	-
Innovation	Enhance public RD&D	+	+	+	o	o	o	o	-	o	n.a.	-	-	-
	Early commercialisa tion	+	o	+	o	o	o	-	-	o	n.a.	o	o	o
(Re)-shaping markets	Demand-pull	+	o	n.a.	-	-	o	-	-	o	-	-	-	-
	Reshaping markets	-	+	+	o	-	o	-	-	o	o	o	-	-
	Transparency & information	o	o	n.a.	o	n.a.	o	o	o	o	n.a.	o	o	-
Policy coherence & integration	Reducing demand	-	o	n.a.	o	-	-	-	-	-	o	-	-	-
	Energy supply & infrastructure	+	o	+	+	o	o	-	o	o	o	o	o	-
	International coherence	o	o	o	+	o	-	-	o	o	+	+	-	-
	Socio-economic implications	o	o	o	o	n.a.	n.a.	-	n.a.	o	o	o	-	-
	Regulatory environment	o	+	+	+	o	+	-	o	-	n.a.	-	-	-
Knowledge & Capacity	Public capacity	o	+	+	o	o	+	-	o	-	n.a.	o	o	-
	Monitoring and evaluation	o	+	+	+	o	o	o	o	o	n.a.	o	o	o

Explanation of assessment scale: The exploitation of each function by existing national policies and measures (as of June 2023) was assessed on a weak – medium – strong scale, whereas:

Strong exploitation (+): function is exploited through comprehensive policies, sufficient funding and enforcement mechanisms. No unproductive policies are in place or those are being phased out.

Medium exploitation (o): some policies are in place but do not fully exploit function. Gaps exist, or policies are not backed by enforcement or sufficient funding. Unproductive policies are still in place.

Weak exploitation (-): no policies exploiting function are in place. Unproductive policies are in place. Relevant barriers are not addressed.

N.a.: no information available, exploitation of function could therefore not be assessed.

The analysis is based on the case studies, available in Annex 1.

Second, we find that the exploitation of the pillars respective policy functions differs significantly, as shown in Table 6. While the policy commitment and innovation pillars are exploited to the largest extent, we find only very limited exploitation of the (re-)shaping markets pillar and a mixed picture regarding the remaining two pillars of policy coherence and knowledge and capacity.

The policy commitment and pathways pillar, and in particular the clarity and guidance function, is the most exploited of all functions assessed. Almost all countries have long-term mitigation targets and EII decarbonisation visions in place or are developing such, although they differ significantly in their ambition, detail and legal bindingness. This provides important clarity and guidance for the relevant (national) actors on the direction and speed of sectoral transformation and is an important lever to accelerate industrial decarbonisation globally. The EU, Norway, China and South Africa even have sector-specific decarbonisation targets or carbon budgets in place. However, it is to be noted that the credibility and political stability of policy commitments vary. To illustrate, while the EU or Chinese targets are anchored in legislation or policy and thus have high credibility, the US targets could potentially be reversed depending on the 2024 presidential election. Long-term finance mechanisms to enable investments and infrastructure development, in contrast, are lacking or insufficient in almost all, but in particular middle-income countries. Considering the high investment requirements for the deep decarbonisation of EIIs, this lack of sufficient finance risks undermining the implementation of decarbonisation pathways, in particular in middle-income countries (see also Sovacool et al., 2023).

Second, the innovation pillar policy functions are being strongly exploited in the US, the EU and Norway and to a lesser extent in Japan, China and Saudi Arabia, but are lacking in all other middle-income countries. However, strong policies to drive innovation and commercialisation of breakthrough technologies in high-income countries might be sufficient to ensure the broad availability of deep decarbonisation technologies by around 2030 (IEA, 2022b). Given the limited economic capacity of most middle-income countries, it might be appropriate to focus on the exploitation of different policy functions here, especially when considering equity considerations under the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC). It is important that the transfer of breakthrough technologies to emerging and developing economies is ensured through domestic policies (in high-income countries) and international cooperation (Oberthür et al., 2021; Sovacool et al., 2023). Yet such mechanisms remain lacking, presenting a serious gap (Otto & Oberthür, 2022).

Third, we find a very mixed picture regarding the exploitation of the (re-)shaping markets pillar. First, public demand-pull policies and private procurement for green basic materials (mainly for steel) are emerging in the US and the EU. However, it remains to be seen if this will create a significant demand-pull effect domestically, but also beyond these countries. In contrast, strong tendencies towards more protectionist industrial policies can be observed in the EU, the US and other relevant major basic materials importers such as China, suggesting the opposite regarding the latter (see Kaufman et al., 2023). To exploit this function beyond industrialised countries, emerging lead markets need to be opened to emerging and developing economies. Second, policies to reshape existing markets are hardly exploited. Emissions pricing mechanisms exist in several countries, including the EU, Norway, Japan, and South Africa, and are under development or political consideration in China, India, Turkey, and Morocco (see also World Bank, 2023). However, emission prices generally remain too low to have a relevant impact or include exemptions for EIIs to prevent carbon leakage. The EU ETS, which also covers Norwegian EIIs, remains the sole exception with prices of around EUR 80/tonne of CO2eq through 2022 and the phase-out of (still existing) exemptions for EIIs until 2034. Additionally, from 2026 onwards the EU will apply a carbon tariff to imports of carbon-intensive goods (including steel, cement, aluminium and fertilisers), which might also trigger EII mitigation beyond the EU (Magacho et al., 2023; Pauw et al., 2022). However, at large, policies aimed at reshaping existing markets are insufficient, while counterproductive policies such as fossil-fuel subsidies continue to exist in all countries studied (OECD & ISSD, 2023). Finally, policies to increase the transparency and information of basic materials are so far lacking but are planned as part of industrial climate policies in some countries, including the US, the EU, or Morocco. Overall, the availability of data and information on basic materials supply chains and embedded emissions remains limited.

The policy integration pillar functions are exploited to differing extents. First, we could identify only very few policies aimed at reducing demand for primary basic materials. The EU, Japan, or India have general circular economy strategies in place that aim on increasing the circularity of materials flows and secondary production. However, policies to incentivise emissions savings through material efficiency requirements are behavioural change or generally lacking, leaving this mitigation potential hugely underexploited. In contrast, almost all countries studied have adopted ambitious policies to increase the supply of clean energy and related infrastructure, including support for renewable energy uptake, industrial energy efficiency policies and infrastructure development. While some room for improvement continues to exist almost everywhere, existing policies are likely to lead to a significant increase in the availability of clean energy globally, addressing one of the crucial barriers to the decarbonisation of EIIs.

Furthermore, most countries studied are actively involved in international cooperation on industrial decarbonisation, which carries a high potential to support the decarbonisation of EIIs globally (Oberthür et al., 2021; Otto & Oberthür, 2022) and is also an important transformation diver from a national perspective as discussed in Section 4. On the other hand, high-income industrialised countries that are increasingly turning to protectionist industrial policies, aimed at exploiting the potential of clean technology leadership (see IRA in the US), sheltering domestic EIIs from carbon leakage pressures (see CBAM in the EU), or fostering domestic production growth (see China). To avoid that these protectionist tendencies undermine the global sectoral transformation, it will be essential to further strengthen international cooperation. The regulatory environment was found to be stable in high-income countries, whereas lower-income countries struggle with the implementation and enforcement of existing policies and measures, as already discussed in Section 4. Finally, regarding socio-economic implications and phase-outs, we could not identify targeted policies beyond general just transition policies or concerns mentioned in general strategies in most countries. In particular, the governance of potential phase-outs of fossil-fuel-based production facilities remains largely underregulated.

Finally, we evaluate the exploitation of the public capacity and knowledge pillar as only medium on average. Most countries have institutions overseeing the development of climate policy, but their competencies and resources differ significantly (Peterson et al., 2022). Specific government expertise and capacity to manage and govern the complexities and challenges of industrial decarbonisation remains scarce across all countries, including high-income countries. While countries with a strong history in state-led industrial policy, such as China, India or Turkey, might be better placed in this regard, this has so far mainly focused on economic development and not GHG mitigation. Room to improve collaboration among governments and stakeholders exists in all countries, with some lacking institutionalised mechanisms for this in the first place. Finally, almost all countries have national GHG emission monitoring systems in place, although significant differences continue to exist and only a few countries specifically monitor emissions from EII production sites (e.g. EU and South Africa).

To conclude, existing industrial climate policies and measures focus mostly on incremental changes and, to a large part, fail to exploit the policy functions needed to trigger the deep decarbonisation of EIIs. The EU, Norway and the US are somewhat an exception given that here transformative policies are emerging. These policies hold potential to advance industrial decarbonisation globally, but this is undermined by increasingly protectionist tendencies and gaps in international cooperation. Despite technological advances and the growing political focus on industrial decarbonisation, national policy frameworks therefore do not seem to be fit for purpose to put national EIIs on Paris-compatible pathways. This highlights the need for more comprehensive and transformative industrial climate policies and accompanying measures.

6.3 Potential to strengthen sectoral climate policy

The analysis presented above shows that national industrial climate policies are not fit to decarbonise EIIs by mid-century. Most industrial climate policy frameworks fail to go beyond incremental changes and emissions reductions and significantly fall short of triggering transformative change. Therefore, more ambitious and radical industrial climate policies are needed to achieve a Paris-compatible pathway for EIIs. Given the space and resources available it is beyond this paper to provide country-specific recommendations to that end, but some country-specific policy recommendations are provided in the case studies (see Annex 1). Nonetheless, the analysis presented in this paper allows us to make some general observations on how to advance the global sectoral transformations of EIIs.

First, our analysis shows that the deep decarbonisation of EIIs is possible, but requires ambitious, proactive, and radical industrial climate policies that address national barriers and exploit opportunities. Although existing policies fall short of triggering transformative change, they are nonetheless essential enablers of sectoral mitigation already. Additionally, most countries studied have developed ambitious decarbonisation plans and visions for their domestic EIIs, which signals an increased political interest in and focus on industrial decarbonisation and the economic benefits this can bring along. This highlights the need to advance and intensify political, academic, and private sector engagement with industrial climate policies and related opportunities and challenges.

Second, the lack of policies and measures focused on material efficiency, enhancing circularity, and increasing the transparency of basic material flows is leaving huge emissions savings potentials underexploited. Governments need to increase focus on developing and implementing such policies, accompanied by strong research support to further explore potential and specific instruments. Such policies are becoming more and more crucial given the expected increase in global demand for basic materials.

Third, high-income countries need to further strengthen measures aimed at accelerating the development and early commercialisation of breakthrough technologies. Next to support for research and innovation, this includes the development of demand-pull mechanisms and technology transfer towards emerging and developing economies, including through international cooperation (see also Sovacool et al., 2023). At the same time, high-income countries should avoid adopting protectionist measures and instead focus on international cooperation and partnerships to prevent a costly global subsidy race and, most importantly, avoid the danger of low- and middle-income countries being left behind in the industrial transformation.

Fourth, given the high complexity of industrial decarbonisation, public capacity and expertise to govern and steer the industrial transformation need to be strengthened. This encompasses the build-up of general capacity to monitor and enforce compliance with existing policies and rules, but also specific expertise related to the specific challenges and opportunities of industrial decarbonisation and engagement with relevant stakeholders.

Finally, our findings underline the need to further strengthen international cooperation on industrial decarbonisation. International cooperation holds the potential to advance technology transfer, create international lead markets for green materials, set general framework conditions such as common standards and definitions, and address carbon leakage and international competition (Oberthür et al. 2021; Otto & Oberthür, 2022, 2023).

7 Conclusion

This study identified national barriers, enablers and policies relevant to the decarbonisation of EIIs for 13 major EII producing countries. Additionally, it was assessed if existing national industrial climate policies are sufficient to put domestic EIIs on track to achieve a Paris-compatible pathway. Overall, we find that this is not the case. Existing industrial climate policies, with few exceptions, fall short of triggering the transformative change required for deep sectoral decarbonisation, but instead focus on incremental changes and limited emissions reductions. Existing policies furthermore mostly fail to sufficiently address major barriers to the decarbonisation of EIIs such as an increase in demand, low competitiveness of green basic materials, lack of fiscal and governance capacity or sufficient clean energy supply and supporting infrastructure. Decarbonisation enablers, such as opportunities for economic development, international cooperation, or proactive industrial climate policies remain mostly underexploited as well. At the same time, our analysis shows that existing decarbonisation barriers can be addressed, and existing enablers exploited, if the right policies are put in place.

This shows that more ambitious, proactive, and radical industrial climate policies are needed to put the sector on track to achieve a Paris-compatible pathway. Achieving this will require further engagement by policymakers, academics, researchers, and industry on the design of the required policies and mechanisms to government the transformation of the industry sector and EIIs specifically. Particular attention thereby needs to be given to policies focused on demand reduction, material efficiency and circularity strategies, the build-up of public capacity to steer the industrial transformation as well as the opportunities of international cooperation, as these elements remain particularly underexploited.

The empirical findings of the study thereby serve as an important input to this discussion, although they only provide a snapshot of the state of national sectoral decarbonisation barriers and enablers and industrial climate policies. Nonetheless, the detailed systematic assessment and comparison of national industrial decarbonisation barriers, emerging opportunities and gaps in policy frameworks for 13 major EII producing countries in a systematic manner provide relevant input and considerations for (national) policymakers and further academic research. This study, therefore, provides a highly relevant and timely contribution to the discussion on industrial decarbonisation.

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Annex 1 – Country Case Studies

This annex contains the country case studies of national barriers, enablers and policies relevant to the decarbonisation of energy-intensive industries (EIIs). These case studies were conducted from June 2022 to June 2023 and based on existing relevant literature, official government documents (e.g. reporting under the UNFCCC), grey literature as well as specialised news reporting. The case studies were either conducted or reviewed by national or sectoral experts to ensure a high validity and reliability of results.

Each case study contains an assessment of national industrial climate policies for the 13 countries studied for this paper. For each country it is assessed to what extent the policy functions presented in Section 6.1 and Table 5 are exploited by existing national policies and measures, on a weak, medium to strong scale:

Strong exploitation (+): function is exploited through comprehensive policies, sufficient funding and enforcement mechanisms. No unproductive policies are in place or those are being phased out.

Medium exploitation (o): some policies are in place but do not fully exploit function. Gaps exist, or policies are not backed by enforcement or sufficient funding. Unproductive policies are in place.

Weak exploitation (-): no policies exploiting function are in place. Unproductive policies are in place. Relevant barriers are not addressed.

Overview of case studies

Note: This Annex was updated on 3 July 2023 to include an expert review of the Russia case study.

China

Annika Tönjes (Wuppertal Institute for Climate, Environment and Energy), with support from Stefanie Lill (Wuppertal Institute for Climate, Environment and Energy), 6 June 2023.

Big picture: Current EIIs-sector decarbonisation status and prospects

Sectoral GHG emissions

Industry accounts for about 59% of China's final energy consumption; half of direct energy use in industry comes from unabated coal (~70% of China's total coal consumption). EIIs account for about 20-25% of China's total emissions. Emissions from industry are growing, largely due to steel and cement production for real estate and infrastructure construction. China's overall target is to peak emissions before 2030. While there is a proposal to peak emissions from EIIs like steel, cement, aluminium and chemicals before 2025, a recent guidance on the steel sector sets the more conservative deadline of peaking by 2030 (*Policies & action, 2022;* Hongqiao, 2022).

Sub-sector relevance for national economy

Global cement demand largely driven by China and other Asian countries (together responsible for 80% of cement production in 2014); responsible for more than half of global steel production in 2018 (Rissman et al., 2020); "China's economic growth is dominated by the industrial sector at the industrialization stage. […] sectoral employment accounts for 30 percent of China's total employment, and that industrial value added accounts for nearly 40 percent of GDP, etc. China's industrial sector has developed rapidly over the past three decades, which was mainly driven by the accelerating speed of industrialization and urbanization. […] The importance of industrial sector also highlighted by its role in providing raw materials for meeting the massive infrastructure needs during urbanization process. […] iron and steel industry of China (ISI) produced 683.9 million tons of crude steel in 2011 […], which ranked first in the world and accounted for 45.1% of the world's total production. […] Cement production of China was 2058 million tons in 2011 […] and ranked first in the world" (Ouyang & Boqiang, 2015).

Transition phase

China's industry sector is best described as still being in the lock-in phase (high coal dependence, sectoral emissions still increasing).

Current general national trends that promote or hinder decarbonization

Decarbonisation is secondary to economic growth. Focus on first peaking emissions, then moving to net-zero. The Chinese approach to climate policy can be characterized as follows: pragmatic with a focus on concrete actions instead of increasing ambition, "under-promise and over-deliver" (China's current policies are more ambitions than its NDC targets), internationally "common but differentiated responsibilities", decarbonisation as a lever for high-quality economic development, transformation driven by both administrative orders and market-based mechanisms (Hongqiao, 2022). Focus on rapidly increasing renewables but not on ending fossil fuel dependency (*Country summary*, 2022).

National sectoral mitigation drivers and barriers

Drivers

Structural context: sizable solar PV and onshore wind potentials (Burandt et al., 2019); "renewables, particularly wind and solar power, have outpaced the capacity addition of coal power in recent years […] In 2018, China ranked first in the cumulative installed capacity of wind power and solar PV" (Hayashi, 2020)

Paradigms/discourses: effective policy for emissions reduction from industry is compatible with development goals (Rissman et al., 2020); reducing coal use goes hand in hand with tackling serious health issues caused by local air pollution (Burandt et al, 2019)

Politics: green technology race (intensified lately by US IRA, EU NZIA --> could speed up RD&D?)

Policies: dual carbon targets of peak emissions before 2030 and carbon neutrality by 2060; target share of non-fossil energy within China's energy mix; "development of wind turbine and PV manufacturing industries […] is largely influenced by government targets and policy support[…][, demonstrating] how public policy influences the growth of innovation capabilities in clean energy industries (Hayashi, 2020).

Economy: great remaining potential for cost-saving efficiency improvements (Rissmann et al., 2020); "China can mass manufacture very cheaply. This is not necessarily because China is better at mass production than other regions, but because it does it at such large scale, given its huge domestic market" (Wong et al., 2023).

Technology: proven green innovation capabilities: **"**Since the mid-2000s, China has witnessed a sharp increase in wind power and solar PV technology patents; moreover, Chinese manufacturers are among the top patent holders in the domestic market." (Hayashi, 2020)

Barriers

Structural context: high coal dependence in the industry sector (Burandt et al., 2019); energy and supply chain security concerns (*Policies & action*, 2022)

Paradigms/discourses: focus on peaking emissions rather than radical technological change

Politics: trade war with the US, potentially intensified by IRA (Expensive/inefficient subsidy race? Unilateralism over international collaboration?)

Policies: strong focus on power sector over other sectors; New Infrastructure Plan creates heavy need for construction materials, which may push strong action on industry decarbonisation further down the road (*Policies & action*, 2022)

Economy: production overcapacity

Technology: low TRL of certain low-carbon technologies

Current status of national-sectoral climate policy

Governance & Planning:

Five-Year Plans (FYP): central tool for shaping the development of the Chinese economy; key for industry decarbonization are the *Five-Year Comprehensive Energy Conservation and Emission Reduction Work Plans*

- **2021: 14th FYP (2021-2025):** "The plan notably aims to implement key projects of energy conservation and emission reduction within key industries such as iron and steel, non-ferrous metals, building materials, petrochemicals and chemicals." (*14th Five-Year comprehensive work plan for Energy saving and Emission reduction 2021-2025 (Notice 33),* 2021)

CCUS strategy: Industrial CCUS is a priority strategy area for Chinese industry, has received increasing national attention in the last two decades, now focusing mainly on large-scale project demonstrations. "As of 2021, CCUS was highlighted in the last three FYPs, the Ministry of Ecology and Environment (MEE) [has] encouraged provinces [...] to pilot and demonstrate CCUS projects, and 29 provinces had already issued policies and plans related to the technology. Since the 10th FYP (2000–2005), China has invested more than 3bn yuan into CCUS R&D (Fan, 2021)." (*Policies & action*, 2022)

2022 Policies and regulations on developing green building materials: "three departments, including the Ministry of Finance (MOF), jointly released the Circular on Extending the Implementation Scope of Policies on Governments' Procurement of Green building materials to Improve Building Quality (the Circular) on October 24, 2022. According to the Circular, from November 2022, the Policies on **Governments' Procurement of Green Building Materials to Improve Building Quality** will be expanded to 48 cities (municipal districts, including the previous six pilot cities) – targeting hospitals, schools, office buildings, exhibition halls, convention centers, stadiums, housing, and other government procurement projects. The Circular also incorporates the Standards on Governments' Procurement Demands Concerning Green Building and Green building materials, which is published for strict enforcement by all cities. On November 7, 2022, the Ministry of Industry and Information Technology (MIIT) released the Action Plan on Peaking Carbon Dioxide Emissions in the Building Materials Industry (Action Plan). The Action Plan sets out 15 key tasks in five aspects to step up total capacity control, improve the level of solid waste utilization, and **reduce the use of high-carbon materials**. It also stresses efforts in **accelerating the research and innovation of low-carbon**

technologies, promoting energy-saving and carbon-reducing technologies and equipment, and building systems for the **production of green building materials and products**" (Zhou & Wu, 2022)

2022 National hydrogen strategy (2021–2035): confirms the technology's key role in China's future energy system and mitigation efforts. Main focus on H2 from coal and gas, with a modest production target of 100,000–200,000 tonnes of green H2 by 2025 (<1% of China's current annual H2 production) (*Policies & action*, 2022)

2021 1+N policy framework: "The framework consists of one main policy document acting the country's overarching guiding principles, representing the "1", and a series of auxiliary policy documents **targeting specific industries**, fields, and goals, representing the "N". The Working Guidance, released on October 23, represents the "1" part of the policy framework. The extensive, 37-article long policy document outlines specific areas of the economy and society that need to change or develop in order to meet China's carbon targets. The **Action Plan**, released on October 24, is the first of the "N" documents and will be followed by several more in the months and years to come." (Arendse, 2021)

2021: Action Plan for Carbon Dioxide Peaking before 2030 ('1+N')

- „Promote green and low-carbon development in the industrial domain. implement the green manufacturing project, vigorously promote green design, refine the green manufacturing system, and build green factories and industrial parks.
- Push the steel industry to peak carbon dioxide emissions
- Push the non-ferrous metals industry to peak carbon dioxide emissions
- Push the building materials industry to peak carbon dioxide emissions *(see above)*
- Push the petrochemical industry to peak carbon dioxide emissions
- Curb the irrational expansion of energy-intensive and high-emission projects" (*Action Plan for Carbon Dioxide Peaking before 2030 ('1+N'),* 2021)
- Sector-specific implementation plans are being released by relevant industries. Almost all provinces and over 70 cities have proposed their carbon peaking targets, along which 4 provincial targets and 55 municipal targets are no later than 2025 (Zhao and Qi, 2022).

Regulatory:

2022 plan on reaching peak CO2 emission in polluting industries

- Steel, aluminium and cement have aligned expectations with the **14th FYP** and NDC update (*Country summary*, 2022)
- "In February 2022, the government released guidelines promoting the High-Quality Development of the **Iron and Steel Industry** and that required to reach **peak CO2 emissions by 2030**. In July, the Ministry of Industry and Information Technology approved a plan to oblige companies in **steel, building materials, petrochemicals, non-ferrous metals, consumer goods, equipment manufacturing and electronics sectors** with an annual revenue of CNY20m (US$2.9m) or more to **slash energy use by 13.5% from 2020 levels in 2025, and to reach peak carbon emissions by 2030**." (*Plan on reaching peak CO2 emissions by 2030 in polluting industries,* 2022)
- "tailored set of **guidelines** for the related authorities and companies in **different industrial sectors**, pointing out what needs to be done by each party to ensure both efficient decarbonization and sustainable economic growth. […] In particular, the plan emphasized to tighten **energy intensity benchmarks** for key industrial products and accelerate the development of **sector-level emission accounting standards**." (*China issues sectoral guidelines for industrial carbon peaking by 2030,* 2022)
- The plan also includes a set of economic instruments (see below)
- True to China's overpromise-underdeliver approach, industrial sectoral peaking targets have been underwhelming: Cement sector discussed **emissions peak** in 2023, iron & steel as well as aluminium initially targeted peak in 2025 → none of these more ambitious targets have been officially adopted (*Country summary*, 2022)(*Policies & action*, 2022)

Regulation of hydrofluorocarbon (HFC) emissions from refrigeration and cooling activities embedded in many industrial activities. China produces – and consumes – more than 60% of the world's HFCs. China's first NDC committed to targeted reductions of HCFC22 production of 35% by 2020 and 67.5% by 2025 below 2010 levels, but there are no numerical targets in its updated NDC (*Policies & action*, 2022).

Phasedown of HFC production and consumption: China finally ratified and started enforcing the Kigali Amendment in 2022; "China reported that it halted new production capacity of five of the 11 HFCs it produces (covering 75% of total HFC production) two years ahead of the freeze requirements of the Amendment" (*Policies & action*, 2022)

Top-1000 and Top-10,000 Energy-Intensive Enterprises Programs: "The Top-1000 Program was initiated in 2006. This program required the largest 1000 energy-consuming industrial enterprises to implement energy-saving measures, with a target of saving 100 million tons of coal equivalent (Mtce) over five years. The program also implemented measures such as carrying out energy audits, conducting energy efficiency benchmarking, improving energy management, and promoting energy-saving technical retrofits. As a result, the program saved a total of 150 Mtce during 2006–2010 [328] and reduced carbon dioxide emissions by 400 million tons. The Economist called the Top-1000 Program "arguably the most important climate policy in the world." China built on the Top-1000 program by launching the "Top-10,000 Energy Efficiency and Low Carbon Action Program" in 2011. The Program targeted over 10,000 enterprises in the industry and transportation sectors that consume more than 10,000 tons of coal equivalent (tce) of primary energy annually, as well as businesses, hotels, and schools that consume more than 5000 tce. The Top-10,000 Program continued the measures implemented in the Top-1000 Program and emphasized establishing energy management systems based on a national standard, conducting energy-efficiency retrofits (especially focusing on waste heat and waste pressure utilization, motor energy efficiency, coal-fired boiler retrofits, and high-efficiency heat exchangers), and promoting energy service companies. By 2014, the program had saved 309 Mtce, exceeding its original target of 250 Mtce [331]." (Rissman et al., 2020)

<u>Economic Instruments:</u>

Numerous loans/investments for national and provincial **rapid renewables scaleup** (*Country summary*, 2020), e.g., 2021 Shanxi province carbon project reduction loans for renewable electricity generation/storage, UHV transmission line investments (Database energypolicytracker.org , n.d.); at national level, China targeted both the production (through grants, low-cost loans and funds from the Ministry of Science and Technology) and demand side (e.g., through the *Golden Sun* programme providing grants for nearly 6 000 MW of capacity and its feed-in tariff programme) of solar PV (IEA 2023).

- Overall, "China's pipeline of announced investments in clean technologies exceeds USD 280 billion (approximately EUR 260 billion)" (European Commission, 2023)
- In 2022, "China was by far the leading country for attracting energy transition investment, accounting for $546 billion or nearly half of the global total" (BloombergNEF, 2023)

2022 plan on reaching peak CO2 emission in polluting industries: "The strategic role of power market reform is also recognized in the plan, highlighting the need to enhance the **differentiated electricity pricing scheme** to motivate energy saving, especially in steel, building materials, refining, chemicals, and non-ferrous metal sectors. The plan also called for the government agencies to systematically **catalogue low-carbon technologies** as references for broader applications, ensure sufficient **financial supports to these low-carbon technologies**, and promote low-carbon industrial products for **Belt and Road** projects."

Key developments, not yet implemented:

- **Possible expansion of China's Emissions Trading System**: **"Key industrial sectors** are expected to be gradually enrolled into China's compliance emission trading scheme." (*China issues sectoral guidelines for industrial carbon peaking by 2030*, 2022); Steel, aluminum and cement likely to be the first targeted in the scope expansion of the country's ETS (*Policies & action*, 2022)
- 2021: The **overall plan for the pilot program** of the comprehensive reform of the market-based allocation of production factors (notice 51 of the State Office): "the government will support the creation of a "**green factor trading mechanism**". This would notably entail the trading of carbon emission rights, pollution discharge rights, energy use rights, water rights, etc. The government will also also explore other schemes, such as a paid-for-acquisition mechanism for carbon emission quotas and energy use rights indicators." (*The overall plan for the pilot program of the comprehensive reform of the market-based allocation of production factors (notice 51 of the State Office,* 2021)

Assessment of national policy framework

This table assesses the extent to which the national policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + 2060 net zero target, 2030 peaking target + target and vision to peak CO2 emissions for EIIs before 2030 or earlier - no EII decarbonisation trajectory for deep decarbonisation
	Long term finance	→ strong exploitation + strong public investments in clean technologies + general availability of public resources
Innovation, Demonstration & Deployment	Enhance public RD&D	→ medium exploitation + policies and funding for demonstration plans + large scale demonstration plans in particular for CCUS
	Accelerate early commercialisation, deployment	→ medium exploitation + large scale demonstration plants + financial support for low carbon technologies, but not specific to EIIs
(Re)-shaping markets	Creation of demand	→ medium exploitation + promotion of low carbon materials in belt and road initiative + procurement of green construction materials for public construction projects + Action Plan on Peaking Carbon Dioxide Emissions in the Building Materials Industry sets out to reduce the use of high-carbon building materials - high domestic infrastructure construction
	Reshaping of existing markets	→ medium exploitation + plans to extend national carbon market to cover EIIs
	Transparency and information	→ medium exploitation + energy audits and installation level emissions monitoring for EIIs under ETS - no policies on product information
Policy coherence and integration	Reducing of demand.	→ weak exploitation - no policies on circularity - overcapacity in production
	Infrastructure & energy supply	→ medium exploitation + industrial energy efficiency + high support for RE development, H2 strategy - strong focus on H2 with coal and gas with CCUS (danger of FF)
	International coherence	→ weak exploitation - limited engagement in international cooperation - trade frictions with US, protectionist tendencies
	Socio-economic implications	No information available
	Regulatory environment.	→ strong exploitation + strong public sector capacity and centralised decision making + stable regulatory environment - unclear if rules are always strictly enforced
Knowledge & Capacity	Public managerial & bureaucratic capacity.	→ strong exploitation + longstanding experience with industrial policy + high public sector capacity - limited experience with industrial decarbonisation
	Monitoring and evaluation	→ medium exploitation + national GHG monitoring, ETS monitoring + sector level emissions accounting standards

How to strengthen national-sectoral climate policy

In order to strengthen its climate policy related to the industry sector, China may

- Set sector-specific mitigation targets for industry (beyond emissions peaking targets)
- Aim to peak industry emissions before the 2030 deadline
- Phase out fossil fuel subsidies
- Develop policies with the direct aim of reducing fossil fuel dependence (esp. coal) in industry
- Implement material efficiency, circular economy and behaviour change policies to reduce pressure from projected demand increase; "reducing demand for industrial materials without compromising development goals or standards of living will play an important role in limiting emissions, using approaches, such as material efficiency and product longevity" (Rissman et al., 2020)
- Develop policies that target radical over incremental technological change, incl. RD&D funding
- Use its track record of driving innovation and increasing green production through targeted public policy (e.g., solar PV and wind turbine manufacturing) and apply this to heavy industry
- Implement policies to achieve targets outlined, e.g., in the Action Plan on Peaking Carbon Dioxide Emissions in the Building Materials Industry, which includes R&D, energy efficiency as well as demand-side aims
- Refocus the hydrogen strategy to increase ambition on green hydrogen as opposed to coal- or NG-based hydrogen
- Implement plans to add Key EII sectors to it ETS and develop proposed green factor trading mechanism
- Increase international collaboration on R&D (Rissman et al., 2020)

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European Union (EU)

Simon Otto (VUB), 3 July 2023. Reviewed by EU industrial policy expert.

Big picture: Current EIIs-sector decarbonisation status and prospects

Current, past, and projected future GHG emissions in the EII sector

In 2020, the industry sector accounted for 22.16% of EU (EU27) GHG emissions.[1] EIIs contribute around 16.5% of EU GHG emissions.[2] In 2202, cement production accounted for 3% of overall EU CO2 emissions, steel production for 2%, while other manufacturing industries and construction accounted for 15%.[3]

Between 1990 and 2020 the EU (incl. UK) decreased its overall GHG emissions (excl. LULUCF) by 34.4%. By 2020 EU emissions from industry decreased by 28% compared to 2005[4] and 39.5% since 1990.[5] Emissions reductions were largest from manufacturing industries and construction, electricity and heat production, iron and steel production (incl. energy-related emissions) and resident fuel combustion.[6] The decrease in industry emissions from can be explained by improved efficiency and lower carbon intensity as well as structural changes in the economy (i.e. higher share of services and a lower share of more-energy-intensive industry in total GDP) and economic recessions.[7] (European Union, 2022).

Since 1990, EU27 EII GHG emissions have decreased by around 35%, but reductions have stagnated since 2015. These reductions were driven by addressing non-CO2 emissions, reducing energy intensity, fuel-shifting towards natural gas and electricity, and an overall decline in production value.[8]

Emissions from the power and EII sector are covered under the EU Emissions Trading System (ETS). Since its start in 2005, emissions under the ETS have decreased by 36%.[9] Emissions reductions were strongest in the power sector and less substantial for EIIs.[10]

Prospect for sectoral decarbonisation

Under current legislation, industrial emissions are expected to decrease 3-5% between 2021 and 2030.[11] ETS emissions are set to decrease by 62% by 2030 compared to 2005, ensured by an annual linear reduction factor (LRF) of annual emissions allocated to installation.

Chiappinelli et al (2021) estimate that up to 20% of EU current basic material production can be switched to low-emission options by 2025, requiring investments of approximately 28.9 billion Euros. This could permit primary production processes to reduce emissions by 80–90% compared to BAT options in use today. However, there is currently no business case to implement such options.[12]

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[1] EEA. (2023). *Greenhouse gas emissions inventory*. https://climate-energy.eea.europa.eu/topics/climate-change-mitigation/greenhouse-gas-emissions-inventory/intro

[2] See Wyns, T. & G. Khandekar. (Forthcoming). Energy-intensive industries in the EU: overcoming barriers to transition?, in *Handbook on European Union climate change policy and politics.*

[3] European Union. (2022). *Eighth National Communication and Fifth Biennial Report from the European Union under the UNFCCC*. UNFCCC., p. 177. https://unfccc.int/documents/624694

[4] EEA. (2022). *Trends and Projections in Europe 2022* (No 10/2022). EEA. https://www.eea.europa.eu//publications/trends-and-projections-in-europe-2022

[5] EEA. (2023). Greenhouse gas emissions inventory.

[6] European Union. (2022). Eighth National Communication and Fifth Biennial Report, pp. 172, 176.

[7] European Union. (2022). Eighth National Communication and Fifth Biennial Report.

[8] See Wyns, T. & G. Khandekar. (Forthcoming). Energy-intensive industries in the EU: overcoming barriers to transition?

[9] EEA. (2023). Greenhouse gas emissions inventory.

[10] European Union. (2022). Eighth National Communication and Fifth Biennial Report.

[11] EEA. (2022). Trends and Projections in Europe 2022 (No 10/2022). EEA.

[12] Chiappinelli et al. (2021). A green COVID-19 recovery of the EU basic materials sector: Identifying potentials, barriers and policy solutions. *Climate Policy*, 1–19. https://doi.org/10.1080/14693062.2021.1922340

Relevance of EIIs for the domestic economy

Overall, the economic relevance of EIIs is declining with the growth of the service sector. However, EII continue to remain important for economic output, in particular in local and regional context and general employment. Nevertheless, basic materials form an integral part of Europe's value chain and are essential to decarbonise other sectors. [13]

Phase of the zero-emission transition of the sector

The EU's EII sector can be considered to be destabilisation phase, potentially soon transitioning towards the reconfiguration phase. Following the most recent reform of the EU-ETS, EIIs will be fully subject to emission pricing by 2035, levelling the playing field of conventional vis-à-vis near-zero emission production methods. Flaking measures are in place to completement the transition, incl. technology finance and infrastructure built up.

National sectoral mitigation drivers and barriers

Barriers to decarbonisation

Structural context

- Lack of cheap and abundant clean energy (carbon-free electricity, green hydrogen) is posing a major barrier to the implementation to deep decarbonisation options.[14]
- Lack of (transport) infrastructure for hydrogen, CO and electricity, which are essential to enable industry to adopt certain mitigation options (e.g. CCS, fuel-switching).
- European EIIs were long reliant on cheap and abundant Russian energy, which is no longer sustainable (in political, economic, and decarbonisation terms) following the Russian invasion of Ukraine. Accordingly, industry will face higher energy costs in the future and will need to adapt accordingly.

Paradigms & discourses

- European countries have a historical aversion to strong state-led industrial policy.

Polity

- Fragmentation of industrial policy across 27 member states, because the EU has only coordinative competences regarding industrial policy (see Art. 6 TFEU). Nonetheless, several EU-level climate policies directly address the decarbonisation of EIIs (see Section 3).
- Involvement of many actors (city, port, local, industry etc) in decisions relevant to industrial decarbonisation makes decision making complex.
- High administrative requirements and complex regulatory processes, such as permitting, common to the EU and its Member States can significantly slow down the implementation of clean production methods.

Domestic Politics

- Concern over decline of EU industrial competitiveness, sparked by introduction of the US Inflation Reduction Act (IRA), combined with high energy prices. This has caused political concern to avoid putting additional climate policy related pressures on EU industry.
- Political opposition (i.e. far left/right) at EU and national level towards decarbonisation/deindustrialization aside from the Russia context.

International Climate Politics

- (Potential) trade conflicts with US (and others) over subsidies on clean technology manufacturing due to fears over potential loss of EU global industrial competitiveness (Williams, 2023).[15] However, EU-US discussions on potential cooperation on this are ongoing.

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[13] Wyns, T. & G. Khandekar. (Forthcoming). Energy-intensive industries in the EU: overcoming barriers to transition?

[14] Chiappinelli et al. (2021). A green COVID-19 recovery of the EU basic materials sector: Identifying potentials, barriers and policy solutions.

[15] Williams, A. (2023, February 27). US-Europe trade tensions heat up over green subsidies. *Financial Times*. https://www.ft.com/content/0f8bf631-f24c-48da-905f-e37f8dc5d5f8

- EU unilateral climate measures (e.g. CBAM, Forest Initiative) have met with scepticism and concerns by EU trading partners, in particular developing countries.[16]

Policy (see Section 3 for detailed policy framework)

- **Carbon leakage exemptions**: EIIs subject to carbon leakage concerns (e.g. Steel, cement) receive most of their emissions allowances under the ETS for free, diminishing their incentive to reduce emissions. However, following recent reforms free allowances will be phased out by 2035 and replaced by a carbon border adjustment mechanism (see Section 3).
- **Lack of effective and predictable carbon pricing mechanisms**: despite being introduced in 2005 EU ETS prices remained too low to incentive investments in deep decarbonisation of EIIs until 2021.[17]
- **EU state aid** rules prevent member states from providing subsidies to specific industries to avoid distorting competition. However, this constrains member states from providing subsidies for EIIs to implement deep decarbonisations measures. EU state aid rules were relaxed in 2022 during the energy crisis and further (more permanent) exemptions were proposed under the Green Industrial Plan.[18]
- EU lacks a sufficient regulatory framework for circularity, which hampers the uptake of secondary production.[19]

Economic

- Most of the 'low hanging fruits' of EII decarbonisation have already been exploited within the EU. Further (deep) emissions reductions in the sector will be much more costly, posing significant financial challenges to EII producer.[20]
- Historically, electricity has been more expensive in the EU than natural gas making electrification of industrial processes unattractive for producers.[21] Gas prices increased drastically in 2022.
- **High natural gas and electricity prices** following western sanctions against Russia in response to Russia's invasion of Ukraine in 2022. This created strong economic short-term pressures for European EII companies, potentially impeding European industrial competitiveness in the medium term. However, prices have returned to more normal levels and throughout 2022 and industrial output remained stable, while European manufacturing cut gas consumption by around 15 percent.[22]
- Shortage of skilled labour to implement clean technologies.[23]
- Currently high investment into LNG import facilities and related infrastructure, in particular in Germany. While infrastructure could potentially be used for green hydrogen, this carries risk of 'lock-in' effects of fossil-fuel based technologies or stranded assets.
- Limited demand for clean and recycled materials, leading to scarce incentives for climate friendly production.[24] However, demand for low emission steel and cement is starting to emerge.

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[16] Moens, B. & Mathiesen, K. (2023, Jan 11). EU's green agenda has its trading partners seeing red. *Politico*. https://pro.politico.eu/news/158492

[17] Chiappinelli et al. (2021). A green COVID-19 recovery of the EU basic materials sector: Identifying potentials, barriers and policy solutions.

[18] European Commission. (2023, Feb 1). *State aid: Commission consults Member States on proposal for a Temporary Crisis and Transition Framework*. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_513

[19] Chiappinelli et al. (2021). A green COVID-19 recovery of the EU basic materials sector: Identifying potentials, barriers and policy solutions.

[20] Wyns, T. & G. Khandekar. (Forthcoming). Energy-intensive industries in the EU: overcoming barriers to transition?

[21] Wyns, T. & G. Khandekar. (Forthcoming). Energy-intensive industries in the EU: overcoming barriers to transition?

[22] Cooper, C., & G. Leali. (2023, Jan 15). Is this the end of Made in Europe? *Politico.* https://pro.politico.eu/news/158642

[23] Hancock, A. (2023, February 28). EU workers lack skills to green the economy, EIB poll finds. *Financial Times*. https://www.ft.com/content/ec47ede3-773a-4bdd-a1e9-1a7f48037099

[24] Chiappinelli et al. (2021). A green COVID-19 recovery of the EU basic materials sector: Identifying potentials, barriers and policy solutions.

Decarbonisation drivers & enablers

Structural context

- Common drivers in emissions decline across most EU countries over past 30 years: shift away from carbon intensive fuels (in particular coal) and increase in renewable energy use, energy efficiency improvements, and structural changes to the economy, i.e. higher share of services and lower share of EII in value added to GDP (especially in Eastern Europe) (European Union, 2022bur).
- High potential for CCS: High concentration of EIIs in industrial hubs in close proximity to potential carbon storage sites, in particular around the North Sea. IEA estimates that in Europe 68% of the CO2 emissions from power industry and EIIs is within 100 km of potential CO2 storage (50% within 50 km) (IEA, 2020, pp 134-141).
- The EU economy is highly developed; EU Member States generally possess high economic and human capital, albeit to somewhat differing degrees.

Paradigms & discourses

- Green growth paradigm of European Green Deal.
- Emerging narrative of benefits for clean technology leadership.

Polity

- The EU has shared competences regarding environmental policy (Art. 4 TFEU; Art. 191-194 TFEU). The EU has a common mitigation target applicable to all 27 member states, and a number of specific mitigation policies (see Section 3).

Domestic Politics

- Climate action has featured highly on the EU policy agenda over the past years, being also one of the political priorities of the von der Leyen Commission (2019-2023).

International Politics

- The EU is widely considered to be a frontrunner in climate policy and providing leadership in international climate negotiations.[25]
- The EU and its member states are actively involved in several international industry decarbonisation initiatives driving the global decarbonisation of EIIs (Otto & Oberthür, 2022).[26]
- The EU is pursuing bilateral cooperation relevant to EII decarbonisation (e.g. on green hydrogen, CCS, technology development) with other countries, including Norway and Japan.

Policy (see Section 3 for detailed policy framework)

- Emission reduction target for 2030 and a climate neutrality target for 2050 enshrined in law.
- The EU has in place a comprehensive climate policy framework, including an overarching European Climate Law and sector specific mitigation policies.
- Several policies focused and/or contributing to the decarbonisation of EIIs are in place, as shown in Section 3. Further policy instruments are under discussion.
- About 75% of EU industry emissions, including EII-installations, are subject to emissions pricing under the EU ETS. In 2022 prices averaged roughly around EUR 80-100 t/CO2.[27]
- Several large-scale funding mechanisms (partially) aimed to accelerate the decarbonisation of the EU are in place, including industry specific instruments such as the Innovation or Mondernisation Fund (see Section 3 for details).

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[25] See Oberthür, S., & Dupont, C. (2021). The European Union's international climate leadership: Towards a grand climate strategy? *Journal of European Public Policy*, *28*(7), 1095–1114. https://doi.org/10.1080/13501763.2021.1918218

[26] Otto, S., & Oberthür, S. (2022). Global Governance for the Decarbonisation of Energy-Intensive Industries: Exploring Sectoral Options (Deliverable D6.1b). *NDC ASPECTS*. http://www.ndc-aspects.eu/sites/default/files/2022-10/D6.1b%20Global%20Governance%20for%20the%20Decarbonisation%20of%20Energy-Intensive%20Industries.pdf

[27] See Ember Climate. *Carbon Price Tracker*. https://ember-climate.org/data/data-tools/carbon-price-viewer/

- The ongoing electricity market reform aims to provide European industry with better access to renewable, non-fossil and affordable power supply.[28]
- In February 2023 the Commission published a Green Deal Industrial Plan with the aim to increase EU industrial competitiveness and accelerate Europe's industrial transformation.

Economics

- The EU (and Norway) are at the forefront of clean EII technology development and home to most current low-zero emission demonstration and pilot plants (e.g. Hybrit).
- **High potential for CCS**: around 68% of CO2 emissions from power industry and EIIs are within 100 km of potential CO2 storage site (50% within 50 km). 19% of industrial plants are located within 100km of a suitable offshore storage site (mainly in the North Sea).[29]
- EU decarbonization goals and significant policy support have **stimulated CCUS development**, particularly in the form of industrial clusters connected to CO2 storage hubs. Around 50 projects could be capturing close to 70 Mt CO2 per year by 2030 around the North Sea in Norway, the United Kingdom, the Netherlands, Sweden and Denmark.[30]
- Northwest Europe is at forefront of renewable and low-emissions hydrogen development, accounting for around half of Europe's total hydrogen demand and vast and untapped RE potential in the North Sea. It has well-developed, interconnected gas network which could be partially repurposed.[31]

Current status of national-sectoral climate policy

The EU has a comprehensive climate policy framework and several EU-level climate policies directly target emissions reduction in EIIs. Next to these EU level policies, EU member states also have emissions reduction policies for the industry sector in place, these are not considered here.

Governance and Planning instruments

European Climate Law [*Regulation (EU) 2021/1119*]: entails the legal objective of EU climate neutrality by 2050 target and the intermediate 2030 target of reducing net GHG by at least 55% compared to 1990.

European Green Deal (EGD) [*COM/2019/640 final*]: EU green growth strategy outlines the EU's path towards climate neutrality by 2050 and transform its economy. Sets out policy initiatives covering all sectors of the economy, including industry. EGD is supplemented by sector specific transformation strategies, including for industry, chemicals and circular economy.

EU Industrial strategy & New Industrial Strategy: outline development priroties for EU industrial policy.

Green Deal Industrial Plan for the Net-zero Age [*COM (2023) 62 final*]: Commission strategy to 'enhance the competitiveness of Europe's net-zero industry and support the fast transition to climate neutrality'. Aims to provide a more supportive environment for scaling up the EU's manufacturing capacity for net-zero technologies and products required'. Based on four pillars: [32]

- Predictable and simplified regulatory environment: Net-Zero Industry Act (see below)
- Speeding up access to finance: relaxation of state-aid rules, proposed European Sovereignty Fund, REPowerEU funding
- Enhancing skills: Net-Zero Industry Academies, foster & align public funding
- Open trade for resilient supply chains: FTAs, Critical Raw Materials Club, Clean Tech/Net-Zero Industrial Partnerships.

[28] European Commission. (2023, Mar 14). Commission proposes reform of the EU electricity market design to boost renewables, better protect consumers and enhance industrial competitiveness. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1591

[29] IEA. (2020). *CCUS in Clean Energy Transitions*. IEA, Paris. pp. 134-141.

[30] IEA. (2022). *Northwest European Hydrogen Monitor*, IEA, Paris. https://www.iea.org/reports/northwest-european-hydrogen-monitor

[31] IEA. (2022). Northwest European Hydrogen Monitor, IEA, Paris.

[32] European Commission. (2023, Feb 1). *The Green Deal Industrial Plan: putting Europe's net-zero industry in the lead.* European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_510

Economic instruments

Emissions Trading system (ETS) [*Directive 2003/87/EC, revised in 2023*]: EU & EEA-EFTA states wide cap-and-trade emissions pricing system with annual defined absolute number of emissions allowances covering emission from electricity and heat generation, manufacturing industry, and intra-EEA aviation and maritime transport (around 36% of total EU emissions).[33]

- EII installations covered: oil refineries, steel works, production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals.
- ETS emissions will be reduced by 62% by 20230 compared to 2005 Emission allowances (EUAs) are reduced annually by 2.2% (until 2024), 4.3% (2024-27) and 4.4% (2028-30).
- Sectors at risk to carbon leakage receive up to 100% of EUAs for free, while sectors at lower risk of carbon leakage receive up to 30% for free. The level of free allowances received is based on a benchmarking system, with only the 10% most efficient installations receive all their allowances for free. As of 2023, Installations benefiting from free allocations will need to comply with conditionality requirements (i.e. energy audits, climate neutrality plans). Free allowances for sectors covered under CBAM will be phased out from 2026 until 2034.
- EUAs are trading between 80-100€ per t/CO2.[34] The ETS is expected to raise close to €700bn by 2030. Revenues are spent through MS budgets (requirement to be spent on climate action), the Modernisation and Innovation Fund.

Carbon Border Adjustment Mechanism (CBAM) [*Regulation (EU) 2023/956*]: carbon-tariff on embedded emissions of emission-intensive goods imported into the EU to avoid carbon leakage while phasing-out free allowances under the ETS. The carbon tariff mirrors ETS prices.

- Applies from October 2023 with transitional reporting only period. External tariffs will be phased in from 2026 onwards (2.5%) and gradually increased until 2034 (100%).
- Applies to direct emissions of imports **cement, electricity**, **fertilisers, iron and steel, aluminium, and hydrogen production,** electricity and certain precursors and downstream products.
- By 2026 the Commission will assess whether to include indirect emissions, increase the scope of products and services covered and assess the risk of export related carbon leakage.
- CBAM revenues will go into the Innovation Fund.

➢ EU funding mechanism relevant to EII decarbonisation[35]

- Funding for technology R&D and innovation: Innovation Fund, Horizon Europe
- Funding for mobilising investments: InvestEU (EIB)
- Directly co-financing for investments: Recovery and Resilient Facility, Cohesion Policy Funds (ERDF, ESF), Just Transition Fund (JTF), Modernisation Fund
- Funding to address market barriers and provide capacity building: LIFE - Clean Energy Transition sub-programme

Innovation Fund: EU level funding programme for the demonstration of highly innovative low-carbon technologies in EIIS, CCUS, renewable energy and energy storage. Funded through the auctioning of ETS allowances. For the 2020-2030 period 450 Mio EUAs are earmarked for the Innovation Fund, which are expected to amount to about EUR 38 bio (assuming an average price of EUR 75/tCO2).[36] The innovation fund succeeds the NER300 Programme which pooled together 2bn EUR in the period from 2012-2020.[37] Following the introduction of CBAM, particular focus will be put on decarbonising affected sectors, including the front-loading of EUAs to ensure adequate resources for innovation.

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[33] See Council of the EU. (2022, Dec 18). *'Fit for 55': Council and Parliament reach provisional deal on EU emissions trading system and the Social Climate Fund*. Council of the EU. https://www.consilium.europa.eu/en/press/press-releases/2022/12/18/fit-for-55-council-and-parliament-reach-provisional-deal-on-eu-emissions-trading-system-and-the-social-climate-fund/

[34] See Ember Climate. *Carbon Price Tracker*. https://ember-climate.org/data/data-tools/carbon-price-viewer/

[35] https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation_en

[36] European Commission. *Innovation Fund – Policy Development.* https://ec.europa.eu/clima/eu-action/funding-climate-action/innovation-fund/policy-development_en

[37] European Commission. *NER 300 programme.* https://ec.europa.eu/clima/eu-action/funding-climate-action/ner-300-programme_en

Horizon Europe: EU's key funding programme for research and innovation with a budget of €95.5 billion until 2027, including specific research programmes for industrial decarbonisation technologies and clean technology leadership.

Modernisation Fund: funding programme to support lower-income member states in modernising their energy systems and improve energy efficiency (including in EIIs). It is funded through the auctioning of 2% of total ETS allowances for the 2021-2030 period as well as additional allowances transferred by beneficiary member states.[38]

Just transition fund: support for the 'transformation of existing carbon-intensive installations, when these investments lead to substantial emission cuts and job protection'.[39] EII relevant investments were approved in JTF plans of France (electrification of glass manufacturing), Croatia (CCS for cement), Lithuania (green ammonia), Romania (transformation of steel and fertiliser production), and Sweden (steel, minerals and cement production).

InvestEU supports sustainable investment, innovation and job creation in Europe. It aims to trigger more than €372 billion in additional investment over the period 2021-27.[40]

NextGenerationEU and **REPowerEU** provide large scale funding for decarbonisation.

Connecting Europe Facility: under revised TEN-E regulation geological CO_2 storage infrastructure is eligible to receive subsidies.[41]

EIB Venture debt for commercialisation phase

Next to EU-level funding most member state have additional funding mechanisms.

Regulatory and 'non-economic' instruments

Net Zero Industry Act [proposed regulation, under negotiations]: proposal to simplify regulatory framework and improve the investment environment for the Union's manufacturing capacity of technologies that are key to meet the Union's climate neutrality goals. It aims to address core drivers of net-zero technology manufacturing investments:

- Improving investment certainty, policy focus and coordination through the setting of clear objectives and monitoring mechanisms;
- Lowering administrative burden for developing net-zero manufacturing projects, including by streamlining administrative requirements and facilitating permitting, setting up regulatory sandboxes and ensuring access to information;
- Facilitating access to markets by specific measures relate to public demand through public procurement procedures and auctions, as well as through schemes to support private demand by consumers;
- Facilitating and enabling CCS projects, including by enhancing the availability of CO2 storage sites;
- Supporting innovation, including through regulatory sandboxes;
- Enhancing skills for quality job creating in net-zero technologies;
- Coordinating net-zero industrial partnerships;

Energy Efficiency Directive [Directive 2012/27/EU, revised 2023 (provisional agreement)]:[42] large energy consumers with more than 85TJ of annual energy consumption have to implement an energy management system. Otherwise, they will be subject to an energy audit (if their annual consumption exceeds 10TJ).

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[38] European Commission. *Modernisation fund*. https://ec.europa.eu/clima/eu-action/funding-climate-action/modernisation-fund_en

[39] European Commission. *The three pillars of the Just Transition Mechanism*. https://ec.europa.eu/regional_policy/funding/just-transition-fund/just-transition-platform/opportunities_en

[40] European Commission. About Invest EU. https://investeu.europa.eu/about-investeu_en

[41] IEA (2022), CO2 Transport and Storage, IEA, Paris https://www.iea.org/reports/co2-transport-and-storage

[42] European Commission. (2023, March 10). European Green Deal: EU agrees stronger rules to boost energy efficiency. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1665

Renewable Energy Directive [revised 2023 (provisional agreement)]:[43] EU wide RE target; further includes specific rules for uptake of renewable energy in industry: annually increase of RE used in industry by 1.6%; 42% of the hydrogen used in industry should come from renewable fuels of non-biological origin (RFNBOs) by 2030 and 60% by 2035. The agreement introduces the possibility for member states to discount the contribution of RFNBOs in industry use by 20% under certain conditions: if the member states' national contribution to the binding overall EU target meets their expected contribution, and the share of hydrogen from fossil fuels consumed in the member state is not more 23% in 2030 and 20% in 2035.

Industrial Emissions Directive [Directive 2010/75/EU, currently under revision]:[44] regulates pollutant emissions from industrial installations. Installations need to comply to emissions conditions by applying activity specific 'Best Available Techniques'. The revision aims to spur innovation, reward frontrunners, and help level the playing field on the EU market, among others by introducing environmental performance requirements.[45]

Carbon Capture and Storage Directive [Directive 2009/1/EC]:[46] establishes a legal framework for the environmentally safe geological storage of CO2. It covers all CO2 storage in geological formations in the EU and the entire lifetime of storage sites. It also contains provisions on the capture and transport components of CCS, though these activities are covered mainly elsewhere.

Fluorinated GHGs Regulation [REGULATION (EU) No 517/2014; currently under revision]: regulates the reduction of emissions of fluorinated greenhouse gases.

REACH Regulation [Regulation EC 1907/2006, currently under revision]:[47] Regulation on the registration, evaluation, authorisation and restriction of chemicals (REACH). This is done by better and earlier identification of the intrinsic properties of chemical substances and by taking measures, such as phasing out or restricting substances of very high concern. REACH also aims to enhance innovation and the competitiveness of the EU chemicals industry.

Proposal for Eco-design requirements [regulation, currently being negotiated]:[48] includes revision of Ecodesign Directive. Proposes, among others, minimum ecodesign requirement for all products placed on internal market, digital product passport, possibilities for Green public procurement requirements for member states, and allows member state incentives for sustainable products. Industrial intermediaries iron of and steel, aluminium, non-ferrous metals, chemicals, plastics and polymers, paper, and glass, could be among the first products to be covered under new regulation.[49]

Revision of Construction Products Regulation (REFIT) [currently under negotiations]:[50] harmonised framework to assess and communicate the environmental and climate performance of construction products. New product requirements will ensure that the design and manufacture of construction products is based on state of the art to make these more durable, repairable, recyclable, easier to re-manufacture. Sustainability requirements will be covered under this regulation.

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[43] Council of the EU. (2023, March 30). Council and Parliament reach provisional deal on renewable energy directive. https://www.consilium.europa.eu/en/press/press-releases/2023/03/30/council-and-parliament-reach-deal-on-renewable-energy-directive/

[44] European Commission. *Industrial Emissions Directive*. https://ec.europa.eu/environment/industry/stationary/ied/legislation.htm

[45] European Commission. (2022, April 5). Green Deal: Modernising EU industrial emissions rules to steer large industry in long-term green transition. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2238

[46] European Commission. A legal framework for the safe geological storage of carbon dioxide. https://climate.ec.europa.eu/eu-action/carbon-capture-use-and-storage/legal-framework-safe-geological-storage-carbon-dioxide_en

[47] European Commission. *REACH Regulation*. https://environment.ec.europa.eu/topics/chemicals/reach-regulation_en

[48] European Commission. (2022, March 30). Green Deal: New proposals to make sustainable products the norm and boost Europe's resource independence. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2013

[49] European Commission. (2022). Proposal for a Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC (COM (2022) 142 final). European Commission. https://environment.ec.europa.eu/system/files/2022-03/COM_2022_142_1_EN_ACT_part1_v6.pdf

[50] European Commission. (2022, March 30). Green Deal: New proposals to make sustainable products the norm and boost Europe's resource independence. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2013

Educational, Informational, 'soft' instruments

Taxonomy for sustainable activities [Regulation (EU) 2020/852]: classifies sustainable economic activities. It includes definitions of conditions under which manufacturing (including steel, aluminium, cement, ammonia and hydrogen) can qualify as contributing substantially to climate change mitigation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives.[51]

Voluntary agreements

Sector specific transition pathways: pathways co-created by industry, public authorities, social partners and stakeholders outlining oncrete and actionable plans (transition pathways) to transform business models and value chains of individual industrial ecosystems. Several pathways have been developed for EIIs:[52]

- Masterplan for a competitive transformation of EU energy-intensive industries (2019)
- Transition pathway for the chemical industry (January 2023)
- A more resilient, green and digital construction ecosystem (March 2023)
- Transition pathway for EIIs in development based on the SWD: For a resilient, innovative, sustainable and digital energy-intensive industries ecosystem: Scenarios for a transition pathway.

Assessment of EU policy framework to advance the decarbonization of EIIs

This table assesses the extent to which the EU's policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ strong exploitation + 2050 net zero target, 2030 target in law. Provides directionality for all sectors, including for EIIs + ETS entails specific annual emission budgets for EIIs, providing clear directionality + European Green Deal and industrial strategies provide general decarbonisation visions for EIIs; + industry specific decarbonisation pathways exist. - Specific EII decarbonisation targets missing for after 2030, but under consideration
	Long term finance	→ strong exploitation + large scale EU level climate finance available (e.g. Next Gen EU; REPowerEU; MFF) + specific funding instruments available for EIIs + sustainable finance taxonomy guiding investments, incl. definitions for EIIs. - state-aid rules constrain MS ability to provide subsidies for EIIs, increased exemptions exist - no direct commercial incentives for policy adoption
Innovation, Demonstration & Deployment	Enhance public RD&D	→ strong exploitation + several large-scale funding mechanisms available for EII RD&D, incl. innovation fund + large number of pilot projects already in place
	Accelerate early commercialisation, deployment	→ medium exploitation + several funding mechanisms for early adoption available (EU + MS level); + specific target for CCS capacity proposed under Net Zero Industry Act *[+ political discussion on EU Sovereignty Fund]* - Public funding for early adoption remains limited
(Re)-shaping markets	Creation of demand	→ medium exploitation *+ demand-pull measures are under considerations (e.g. planned public procurement)* - measures are not yet in force, scale remains unknown
	Reshaping of existing markets	→ strong exploitation + EII emissions covered under ETS (cap & trade) with clear annually decreasing emissions allocations + emission prices have reached relative high level (80-100 EUR t/CO2 in 2022) + existing free allowances will be phased out until 2034 with parallel introduction of CBAM

[51] See Commission Delegated Regulation (EU) 2021/2139. http://data.europa.eu/eli/reg_del/2021/2139/oj

[52] European Commission. *Transition pathways for European industrial ecosystems*. https://single-market-economy.ec.europa.eu/industry/transition-pathways_en

	Transparency and information	→ medium exploitation + energy auditing requirements. + sustainability taxonomy (incl. definitions for EIIs) - no labelling or specific definitions for clean basic materials in place, but under consideration
Policy coherence and integration	Reducing of demand	→ medium exploitation + eco-design requirements under consideration + circular economy measures under considerations - overall limited policies in place at the moment - recycling potential is not adequately exhausted
	Infrastructure & energy supply	→ medium exploitation + industrial energy efficiency policies; + targets for Green H2 use in industry (RED III); CCS target under consideration + high support for RE development (RE target, financing) - limited current supply of green hydrogen and clean electricity - high electricity prices; high demand for clean electricity in other sectors (unclear if sufficient supply)
	International coherence	→ medium exploitation: strong domestic actions, but risk undermining global EII transformation + carbon leakage addressed under CBAM, potential to drive emission reductions outside EU + strong involvement in international cooperation on industrial decarbonization (EU + MS) - protectionist tendencies risk undermining EII transformation elsewhere - CBAM is likely to have negative impacts on other countries, which are not yet adequately addressed
	Socio-economic implications	→ medium exploitation + just transition mechanism and fund to mitigate impacts in affected regions + plans for skills development (net zero academies) - EU level efforts in this regard remain limited (however, mainly MS competence)
	Regulatory environment.	→ strong exploitation + stable regulatory framework in place. plans to further streamlining - complex decision-making procedures - high regulatory requirements can be barrier for implementation of clean technologies
Knowledge & Capacity	Public managerial & bureaucratic capacity	→ strong exploitation + institutionalized stakeholder collaboration, incl. in pathways design; + high expertise in government (but could be elevated for industrial policy) - vested interests have strong influence on policy design (lobbying)
	Monitoring and evaluation	→ strong exploitation + installation level GHG monitoring under ETS + established monitoring procedures

Recommendations to strengthen national industrial climate policy

Recommendations based on synthesis of recent proposal in the relevant literature:

- The recently proposed Green Deal Industrial Plan (GDIP, see above) should be used to create markets for clean materials, open up carbon storage capacity and the development of the needed skills for the sectoral transition.[53]
- Furthermore, for the time being the proposed Net-Zero Industry Act does not specifically include EIIs as strategic for industrial decarbonization. However, as two-thirds of industrial emissions are linked to this sector, they should be included in the considerations of this proposal.[54]
- Proposed policies for increasing funding for industrial decarbonization should actively aim at preventing the fragmentation of the single market.[55]

[53] Waiszewska, A., et al. (2023). How to make the best of the Green Deal Industrial Plan. *E3G*. https://www.e3g.org/publications/how-to-make-the-best-of-the-green-deal-industrial-plan

[54] Neuhoff, K., et al. (2023). Three Principles to Close the Gaps in the EU's Net-Zero Industry Plans. *Climate Strategies*. https://climatestrategies.org/three-principles-to-close-the-gaps-in-the-eus-net-zero-industry-plans/

[55] Waiszewska, A., et al. (2023). How to make the best of the Green Deal Industrial Plan.

- A charge on basic materials like steel, cement clinker, aluminum or high-value chemicals, both imported and produced domestically, could close the persistent carbon pricing gap (i.e. free allowances) until their phase-out until 2034. The raised funds could be used to finance the EU's industrial transformation.[56]
- Increasing the international coherence of EU industrial climate policy (incl. CBAM) by acknowledging and taking into account sustainable development ambitions of partners from the Global South.[57]

[56] Neuhoff, K., et al. (2023). Three Principles to Close the Gaps in the EU's Net-Zero Industry Plans.
[57] Waiszewska, A., et al. (2023). How to make the best of the Green Deal Industrial Plan.

India

Saritha Sudharmma Vishwanathan, 21 February 2023.

Introduction

India's total GHG emissions were 2.83 billion tonne CO2e (excluding Land Use Land-Use Change and Forestry (LULUCF)) in 2016. Carbon dioxide (CO2) emissions accounted for 2.2 million tonne (78.6 %). The energy sector accounted for about 75 % of the total GHG emissions. Electricity production was the single largest source, accounting for about 40 % of the national total GHG emissions. The manufacturing industries and construction together emitted 18.7 % of total emissions from the energy sector (MOEFCC 2020).

Manufacturing and industry sector contributes to 25.9% of India's gross-value add. In 2021-2022, India was the world's second-largest producer of crude steel (after China), second largest producer of cement (after China), and the fourth-largest producer of agrochemicals (after the United States, Japan and China). India accounts for ~16% of the world production of dyestuffs and dye intermediates (ES 2022).

India's mitigation strategy at economy wide level have focussed on reducing its emission intensity of GDP, improving energy efficiency, and increasing renewables share in its generation capacity. The mitigation strategies focus around improving energy efficiency especially in energy intensive industries. The introduction of Perform Achieve Trade (PAT) in 2012 represents an attempt to reduce energy intensities along with overall energy consumption by targeting large point sources (LPS) that have been identified as energy-intensive designated consumers. It is a market mechanism, administered by the Bureau of Energy Efficiency (BEE), covering 478 facilities from eight energy-intensive sectors under PAT cycle I (2012–2015). These are power, aluminium, cement, chlor-alkali, fertilizer, iron and steel, pulp and paper, and textiles. PAT cycle II covers 11 industries, 640 designated consumers, and the time frame of 20 16–2019 (BEE 2022, Vishwanathan et al. 2018).

Sectoral Mitigation drivers and barriers

Structural context

Indian manufacturing and construction industry in India contributes significantly to India's labour and economy after the services industry. It supports the on-going development and urbanization. Iron and steel industry play an essential role in contributing to the construction, infrastructure, automobiles and consumer good industry.

India's industrial sector, including non-energy consumption in process industries and construction, accounted for 42% of TFC in 2017. Iron and steel is the largest energy-consuming industry sector, accounting for 23% of total industrial consumption. However, over 40% of industrial energy consumption is not specified by industry sector, which makes the size comparison uncertain. Iron and steel production consumes mainly coal products. Overall, coal accounts for 36% of total industrial energy consumption. Chemical and petrochemical industries are the second-largest energy consumers in the industrial sector. They mostly consume oil products and natural gas used for non-energy purposes as feedstock in the processes. Oil accounts for 23% of total industrial demand and natural gas 13%; both are steadily increasing. Iron and steel, chemical and petrochemical, and textile and leather are the industries with the highest electricity consumption.[1]

Paradigms & discourses

At G20, India has emphasized the role of Asia in steel decarbonization. Ongoing discussions are stating the need for a market for responsibly produced steel. The Ministry of Steel is committed towards national NZ target by 2070. In the short term (FY 2030), it is recommended to focus on reduction of carbon emissions in steel industry through promotion of energy and resource efficiency, and renewable energy. For the medium term (2030-2047), the focus areas are around green hydrogen and carbon capture, utilisation and

[1] https://iea.blob.core.windows.net/assets/2571ae38-c895-430e-8b62-bc19019c6807/India_2020_Energy_Policy_Review.pdf

storage. In the long term (2047-2070), disruptive alternative technological innovations could help achieve the transition to net-zero[2].

At international level, India along with Sweden (supported by World Economic Forum) launched the Leadership Group for Industry Transition (LeadIT) gathering countries (18) and companies (18) that are committed to action to achieve the Paris Agreement in 2019.[3]

Polity

India's electricity and industry demand is heavily dependant on coal. The focus of nationally determined contributions (NDC) is based reduction of carbon intensity of GDP over 2005 and decoupling energy systems by installing non-fossil fuel generation capacity. As of February 2023, India has installed 120 GW of renewable energy source (wind, solar, small hydro, biomass/co-generation, waste to energy) meeting its Paris Agreement voluntary commitments. The NDC focuses more on power sector decarbonization and improving energy efficiency in the industry sector.

The industrial policies in the past decade have established and facilitated energy savings markets to support the Mission in the National Action Plan on Climate Change (NAPCC) under Copenhagen Accord (2010) which was ratcheted in the NDC under the Paris Agreement. The Indian iron and steel industry is one of the most cost-efficient industries in the world and the cement industry is one of the energy efficient industries in the world. Decarbonization of industry sector in India is challenging due to high capital investment and the capacity built has been in the past couple of decades, making it a younger fleet when compared with developed nations.

Politics

The industry sector especially the iron and steel and cement industry have been 'hard to abate' sectors due to the high capital investment for transformation. With international policies such as carbon border adjustment, domestic policy support and end-use demand in European countries shifting the steel processing technologies to produce green steel in Europe, have encouraged developing countries like India to discuss domestic possibilities.

Policy

At COP26 in Glasgow, India committed towards net zero target by 2070. The updated NDC[4] increased its current reduction in emissions intensity of its GDP by 45 percent by 2030, from 2005 level; and achieve about 50 % cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of transfer of technology and low-cost international finance including from Green Climate Fund. Additionally, the latest Energy Conservation (Amendment) Bill 2022[5] a) empowers the carbon credit trading scheme at national level, b) requires designated consumers (especially energy intensive industries) to meet a minimum share of energy consumption from non-fossil sources, and c) provides new code will provide norms for energy efficiency and conservation, use of renewable energy, and other requirements for green buildings.

Economy

Indian economy underwent wide-ranging structural and governance reforms that strengthened the economy's fundamentals by enhancing its overall efficiency during 2014-2022. India's GDP forecast for FY24 to be in the range of 6-6.8%.

Decarbonizing the industry sector will require huge capital to move away from a coal-intensive industry. At a national level, there is a lack of demand for green steel (which is more expensive). There is lack of carbon market and product market, hence there is high risk on various levels. International policies such as carbon border adjustment, protectionism in developed countries will lead to unfair, unjust competition.

National trade-offs and synergies with SDGs

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[2] https://www.pib.gov.in/PressReleseDetail.aspx?PRID=1884845

[3] https://www.industrytransition.org/who-we-are/

[4] https://pib.gov.in/PressReleasePage.aspx?PRID=1882840.

[5] https://prsindia.org/billtrack/the-energy-conservation-amendment-bill-2022.

India is committed to achieve its SDG and NDC goals by 2030. The Indian government stresses on meeting both development goals and climate targets. Implementing NDC policies will result in the achievement of targets under SDG3, SDG6, SDG7, SDG8, SDG9, SDG11, SDG13 and SDG15. On the other hand, achieving the SDG targets can help accomplish resource-use efficiency goals in addition to NDC and Paris Agreement goals (as these targets are a subset of SDG13) (Garg et al. 2021, Vishwanathan et al. 2020).

SDG13, SDG7, SDG15 for India are highly synergistic with NDC. SDG 3 and SDG6 will be subsequently impacted as we achieve the current NDC. At the same time, SDG16 (peace, justice, strong institutions) and SDG17 (global cooperation) are required to attain both SDGs and NDC. Sub-targets under SDG1, SDG2, SDG6, SDG8, SDG9, SDG11, SDG12, SDG15 are the drivers that have been used to model India's energy-economy-environment systems. SDG4 (education and awareness especially pertaining to environment) impacts the achievement of all the SDGs as well as NDC. More work is required to capture the impact of SDG5 (gender equality), SDG10 (reduced inequalities), and SDG14 (life below water) on the current NDC (Garg et al. 2021).

Status of policies

Governance and Planning instruments

The Indian government committed to the Copenhagen Accord in 2009 and the Paris Agreement in 2015 by submitting its National Action Plan on Climate Change and its first Nationally Determined Contribution (NDC) respectively. At COP26 (Glasgow Pact 2021), India pledged to updating its first NDC with declaring to be Net Zero by 2070. India has progressively continued to decouple its economic growth from greenhouse gas emissions. India exceeded to reduce its emission intensity of GDP by more than 25% per cent from 2005 levels by 2020 (Copenhagen Accord).

India declared the Net Zero Pledge to achieve net zero emissions goal by 2070. India achieved its target of 40% installed electric capacity from non-fossil fuels ahead of 2030. The likely installed capacity from non-fossil fuels to be more than 500 GW by 2030 resulting in the decline of average emission rate by around 29% by 2029-30, compared to 2014-15. India to reduce emissions intensity of its GDP by 45% by 2030 from 2005 levels. About 50% cumulative electric power installed capacity to come from non-fossil fuel-based energy resources by 2030.

Make in India is a major national programme of the Government of India designed to facilitate investment, foster innovation, enhance skill development, protect intellectual property, and build best in class manufacturing infrastructure in the country. It aims to increase the manufacturing sector's growth rate to 12-14% per annum; to create 100 million additional manufacturing jobs in the economy by 2025; to ensure that the manufacturing sector's contribution to GDP is increased to 25% by 2025.

National Steel Policy (NSP) 2017 envisages to domestically meet the entire demand of steel and high-grade automotive steel, electrical steel, special steel, and alloys for strategic applications. Steel Scrap Recycling Policy only furthers the role envisaged in the NSP-2017 to ensure scrap segregation (quality wise), collection, processing, and recycling.

Economic instruments

The Perform, Achieve, Trade (PAT) scheme was established by National Mission for Enhanced Energy Efficiency. It is regulatory instrument to reduce specific energy consumption in energy intensive industries, with an associated market-based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded. The first phase (PAT cycle I) was implemented from 2012 to 2015, covering 478 facilities, while the second phase (PAT cycle II) focuses on deepening and widening of PAT I. This comprised inclusion of 170 designated consumers (DCs) from three new sectors – namely railways, refineries, and electricity distribution companies (DISCOMs) – in addition to 61 new DCs from the existing eight sectors. The coverage from 30% to 57% of total primary energy consumption by the industries and railways. To maintain consistency with the model sector, DISCOMs are part of the power sector, while railways are part of the transport sector.

In 2022, the India government announced the developing a national carbon market.

Regulatory and 'non-economic' instruments

In August 2022, India amended its 2001 Energy Conservation Act to promote energy efficiency and conservation, and regulate the energy consumption of certain equipment, appliances, buildings and industries through energy consumption standards and codes, and the introduction of a carbon credit market (PRS 2022).

Educational, Informational, ‘soft’ instruments

The Bureau of Energy Efficiency (BEE) institutionalizes energy efficiency services in the context of Energy Conservation Act 2001. BEE had launched Standards and Labelling Scheme as voluntary basis under National Energy Labeling Programme in 2006. Currently, the scheme provides standards for 12 appliances (mandatory) and 19 (voluntary).

Assessment of national policy framework

Industry sector is the second largest energy consumer after power sector. Energy efficiency enhancements through deepening and widening of PAT in medium- and small-scale enterprises of each major energy-intensive industry will require upfront capital investments. Fuels switching to gas from coal, automation and electrification of industry, modernization of old plants are some of the low hanging measures, the large industries have been implementing. However, for significant decrease of carbon emissions, installation of CCUS in steel and cement plant clusters will be required. Policy measures on hydrogen economy, DRI-H2 technology and CCUS technology have been under discussion.

This table assesses the extent to which India's policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + near-zero emissions 2070 and 2030 mitigation target - focus on growth of industrial sector not mitigation - no sector level decarbonisation targets
	Long term finance	→ medium exploitation + availability low-cost international climate finance - high capital needs for industrial decarbonisation (e.g. young fleet)
Innovation, Demonstration & Deployment	Enhance public RD&D	No information available
	Accelerate early commercialisation, deployment	No information available
(Re)-shaping markets	Creation of demand	→ Weak expectation: no measures in place, but growth of demand expected
	Reshaping of existing markets	→ medium expectation: + carbon crediting system for large plants + minimum non-fossil energy requirements + plans for national carbon market - no carbon pricing scheme (for the time being)
	Transparency and information	No information available
Policy coherence and integration	Reducing of demand.	→ medium exploitation + resource efficiency + recycling policies - demand growth expected
	Infrastructure & energy supply	→ medium exploitation + policies for energy efficiency (PAT) + RE development, incl. ambitious target - continued dependence on coal for energy production, in particular for EIIs
	International coherence	→ strong exploitation + strong engagement in international cooperation + international climate finance reception
	Socio-economic implications	→ medium exploitation + development of EIIs for economic growth
	Regulatory environment	No information available
Knowledge & Capacity	Public managerial & bureaucratic capacity	No information available
	Monitoring and evaluation	No information available

Iran

Annika Tönjes (Wuppertal Institute for Climate, Environment and Energy), 6 June, 2023

Big picture: Current EIIs-sector decarbonisation status and prospects

Sectoral GHG emissions:

- In terms of **final energy consumption**, Industry is the second largest energy consuming sector after the Residential sector (24.8% in 2020 excluding feedstock of petrochemical industry); it is roughly tied with the Residential sector for highest electricity consumption; it is the largest consumer of coal and the second largest consumer of natural gas (*Iran - Countries & Regions*, n.d.
- Industry is the **4th highest CO2 emitting sector** (99 Mt in 2020) (ibid.)
- "Emissions from industrial processes and product use (IPPU) represented 8% of total emissions in 2010 (Department of Environment of Iran, 2017). Combined with energy use from manufacturing industries and construction, **total emissions from industry** represent nearly a fifth of emissions" (*Iran. Policies & Action.*, 2021).
- "the share of **non-energy related emissions** from the industry sector has grown steadily in the past two decades. There is however a considerable **lack of publicly available information** on emissions shares and trends by sector" (Yetano Roche et al., 2018).

Sub-sector relevance for national economy:

- Iran is the tenth largest producer of crude steel in the world (World Steel in Figures 2022, n.d.)
- "Amid United States' sanctions on Iran's oil exports, steel is one of the main exports earning foreign currency for the government" (Sinaee, 2022).
- "Iran's vision is to have 55 million tons production by 2025, and crude steel production in Iran increased by 30 % in 2019 that has transcended its ranking from 13th to 10th as a world steel producer. In 2019, Iran produced 31.9 million tons (MT) steel. In Iran, the largest share of production is in the three major manufacturing companies, Isfahan, Mobarakeh, and Khouzestan steel company (about 17.8 MT out of a total of 21.8 MT in 2017) that most of them are ore-based reduction plants" (Rahmani & Sani, 2020). The Chadermaloo, Ghadir, Butia, Ghaenat and Mianeh steel plants have been in operation since 3 years ago. Therefore, the share of the above mentioned three plants is now about 50%, while the share of their production capacity is less than 50%. In recent years, Iran has had to decrease its steel production rather than increase it as planned, due to the shortage of electricity and natural gas supply in the summer and winter respectively. It is currently using only around 30 Mt of its 40 Mt installed capacity [expert interview].

Transition phase

- Due to high dependence on fossil fuels, low development of renewables, increasing energy intensity of its economy and no serious mitigation ambition or action, Iran's economy can best be described as being firmly in the lock-in phase.

Current general national trends that promote or hinder decarbonization:

- Iran is very vulnerable to the effects of climate change (erosion, droughts, floods) (Amiraslani & Caiserman, 2018)
- "Iran's climate policies and commitments reflect minimal to no action and are not at all consistent with the Paris Agreement. […] Iran has developed few mitigation policies. Some of the policies it had begun to put in place, such as the development of renewable energy, have been slowed down or halted due to international economic sanctions. […] Investments in key mitigation technologies, such as renewable energy, picked up during the absence of international economic sanctions in 2015–2018 following the Iran nuclear deal. In 2018, the US withdrew from the agreement, reimposing sanctions on Iran. The Iranian government made it clear in its intended Paris Agreement pledge that its mitigation objectives are conditional on an absence of international economic sanctions. It is unclear to what extent Iran will pursue mitigation policies under these conditions" (Iran (Islamic Republic Of), 2021).
- Amid economic instability (recession, high inflation, sanctions), high rates of disapproval of the political system and continued mass protests, heavy government crackdown and oppression, the

political and social problems overshadow climate-related concerns. A recent study published by the Iranian Parliament's research department estimates that 30% of the Iranian population now live below the poverty line. Living conditions have deteriorated, particularly over the past two years. "They don't have enough bread to eat" [expert interview]. This is the public's number one concern, followed by the movement against oppression, for social freedom. "When you have this situation, you cannot think of the global issues at all" [expert interview].

National sectoral mitigation drivers and barriers

Drivers

Structural context: vast untapped RE potential, particularly solar power (Iran. Policies & Action., 2021), large iron ore reserves, existing infrastructure, large numbers of well-skilled people (Rahmani & Sani, 2020), high stakes: high impact of climate change on Iran (which is already leading to increasing rates of climate-induced internal migration) (Keynoush, 2023) as well as adverse local environmental impacts of fossil fuels (esp. in the country's mega-cities) (Ghadaksaz & Saboohi, 2020)

Economy: There is huge potential for (economical) energy efficiency improvements in Iran's steel industry (especially in heat recovery in the ironmaking stage), as much as 20% of gas and another 18–20% of electricity consumption [expert interview]

Technology: Due to cheap natural gas, Iran has already changed much of its steel industry from BF-BOF to DRI-EAF technology. Direct reduction in EAF accounts for 89.5 % in 2017. It is the world's second largest producer of sponge iron after India. "According to Midrex statistics (2016), Iran […] is the number one gas-based Direct Reduction Iron (DRI) producer" (Rahmani & Sani, 2020)

Barriers & Challenges:

Structural context: renewables remain underdeveloped; large natural gas reserves/ cheap availability of natural gas makes exploring greener alternatives unattractive (ibid.); unstable energy supplies negatively affect steel industry, leading to shutdowns (Gas Curbs Doom Steel Industry in Iran, 2023): over the past three or four years, electricity shortages in the summer months and natural gas shortages in the winter months have led to industry being cut off from supplies in order to meet the demands of households [expert interview]; while the current recession has led to stagnating demand, continued projected population and economic growth and urbanisation can be expected to lead to an increase in demand for basic materials like steel in the medium term [expert interview]

Paradigms/Discourse: Iranian companies do not have any explicit strong climate targets yet; low level of environmental activities and political oppression of environmentalist groups, lack of awareness/education on environmental issues and solutions in different sectors, lack of social trust, and focus on other, more immediate political, social and economic concerns leading to lack of public pressure; the importance of tackling fossil fuel use in steelmaking has been underestimated by the government (Rahmani & Sani, 2020) [expert interview]

Polity: lack of proper government oversight in the companies (ibid.); "lack of cooperation among policymakers from National Steel Company of Iran, IMIDRO, and the Ministry of Industry, Mine, and Trade in formulating convergent policies. Further, the state institutions dominate the company's decisions. They exert strategies without examining the needs of companies" (ibid.); high level of corruption (2022 Corruption Perceptions Index - Explore Iran's Results, 2023).

Politics: The Iranian government has underlined its position to commit to climate goals only if economic sanctions are lifted (McGrath, 2021).

Policies: policies for sustainable development mentioned in the Fifth and Sixth Five-year Development plan not strong enough to put pressure on sectors (Rahmani & Sani, 2020); "Lack of proper executive policies related to the transition in steel" (ibid.)

Economy: high fossil fuel export dependency, economic decline as a result of international sanctions and the Covid-19 pandemic (Mahoozi, 2021); restricted access to foreign investment due to economic sanctions; lack of R&D spending (Rahmani & Sani, 2020); high subsidies for fossil fuels make energy saving and green alternatives unattractive (ibid.) (share of energy costs in steel production costs in Iran is less than 6%, compared to 30% elsewhere) – and the state monopoly and lack of market competition in the energy sector make it exceedingly difficult to change this, as the government has strong incentives to preserve the status quo; after COP26 where the phaseout of fossil fuel subsidies was on the agenda, Iran's current government declared this to be a "colonial" policy [expert interview]. "Though they are allegedly private, they are still state-owned or public-private ownership. In such a case, because of the transfer of the public share to private, the government does not engage in financial support. Additionally, the units are large because they were initially launched by the government and then privatized. So, the capital is high, and the private sector is not able to provide this amount of investment" (Rahmani & Sani, 2020). The energy shortages forcing the steel industry to run below capacity have weakened the industry economically [expert interview]. Due to the recession, high rates of inflation and a budget deficit, the government cannot afford to support extensive R&D activities [expert interview].

Technology: "Iran's steel industry does not have a specific R&D structure for facilitating the actors' relationships. All of the R&D activities have been done by companies separately in the form of sporadic R&D" (Rahmani & Sani, 2020).

Current status of national-sectoral climate policy

Governance and Planning instruments

2017 Third National Communication to UNFCCC: "Mitigation measures set out in the Third National Communication include replacing part of the clinker used for cement production with industrial by-products, including blast furnace slag, and by replacing oil as a feedstock with natural gas in some industrial applications. These measures are to be implemented by 2025, but there is no detailed timetable" (Iran. Policies & Action., 2021).

Economic instruments

Tax exemptions for steel industry R&D: However, they are used "for maintenance and also identifying some problems in the production line, but they are not interested in developing new technologies" [expert interview].

2023 Iran Green Electricity Stock Market: Launched in May 2023, "a stock exchange-like platform that allows buyers and sellers of green electricity to trade directly with each other. […] The launch of the renewable electricity market is expected to help to attract investment in the country's clean energy sector" (Iran Launches First Renewable Electricity Transactions, 2023). It appears that the steel as well as the cement industry are buying electricity through this market, albeit rather small amounts at this point [expert interview].

[approved but not implemented:] 2016 Energy Efficiency and Environment Market: This policy was formulated with the goal of utilizing the gas price differential that exists in Iran (households pay around 1 ct/m3 for natural gas; steel industry pays around 5 ct/m3; as a feedstock for the chemical industry the price is around 14 ct/m3) to incentivize energy efficiency improvements. When a household or company invests in energy efficiency, the energy savings are monitored and a certificate is issued that can be traded in the market. This way, some investments (e.g., in households but also in the steel industry) can become economical by making use of the price differential. This incentivises energy savings without increasing gas prices, which is a highly sensitive social and political issue. The idea was to extend the market to other environmental factors such as pollution or GHG emissions. The formulated policy on Market for Energy Efficiency and Environment (M3E) was presented to the National Energy Council, the highest body for energy policies, in 2016 and it was approved. Then a Letter of Intent (LoI) was signed between the Vice Presidency for Science and Technology (VPST) of Iran and BMUB (Federal Ministry for the Environment, Nature Conservation, Buildings and Nuclear Safety) in Germany in 2017. The objective of the LoI was to support Iran in implementing the Market for Energy Efficiency and Environment. The 3-year implementation phase began in 2017, led by a company affiliated with the German Institute for Economic Research (DIW Econ) on the German side and a working group at the Vice Presidency for Science and Technology on the Iranian side. However, after the US withdrawal from JCPOA in 2019, Iran stopped the project so that it was never completely implemented. On the other hand, the implementation of M3E is now being discussed again as a solution to the promotion of energy efficiency and tackling the challenges of energy shortages in the country. However, it is being hindered by vested interests in energy subsidies, as a market like this would introduce competition into the Iranian energy economy. So far, only the green electricity stock market (see above) has been implemented as an offshoot of this policy [expert interview].

Regulatory and 'non-economic' instruments:

According to Energy Minister Ali-Akbar Mehrabian and Mahmoud Kamani (head of Iran's Renewable Energy Organization) "industries with electricity consumption of more than 1 megawatt are obliged to supply one percent of their electricity from renewable energy, which is available to buy on Iran Energy Exchange. [...] this figure will increase to 5% in the next 5 years. Also. the administrative sector of the government is also obliged to provide 5% of their electricity in the first year, and up to 20% in the next 4 years from renewable energy sources" (*Iran Launches First Renewable Electricity Transactions*, 2023).

Voluntary agreements

A deal has been made between the steel industry and the Ministry of Electricity stating that if companies install their own solar power and feed the excess into the grid during the day peak of summer, the government will ensure that the company receives a stable amount of electricity during night hours, preventing production stops. However, there are difficulties in implementing this [expert interview].

Assessment of Iran's policy framework to advance the decarbonization of EIIs

This table assesses the extent to which Iran's policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ weak exploitation + roadmap for sustainable development + roadmap for hydrogen economy + limited mitigation measures for EIIs planned - no real EII mitigation policies and national mitigation vision in place
	Long term finance	→ weak exploitation + plans for financial support for decarbonisation - economic instability - international sanctions and ltd. access to international markets
Innovation, Demonstration & Deployment	Enhance public RD&D	→ weak exploitation + tax exemptions for steel industry R&D + company level R&D ongoing - lack of public RD&D spending
	Accelerate early commercialisation, deployment	→ medium exploitation + plans for tax incentives and other measures + public fund for innovation
(Re)-shaping markets	Creation of demand	→ weak exploitation: no measures could be identified
	Reshaping of existing markets	→ weak exploitation + plans for development of ETS + emissions regulations and standards
	Transparency and information	→ weak exploitation: no measures could be identified
Policy coherence and integration	Reducing of demand.	→ weak exploitation: no measures could be identified
	Infrastructure & energy supply	→ weak exploitation + Iran green electricity stock market + energy efficiency law & action plan + energy management requirements and audits - high dependence on FF
	International coherence	→ weak exploitation: no involvement in international cooperation
	Socio-economic implications	→ weak exploitation: no measures could be identified
	Regulatory environment	→ weak exploitation - lack of government oversight - limited implementation of existing policies - high level of corruption - no climate policies in place

Knowledge & Capacity	Public managerial & bureaucratic capacity	→ weak exploitation - lack of government oversight - lack of policy integration and cooperation - ltd stakeholder engagement
	Monitoring and evaluation	→ medium exploitation

Potential to strengthen national industrial climate policy

In order to strengthen its climate policy related to the steel industry, Iran may:

- Make climate change mitigation a national mission, develop a climate neutrality vision, implement a net-zero target and (sectoral) mitigation targets
- Implement the proposed Energy Efficiency and Environment Market and other policies to utilize the sector's (and the country's) enormous energy efficiency potential
- Phase out fossil fuel subsidies
- Overcome barriers to implementing the deal made with the industry on solar power installation
- Develop policies on energy and water recovery in steelmaking (e.g., from exhaust gases) to combat water shortages in water-stressed steelmaking sites in central Iran instead of transporting water from the Persian Gulf to central Iran, as has been proposed [expert interview]
- Develop and implement a policy of recycling iron and steel and increase the utilization of scrap in steel production
- Redefine the mission of the National Iranian Steel Company (NISCO) and IMIDRO to concentrate on promoting RD&D of new energy efficient and environment technologies and refocus existing R&D tax incentives to promote green R&D, deep decarbonization, radical technological change over incremental improvements
- Implement material efficiency and circular economy policies to reduce pressure from demand increase
- Address the reasons for and re-engage in negotiations of economic sanctions and take steps toward more international collaboration, e.g., R&D partnerships
- Develop strategies to improve and stabilize the business climate for private sector investment

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Japan

Lauri Peterson, UEF, 19 Jan 2023. Two expert interviews were conducted.

Big picture: Current EIIs-sector decarbonisation status and prospects

Japan has a large energy-intensive industry sector, which accounts for 41% of total final energy consumption (IEA 2021). The chemical industry in Japan has the second highest CO2 emissions in the industrial sector after the steel industry and accounted for 57 million tonnes of the 285 million tonnes of CO2 emitted by the industrial sector in 2018. In the same year, emissions from industry constituted 25% of total emissions (Kawai, Ozawa, and Leibowicz 2022).

Japan is the second largest steel producing country in the world after China, producing 110 Mt of crude steel in 2010. Japan share of its industries in comparison to its total final energy consumption is much higher than the G7 average. In fact, it is closer to the average of the Group of Twenty (G20), which includes emerging economies (Ju et al. 2021). Japan's electricity sector is still carbon intensive with electricity sourced from fossil fuels amounting to about 70% (U.S. Energy Information Administration (EIA 2020).

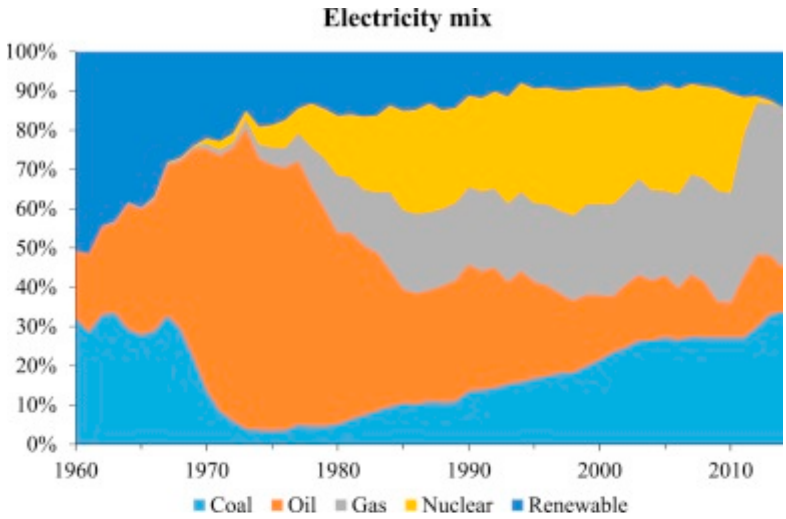

Figure 1. Japan's electricity mix (Kuriyama, Tamura, and Kuramochi 2019)

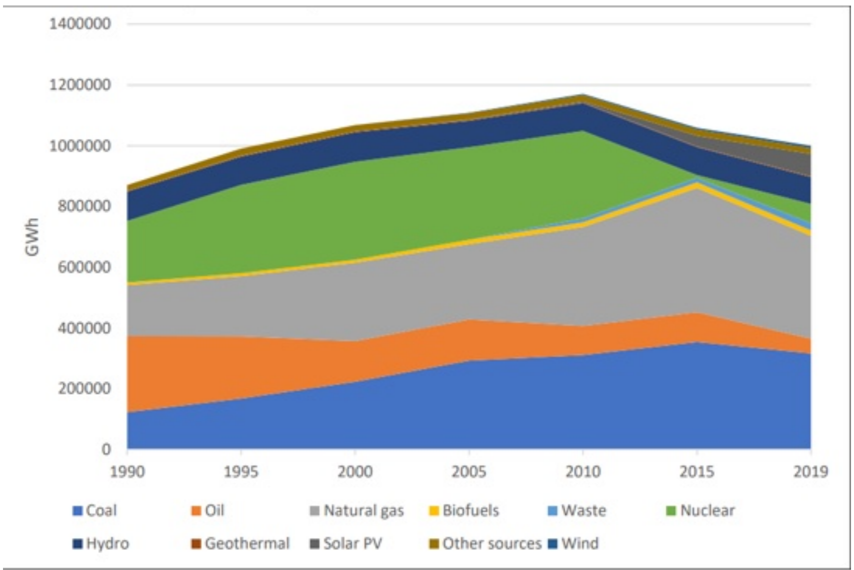

Figure 2. Japanese power generation by source 1990-2019 (Lambert 2021)

Japan's main mitigations strategy in the energy-intensive industry sector has been focused mainly on energy efficiency, which has made Japan one of the most energy efficient economies. However, Japan has reached a decreasing return to energy efficiency investments, since it now faces a limited domestic energy conservation potential (Kuramochi 2016). The potential for GHG mitigation in the Japanese iron and steel industry through energy efficiency improvement is very limited due to very high energy efficiency standards. An increased use of recycled steel is expected to be the most promising in the short-term (Kuramochi 2016).

In the materials sector, there is also a shift from oil, coal, and other energy sources to electricity, hydrogen, and other energy sources, as well as the adoption of CCUS (Carbon dioxide Capture, Utilization and Storage) technologies (Kurachi et al. 2022).

Japanese industrial policy emphasizes heavily technological climate measures, such as Carbon Capture and Storage (CCS), Carbon Capture, Utilization, and Storage (CCUS), but also the introduction of hydrogen and ammonia into industrial production processes (Ju et al. 2021). Based on prior studies, Japanese government assumes a domestic CO2 storage potential of approximately 240 billion tons (METI 2022a). Japan has several CCS projects starting or in progress (Figure 3). METI has the following CCS projects planned in line with its climate commitments by 2030:

1. Tomakomai demonstration project – promote public acceptance
2. CO2 shipping project – establish transport methods
3. R&Ds for storage and monitoring technologies – improve safety and cost efficiency
4. Investigation of Potential CO2 storage sites
5. International collaboration through Asia CCUS Network, CEM CCUS Initiative, IEAGHG, etc, ISO/TC265

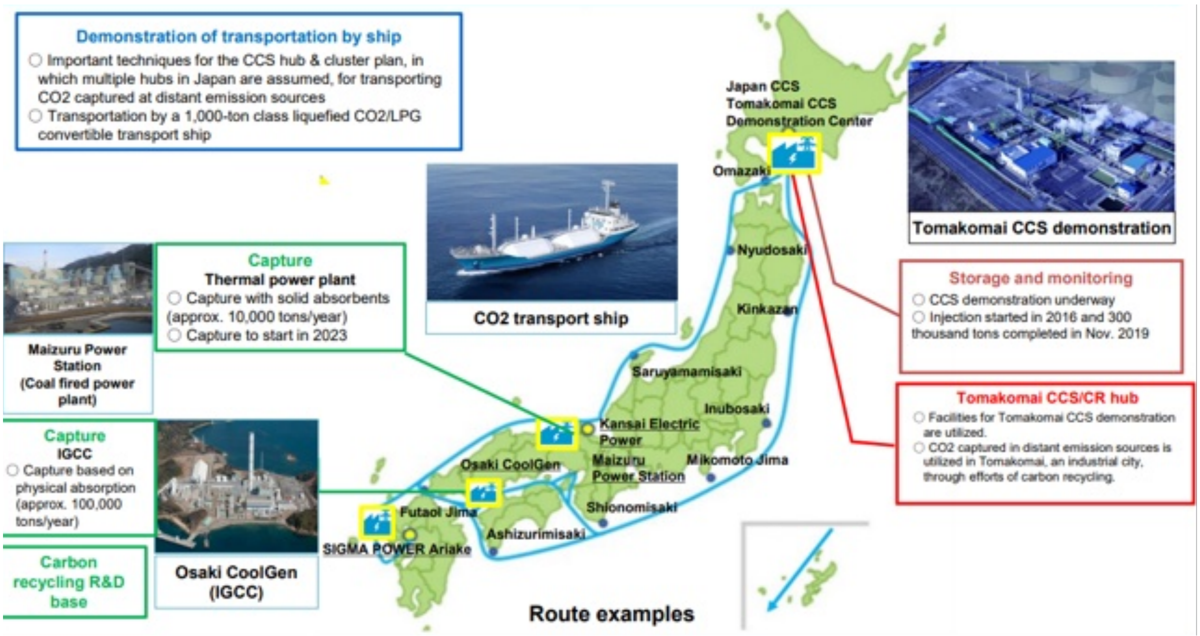

Figure 3. CCS demonstration projects in Japan (METI 2022a)

National sectoral mitigation drivers and barriers

Structural context

Japanese industry consumes a higher share of final energy and is responsible for a higher share of CO2 emissions than in the United States or the European Union (Sugiyama et al. 2021). The main structural challenge of decarbonizing the energy-intensive industrial sector is the difficulty of electrifying the manufacturing processes in the iron, steel, and chemical production sectors, which emit the greatest amounts of CO2 (Kawai, Ozawa, and Leibowicz 2022). The Green Growth Strategy emphasizes investments in hydrogen and carbon recycling technology to reduce emissions in "hard to abate sectors" (IEA 2021). The strategy notes the future development of local production of hydrogen energy combined with heat supply for industrial process. This entails the development of carbon-free hydrogen production methods using ultra high temperature heat and the support of IS processes and methane pyrolysis methods. The strategy will also promote the conversion of coal-fired private power generation to gas and the upgrading of low-efficiency blast furnaces, coke ovens, industrial furnaces, and other facilities to higher efficiency.

Paradigms & discourses

Greater focus on technological development, economic growth, and energy efficiency, rather than the reduction of emissions (Wong 2018).

The Suga government emphasizes the opportunity for economic growth with climate change mitigation. However, the government is far from leading the global climate change discourse—or international climate politics for that matter (Koppenborg and Hanssen 2021). The main barrier is the conflicting goals of economic growth, international contribution and environmental protection.

Japan’s green growth paradigm “is specifically designated as an industrial policy and promotes the creation of a virtuous cycle of economic growth and environmental protection, together with the business community” (IEA 2021, 13).

Polity

Japan is a parliamentary constitutional monarchy. Despite reforms in the 1990s, Japanese bureaucratic authorities tend to intervene in energy and industrial policy when they consider it necessary (Saito 2021).

Politics

Japan’s climate policy has been previously criticized for being hollowed out by vested interests that have led to cutbacks of clean energy investments. Moe (2012) and Kameyama (2021) note the role of “the iron triangle” of the Liberal Democratic Party rule, the Ministry of International Trade and Industry (METI) and the business associations (primarily Keidanren), which has allowed for “very lax emissions regulations, letting the major industries write their own voluntary emissions targets and letting them regulate themselves. Recent energy plans have been lenient on industry, opaque and hard to evaluate”. METI is especially known to represent the interests of the energy-intensive industry and objected to the implementation of emission reductions (Kameyama 2021). Incerti and Lipscy (2018) also note widespread amakudari (retired government officials moving to the private sector) among METI bureaucrats to was also blamed for regulatory capture.

Policy

On October 26, 2020, Prime Minister Suga pledged that Japan would be carbon-neutral by 2050. The target was integrated into the amended Promotion Act of Global Warming Countermeasures in 2021. Furthermore, the Green Growth Strategy was accordingly revised in June 2021 to provide further information on sector-level roadmaps towards net zero, which was reflected on Japan’s updated Long Term Strategy submitted before COP26. However, the Green Growth Strategy emphasizes techno-industrial solutions. Net zero targets have been implemented in law, but are lacking details (CAT 2023).

Since 2013, Japan’s Joint Crediting Mechanism (JCM) has been aiding partner countries in reducing their emissions through the diffusion of decarbonizing technologies, products, systems, services, and infrastructure that enable implementation of mitigation actions in partner countries, while promoting sustainable development (IISD 2021).

Economy

In January 2020, the government created the Environment Innovation Strategy to develop new technologies that will help achieve the "Beyond-Zero" goal of reducing CO2 emissions since the Industrial Revolution. The Japanese government has identified the challenges that need to be overcome and is actively discussing solutions. These challenges include the implementation of these new technologies on a societal level and reducing the cost of mass production through investment. To achieve this goal, the government will use various policy measures such as budget allocation, tax incentives, financing options, regulatory reform, standardization and international cooperation to encourage private companies to invest in these new technologies. The Environment Innovation Strategy is expected to have a positive economic impact of 90 trillion yen in 2030 and 190 trillion yen in 2050 (METI 2021).

The Japanese economy’s challenge is its "sluggish response to structural change" (Kurachi et al. 2022). The Japanese industry has taken a cautious stance towards spending, with an excess in savings (Kurachi et al. 2022). The expectation is to increase investments in innovative technology to decarbonize.

National trade-offs and synergies with SDGs

Japan has mainly focused on energy efficiency and innovative technology instead on emission reductions to protect its domestic energy-intensive industry, which relates to SDG 8 on decent work and economic growth, SDG 9 on industry, innovation, and infrastructure.

However, IGES (2021) finds that JCM activities have resulted in a number of best practices of the Mechanism’s contributions to SDG achievement. JCM projects focusing on renewable energy, energy efficiency and energy transmission, agriculture, waste recycling, transport, and water have made to implementation of the SDGs and related targets. For example, it demonstrates how, in addition to contributing to SDG 7 (affordable and clean energy), projects introducing energy efficiency technologies in different industries and sectors also promote, inter alia: SDG 4 (quality education) by providing technical capacity training to local employees; SDG 13 (climate action) by contributing to climate change mitigation; SDG 8 (decent work and economic growth) by providing employment opportunities; SDG 9 (industry, innovation and infrastructure) by encouraging industry innovation; SDG 12 (responsible consumption and production) by promoting sustainable use of resources; and SDG 17 (partnerships for the Goals) by ensuring technology diffusion and transfer to developing countries (IGES 2021).

Current status of national-sectoral climate policy

Governance and Planning instruments

On October 26, 2020, Prime Minister Suga pledged that Japan would be carbon-neutral by 2050. This goal is expressed in Japan’s 2021 updated NDC: “Japan aims to reduce greenhouse gas emissions to net-zero, that is, to realize carbon neutrality by 2050, based on the idea that addressing climate change is no longer a constraint on economic growth and that proactive climate change measures bring transformation of industrial structures as well as its economy and society, leading to dynamic economic growth (Japan 2021).”

Japan also aims to reduce GHG emissions by 46% by 2030 (from 2013 levels) and "…furthermore, we will continue to take on the challenge of reaching the 50% goal." In particular, Japan plans to remove 289 million t-CO_2 from energy-related industry sources by 2030 (Japan 2021).

The government issued the Green Growth Strategy in December 2020 to support the private sector’s efforts toward carbon neutrality by 2050. The strategy includes 5 cross sectoral policy tools (support measures) and action plans for 14 sectors, and will be updated continuously (METI 2021). The strategy aims to increase hydrogen consumption across all industries to around 20 million metric tons by year by 2050.

The 14 key sectors of the Green Growth Strategy:

- Energy
  1. Offshore wind (wind turbines, components, floating turbines)
  2. Ammonia fuel (transition period to the hydrogen society)
  3. Hydrogen (hydrogen power generation, hydrogen-fueled steelmaking, hydrogen carrier ships, electrolyzers)
  4. Nuclear power (small modular reactors, hydrogen production from nuclear)
- Transport & Industry
  5. Mobility and batteries (electric vehicles, fuel cell vehicles, next generation batteries)
  6. Semiconductors and ICT (data centers, energy efficient semiconductors)
  7. Maritime transport (hydrogen ships, electric ships, gas-fueled ships)
  8. Logistics (smart transportation, logistics drones, hydrogen machinery for construction)
  9. Food, agriculture, forestry, fisheries (smart agriculture, high rise wood construction, blue carbon)
  10. Aviation (hybrid electric aircrafts, hydrogen aircrafts)
  11. Carbon recycling (concrete, biofuels, plastics)
- Home & Office
  12. Next generation solar panels for housing and building (perovskite solar cells)

13. Resource circularity (biomaterials, recycled materials, power generation from waste)
14. Lifestyle industry (local decarbonization of businesses)

The strategy includes five policy tools (METI 2021):

1) Grant funding – Green Innovation Fund (2 trillion yen over 10 years) and stimulate 15 trillion yen private R&D and investment. The sectors that receive priority are
    a. energy-related industries (offshore wind, solar and geothermal, hydrogen, fuel and ammonia, next-generation thermal energy and nuclear),
    b. transport/manufacturing (automotive and battery storage, semiconductor and telecommunications, shipbuilding, logistics, circulation of individuals and civil infrastructure, food, agriculture, forestry and fisheries, aircraft, carbon recycling and materials), and
    c. home/office-related industries (housing, building industry, resource circulation, lifestyle emissions).
2) Tax incentive – stimulate 1.7 trillion yen of private investment over 10 years in production facilities and processes that contribute to decarbonization, and research and development programs for green innovation.
    a. Establishment of the Investment Promotion Tax System (tax deduction or special depreciation) toward Carbon Neutrality.
3) Guidance policy on finance – transition finance and establish long-term funds with an interest subsidy
    a. A fund of 2 trillion yen over the next 10 years is established to support green innovation. It aims at stimulating 15 trillion yen of private investment. Subsidies will support long term R&D and demonstrators in the 14 sectors.
4) Regulatory reform (in areas of hydrogen, offshore wind power and mobility/batteries) and standardization
    a. Economic methods that use market mechanisms (e.g., carbon pricing)
    b. Regulations will be reformed to facilitate and reduce the cost of new projects, for example in the areas of hydrogen charging stations, power grid and emission standards of vehicles.
    c. Standards will be developed to facilitate the generalization of new technologies, such as biofuels and charging stations for electric vehicles.
5) International collaboration – cooperation with developed and developing countries

The 2019 Strategic Roadmap for Hydrogen and Fuel Cells and 2017 Basic Hydrogen Strategy sets out Japan's vision and action plan on how to decarbonize energy, industry and transport sectors based on hydrogen and fuel cells by 2050.

The Strategic Roadmap for Hydrogen and Fuel Cells defines 1) new targets on the specification of basic technologies and the breakdown of costs, 2) necessary measures for achieving these goals; and 3) that Japan will convene a working group consisting of experts to review the status of implementation in each area stipulated by the roadmap.

<u>Economic instruments</u>

Japan was the first Asian country to implement a carbon tax, which applies to fossil fuels, such as petroleum, oil products, natural gas and coal (Gokhale 2021). However, the carbon tax has a low effective carbon rate in industrial and electricity sectors and extends several exemptions and refund measures on carbon tax rates for certain fossil fuel products used by EIIs. Carbon tax exemptions and refund measures are extended to imported coal used for home generation of electricity, caustic soda production in caustic soda manufacturing industry, heavy oil and light oil used for domestic cargo ships and passenger ships, light oil used in railways, aviation fuel used in domestic flights, imported coal used for home generation of electricity, salt production in salt manufacturing (ion exchange membrane effort), and light oil used in agriculture, forestry and fishery (Ministry of Environment, 2012b). Japan's effective carbon rate in 2018 was €24 (60 per ton of CO_2) one of the lowest among OECD countries behind Colombia and Argentina (OECD 2021). The stringency of the carbon tax is weak as it has allowed for exemptions and refunds in certain raw material industries (MOE 2014). Emission trading schemes exist that cover a total of ~520 factories as liable entities (ICAP

2022b; 2022a). However, the schemes have been implemented in only 2 prefectures out of 47. One began in metropolitan Tokyo in 2010 and another launched in the prefecture of Saitama in 2011.

The government is currently testing out a new carbon credit system. Under the trial, 145 registered members can trade existing carbon credits, known as J-Credits, that are certified by the government.

In 2012, Japan adopted a Tax for Climate Change Mitigation and 2018 a Tax System for Promoting Energy Efficiency and Renewable Energy.

The National Budget for 2021 includes the Green Innovation Fund, a JPY 2 trillion fund, to assist ambitious green projects over the next decade in the areas of energy-related industries, transportation and manufacturing industries, home and office-related industries. The R&D and Social Implementation Plans for "Next-Generation Solar Cell Development" and "Cost Reductions for Offshore Wind Power Generation" projects from 2021 define how to achieve a power generation cost of 14 yen/kWh or less by 2030 and a power generation cost of 8 to 9 yen/kWh with fixed-bottom wind turbines and technology to commercialise floating offshore wind turbines at internationally competitive cost levels, respectively (LSE Grantham Research Institute 2022b).

In 2022, the government approved the advanced energy-saving investment promotion support project, which subsidizes the renewal of equipment at factories and businesses for energy consumption efficiency (LSE Grantham Research Institute 2022b).

Regulatory and 'non-economic' instruments

The Act on Promotion of Global Warming Countermeasures (Law No. 117 of 1998) is one of the two key climate laws in Japan along with the Energy Conservation Law. The purpose of the Law is to reduce emissions of GHGs derived from anthropogenic activities. On June 4th, 2021, the Diet approved the amending Act 54/2021 introducing a net zero target by 2050 into the law (LSE Grantham Research Institute 2022a).

The Rational Use of Energy Law is the pillar of Japanese energy conservation policy. It was initially enacted in 1979 in the light of the oil shock conserve energy. It covers the following sectors: energy management in the industrial, commercial, residential and transport sectors; energy efficiency standards for vehicles and appliances. The subjects of the Law are factories and workplaces that consume more than 1,500kL of oil equivalent energy annually. The 2018 Act of the Partial Revision of the Act on the Rational Use of Energy promotes a cross-industry capital investment where more than one company collaborates with one another (LSE Grantham Research Institute 2022b).

Japan released the Sixth Strategic Energy Plan in October 2021, which increased the country's renewable power (including hydropower) generation target from the previous 22%-24% to 36%-38% by 2030.

2019 Roadmap for Carbon Recycling Technologies to promote carbon capture and carbon capture, utilisation and storage (CCUS).

Educational, Informational, 'soft' instruments

Various research programmes, such as the COURSE50 project (CO2 Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50) for steel making, are aimed at long-term emission reductions of 30% by 2050 through suppression of CO2 emissions from blast furnaces as well as capture - separation and recovery - of CO2 from blast furnace gas (BFG).

Voluntary agreements

Japan mainly relies heavily on voluntary agreements to reach its climate goals (IEA 2021). The main voluntary energy efficiency measures in the industry are *Keidanren*'s Voluntary Commitment to a Low-Carbon Society, and the sector benchmarks introduced in 2010 under the amended Energy Conservation Act. The former is an extension of the Voluntary Action Plan (VAP) that started in 1997 as part of the government plan to achieve the mitigation target under the first commitment period of the Kyoto Protocol (Fekete et al. 2021). Under the guidance of the government and the Japan Business Federation (Keidanren), as well as through collaboration with their respective industrial associations, Japanese companies have established voluntary action plans to mitigate climate change (Hori et al. 2022). Since 2008, evaluation of emission reduction has been conducted annually by a government committee and a third-party committee. In response to Japan's long-term strategy, Keidanren initiated and encouraged member companies to formulate their long-term vision toward 2050. In the 2014 evaluation report (JBF 2014), it was reported that Japanese

Business Federation (*Keidanren*) members contributed over 80% to the total domestic industrial emissions and achieved a 5.6% reduction in emissions, as compared to the 2005 level.

Chemical industries plan to reduce CO2 emissions by 2 million tonnes by 2030 (compared to the emissions in 2005), ahead of schedule, through strict energy conservation, in accordance with the "Low Carbon Society Action Plan" set forth by the Japan Chemical Industry Association in 2013.

Analysis of national policy framework to advance the decarbonisation of EIIs

This table assesses the extent to which Japan's policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation Long Term Strategy - reiterating its 2050 target of reducing GHG emissions by 80% and aiming to achieve net-zero emissions "as early as possible during the second half of the 21st century". The Green Growth Strategy to achieve carbon neutrality by 2050 is defined as an industrial policy towards a "Positive cycle of economic growth and environmental protection" (METI 2021). Green Growth Strategy (revised in June 2021) Sixth Strategic Energy Plan (Oct 2021) The Act on Promotion of Global Warming Countermeasures (Law No. 117 of 1998) is one of the two key climate laws in Japan along with the Energy Conservation Law. The Rational Use of Energy Law (1979, revised in 2018) covers 90% of industrial use of energy. Roadmap for Carbon Recycling Technologies (2019)
	Long term finance	→ strong exploitation The Green Growth Strategy includes Grant funding - Green Innovation Fund (2 trillion yen over 10 years) and stimulate 15 trillion yen private R&D and investment. The sectors that receive priority are: energy-related industries (offshore wind, solar and geothermal, hydrogen, fuel and ammonia, next-generation thermal energy and nuclear), transport/manufacturing (automotive and battery storage, semiconductor and telecommunications, shipbuilding, logistics, circulation of individuals and civil infrastructure, food, agriculture, forestry and fisheries, aircraft, carbon recycling and materials), and home/office-related industries (housing, building industry, resource circulation, lifestyle emissions). The Green Growth Strategy also includes guidance policy on finance, transition finance and establish long-term funds with an interest subsidy, including a fund of 2 trillion yen over the next 10 years is established to support green innovation. It aims at stimulating 15 trillion yen of private investment. Subsidies will support long term R&D and demonstrators in the 14 sectors.
Innovation, Demonstration & Deployment	Enhance public RD&D	→ medium exploitation Japan already invests and plans to invest heavily in CCS, but also the introduction of hydrogen and ammonia into industrial production processes. As mentioned before, the Green Growth Strategy entails grant funding - Green Innovation Fund (2 trillion yen over 10 years) and stimulate 15 trillion yen private R&D and investment. The sectors that receive priority are: energy-related industries (offshore wind, solar and geothermal, hydrogen, fuel and ammonia, next-generation thermal energy and nuclear), transport/manufacturing (automotive and battery storage, semiconductor and telecommunications, shipbuilding, logistics, circulation of individuals and civil infrastructure, food, agriculture, forestry and fisheries, aircraft, carbon recycling and materials), and home/office-related industries (housing, building industry, resource circulation, lifestyle emissions). New hydrogen and CCUS technologies are being developed as part of current RDI policies. Japan invests significantly into the development of these technologies and the government aims to improve the cost competitiveness of hydrogen and achieve cost parity with liquid natural gas (Nagashi 2018).

		However, CCS has remained unproven practically and reductions in the cost of hydrogen and fuel cells require a greater commitment to scale up hydrogen at home and internationally (Nagashi 2018). However, international cooperation has been slow. Hydrogen and fuel cell technology requires highly expensive and advanced infrastructure and skilled technicians.
	Accelerate early commercialisation, deployment	→ medium exploitation Japanese industrial policy emphasizes heavily technological climate measures, such as Carbon Capture and Storage (CCS), Carbon Capture, Utilization, and Storage (CCUS), but also the introduction of hydrogen and ammonia into industrial production processes (Ju et al. 2021). Based on prior studies, Japanese government assumes a domestic CO2 storage potential of approximately 240 billion tons (METI 2022a). Japan has several CCS projects starting or in progress (Figure 3). METI has the following CCS projects planned in line with its climate commitments by 2030: Tomakomai demonstration project - promote public acceptance, CO2 shipping project - establish transport methods, R&Ds for storage and monitoring technologies - improve safety and cost efficiency, Investigation of Potential CO2 storage sites, International collaboration through Asia CCUS Network, CEM CCUS Initiative, IEAGHG, etc, ISO/TC265, In 2012, Japan adopted a Tax for Climate Change Mitigation and 2018 a Tax System for Promoting Energy Efficiency and Renewable Energy.
(Re)-shaping markets	Creation of demand	→ medium exploitation Green Growth Strategy aims at regulatory reform (in areas of hydrogen, offshore wind power and mobility/batteries) and standardization, Economic methods that use market mechanisms (e.g., carbon pricing). Regulations will be reformed to facilitate and reduce the cost of new projects, for example in the areas of hydrogen charging stations, power grid and emission standards of vehicles. Standards will be developed to facilitate the generalization of new technologies, such as biofuels and charging stations for electric vehicles. The Strategy also accounts for tax incentives to stimulate 1.7 trillion yen of private investment over 10 years in production facilities and processes that contribute to decarbonization, and research and development programs for green innovation. Establishment of the Investment Promotion Tax System (tax deduction or special depreciation) toward Carbon Neutrality. In January 2020, the government created the Environment Innovation Strategy to develop new technologies that will help achieve the "Beyond-Zero" goal of reducing CO2 emissions since the Industrial Revolution. The Japanese government has identified the challenges that need to be overcome and is actively discussing solutions. These challenges include the implementation of these new technologies on a societal level and reducing the cost of mass production through investment. To achieve this goal, the government will use various policy measures such as budget allocation, tax incentives, financing options, regulatory reform, standardization and international cooperation to encourage private companies to invest in these new technologies. The Environment Innovation Strategy is expected to have a positive economic impact of 90 trillion yen in 2030 and 190 trillion yen in 2050 (METI 2021). In 2022, the government approved the advanced energy-saving investment promotion support project, which subsidizes the renewal of equipment at factories and businesses for energy consumption efficiency (LSE Grantham Research Institute 2022b).
	Reshaping of existing markets	→ medium exploitation Japan was the first Asian country to implement a carbon tax, which applies to fossil fuels, such as petroleum, oil products, natural gas and coal (Gokhale 2021). However, the carbon tax has a low effective carbon rate in industrial and electricity sectors and extends several exemptions and refund measures on carbon tax rates for certain fossil fuel products used by EIIs. Carbon tax exemptions and refund measures are extended to imported coal used for home generation of electricity, caustic soda production in caustic soda manufacturing industry, heavy oil and light oil used for domestic cargo ships and passenger ships, light oil used in railways, aviation fuel used in domestic flights, imported coal used for home generation of electricity, salt production in salt manufacturing (ion exchange membrane effort), and light oil used in agriculture, forestry and fishery (Ministry of Environment, 2012b). Japan's effective carbon rate in 2018 was €24

		(60 per ton of CO2) one of the lowest among OECD countries behind Colombia and Argentina (OECD 2021). Japan's LTS notes the need for carbon neutrality in the industrial sector, which needs to take into account the "just transition of the workforce" (The Government of Japan 2021).
	Transparency and information	→ medium exploitation Japan National Greenhouse Gas Inventory Presently, there are 5 types of certified emission reduction in Japan: Domestic credit in Japan, Green energy CO2 reduction amount, Offset credit (J-VER), Japan Credit(J-Credit), and JCM Credits. Japan Greenhouse Gas Emission Reduction/Removal Certification Scheme (J-Credit Scheme) - The Scheme includes certification requirements for emission reductions/removals and requirements for project participants that are designed to prevent double certification and double reporting of emission reduction/removal effects. To ensure international credibility, the Scheme is based on ISO 14064-2, an international standard on quantification and reporting of emission reductions/removals at the project level, and ISO 14064-3, an international standard on validation and verification of greenhouse gas emission reduction/removal projects.
Policy coherence and integration	Reducing of demand.	→ medium exploitation Green Growth Strategy emphasizes resource circularity (biomaterials, recycled materials, power generation from waste). Next generation solar panels for housing and building (perovskite solar cells). Lifestyle industry (local decarbonization of businesses)
	Infrastructure & energy supply	→ strong exploitation See "Accelerate early commercialisation" Japanese industrial policy emphasizes CCS and hydrogen policy along with energy efficiency measures. Japan released the Sixth Strategic Energy Plan in October 2021, which increased the country's renewable power (including hydropower) generation target from the previous 22%-24% to 36%-38% by 2030. 2019 Roadmap for Carbon Recycling Technologies to promote carbon capture and carbon capture, utilisation and storage (CCUS).
	International coherence	→ strong exploitation Since 2013, Japan's Joint Crediting Mechanism (JCM) has been aiding partner countries in reducing their emissions through the diffusion of decarbonizing technologies, products, systems, services, and infrastructure that enable implementation of mitigation actions in partner countries, while promoting sustainable development (IISD 2021). International collaboration through Asia CCUS Network, CEM CCUS Initiative, IEAGHG, etc, ISO/TC265 Japan has previously suggested a 'carve-out model', which would separate EIIs emission reduction targets from the rest of the economy, with little or no differentiation between industries whether located in Annex 1 or in non-Annex 1 countries, which has not found international support (Åhman, Nilsson, and Johansson 2017).
	Socio-economic implications	→ medium exploitation Japan's LTS notes the need for carbon neutrality in the industrial sector, which needs to take into account the "just transition of the workforce" (The Government of Japan 2021). Interviewees noted that just transition is currently not a topic of discussion in Japanese policy circles.
	Regulatory environment.	→ strong exploitation Environmental permits are required for any activity or business that may have a harmful effect on the environment. Environmental permits cannot be transferred. Environmental Impact Assessment Act - assessments needed by large-scale projects.

Knowledge & Capacity	Public managerial & bureaucratic capacity.	→ medium exploitation Japan's climate policy has been previously criticized for being hollowed out by vested interests that have led to cutbacks of clean energy investments. Moe (2012) and Kameyama (2021) note the role of "the iron triangle" of the Liberal Democratic Party rule, the Ministry of International Trade and Industry (METI) and the business associations (primarily Keidanren), which has allowed for "very lax emissions regulations, letting the major industries write their own voluntary emissions targets and letting them regulate themselves. Recent energy plans have been lenient on industry, opaque and hard to evaluate". METI is especially known to represent the interests of the energy-intensive industry and objected to the implementation of emission reductions (Kameyama 2021). Incerti and Lipscy (2018) also note widespread amakudari (retired government officials moving to the private sector) among METI bureaucrats to was also blamed for regulatory capture. METI has been developing decarbonization roadmaps for specific sectors, such as cement, paper/pulp, the chemical sector, steel, electric power, gas, and oil sector to provide climate transition finance (METI 2022b). Main purpose of these roadmaps is to prepare finance to meet the long-term roadmap, whether new tech can solve problems. METI develops roadmaps for each sector, which does not involve other ministries or the national government. It is approved by gov office. The roadmaps are criticized for not showing details how CCS and hydrogen are going to be used in practice.
	Monitoring and evaluation	→ strong exploitation Japan National Greenhouse Gas Inventory - establishment of a system for mandatory accounting, reporting and disclosure of GHG emissions, and a mechanism for the development of emissions reduction plans by private entities, and evaluation of those plans by governments through the utilisation of International Organization for Standardization (ISO) standards. Mandatory CO2 reporting system - Introduced in the revision Act on Promotion of Global Warming Countermeasures in 2005 (Enforced in 2006). Entities with over 3,000t-CO2e annual emissions (specified emitters) are required to report to the government their emissions once a year, and the government disclose the data. Climate Disclosures became mandatory in April 2022. Companies listed on the Tokyo Stock Exchanges 'Prime' market will be required to comply with mandatory climate risk disclosure requirements aligned with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations first.

Summary table

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + net-zero and 2030 target target provide general guidance, + economy wide decarbonisation strategy + mandatory accounting of emissions and emissions reduction plans for private firms + sector specific visions or strategies in place, but focus on CCS - no sector specific mitigation targets
	Long term finance	→ strong exploitation + general greening of finance and specific RD&D funding at large scale + guidance policy on finance, transition finance and est. long-term funds
Innovation, Demonstration & Deployment	Enhance public RD&D	→ medium exploitation + funding for large scale R&D are in place, but focus less on EIIs + specific funding on CCS and ammonia, but not specific to other production routes
	Accelerate early commercialisation, deployment	→ medium exploitation + specific measures are in place regarding CCS - no specific commercialisation policies for EIIs
	Creation of demand	→ medium exploitation

(Re)-shaping markets		+ general policies in place to foster economic decarbonisation - no policies in place to create specific demand for NZE basic materials
	Reshaping of existing markets	→ medium exploitation + general (but low) carbon tax is in place, but not specific to EIIs - government extends several exemptions and refund measures on carbon tax rates for EIIs.
	Transparency and information	→ medium exploitation + mandatory accounting of emissions and emissions reduction plans for private firms + not product specific measures in place
Policy coherence and integration	Reducing of demand.	→ medium exploitation + circular economy measures are emphasised in LTS - no specific provisions for EIIs are in place
	Infrastructure & energy supply	→ Strong exploitation + Investments and plans for RE + Strong policy focus on and finance for green H2 and CCS
	International coherence	→ strong exploitation + Engagement in international cooperation of EIIs, in particular in EIIs + provision of climate finance for industrial decarbonisation - no specific carbon leakage provisions in place
	Socio-economic implications	→ medium exploitation + just transition aspects are acknowledged in policy documents - no specific policies are in place and just transition not discussed in national politics
	Regulatory environment.	→ strong exploitation + stable regulatory environment + environmental permitting
Knowledge & Capacity	Public managerial & bureaucratic capacity.	→ medium exploitation + high bureaucratic capacity, development of EII specific roadmaps + stakeholder engagement - history of vested interests in EII sector
	Monitoring and evaluation	→ strong exploitation + mandatory emissions accounting and emissions reduction plans for private firms + climate risk disclosure + environmental impacts assessments

How to strengthen national-sectoral climate policy

- Prime Minister Kishida has been lately trying to come up with a economic growth strategy in general terms, has been putting decarbonization a priority.
- The Japanese government is planning to rehabilitate nuclear plants and their lifespan has been extended beyond the maximum of 60 years (Dyer 2022; Iida 2022).
- Include consideration of where international means of implementation (e.g. provision of finance, technology transfer, capacity building) hold particular promise to further ambitious NDC development and implementation.
- Consider outputs by the national focal points on gender-responsive climate policies (see WP Research Framework).

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Kingdom of Saudi Arabia

Industry-Sector Sheet – Kingdom of Saudi Arabia (KSA)

Simon Otto, Vrije Universiteit Brussels (VUB), 26 June 2023

Big picture: Current EIIs-sector decarbonisation status and prospects

Current, past, and projected future GHG emissions in the energy-intensive industry sector

KSA's GHG emissions amounted to 723 MtCO2e in 2019, amounting to 1.45% of global GHG emissions, making KSA the world's 11th largest emitter. In 2019, the energy sector was responsible for 80.48% of GHG emissions (581.96 MtCO2e), followed by industrial processes and product use (IPPU) with 14.26% (105.76 MtCO2e).[1]

Petrochemical, iron and steel, and cement manufacturing are the main drivers of IPPU emissions.[2] In 2020, the cement industry emitted 35.5% of IPPU emissions (78,33 MtCO2e in total), followed closely by petrochemicals (32.3%) and iron and steel industries (16.8%).[3] According to estimates, total IPPU emissions could reach between 199.34 and 426.35 million tons of CO2eq in 2050. IPPU accounts for around 41% of total energy consumption, with 80% of energy utilized in petrochemical, cement and iron and steel industries. Total GHG emissions from major IPPU sectors have consistently increase in emissions over last decade, although the rate of increase has slowed for almost all sectors.[4]

In 2018, KSA experienced first ever large decline in total CO2 emissions. However, while 'policy-induced variables of carbon and energy intensity played a significant role in the significant decline of emissions in 2018, less policy-influenced factors of slowing GDP and population growth also contributed to the overall stabilization observed since 2016.[5]

Relevance of EIIs for the national economy

In 2021 the valued added of industry sector was 45.52% of GDP, which includes mining, manufacturing (13.06% in 2021), construction, electricity, water, and gas.[6] Major IPPU sectors that contribute to KSA economy are cement, direct reduced iron (DRI), raw steel, petrochemicals, ammonia, aluminium, zinc, glass, titanium oxide and soda ash. Cement, DRI, raw steel and petrochemicals are most dominant in terms of industrial production.[7]

To reduce the reliance on oil revenues, KSA aims to pursue a strategy of economic diversification. To this end, the 2021 NDC foresees two different scenarios for domestic economic development:[8]

> a) Economic diversification with robust contribution from hydrocarbon and its derivatives exports revenues, channelled into investments in high value-added sectors such as financial services, medical services, tourism, education, renewable energy and energy efficiency technologies to enhance economic growth [reflects current ambition].
>
> b) Accelerated domestic industrialization based on sustainable utilization of hydrocarbons. A heavy industrial base built to use domestic energy resources as feedstock or energy source abated with

[1] Climate Watch. (n.d.). *Saudi Arabia*. https://www.climatewatchdata.org/countries/SAU

[2] Kingdom of Saudi Arabia. (2022). *Fourth National Communication*. UNFCCC. https://unfccc.int/sites/default/files/resource/7123846_Saudi%20Arabia-NC4-1-Fourth%20National%20Communication%20NC4%20Kingdom%20of%20Saudi%20Arabia%20March%202022.pdf

[3] Rahman, M. M., Rahman, M. S., Chowdhury, S. R., Elhaj, A., Razzak, S. A., Abu Shoaib, S., Islam, M. K., Islam, M. M., Rushd, S., & Rahman, S. M. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge. *Sustainability, 14*(12), 7388. https://doi.org/10.3390/su14127388

[4] Ibid.

[5] Shehri, T. A., Braun, J. F., Howarth, N., Lanza, A., & Luomi, M. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach. *Climate Policy*, 1–17. https://doi.org/10.1080/14693062.2022.2070118

[6] World Bank. (n.d.). *World Development Indicators*. https://databank.worldbank.org/source/world-development-indicators

[7] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[8] Kingdom of Saudi Arabia. 2021. *Updated first nationally determined contribution*. UNFCCC. https://unfccc.int/sites/default/files/resource/202203111154---KSA%20NDC%202021.pdf

best suitable technologies. Increasing contributions of petrochemical, cement, mining and metal production industries to the national economy → this scenario implies a significant increase in EII related GHG.

Phase of the zero-emission transition of the sector currently

KSA can best be described to continue to be in the lock-in phase of the transition to a low carbon society. The state is heavily reliant on fossil-fuel revenues and does not have plans to reduce production. There are currently no plans in place to fundamentally change that.

Current general national trends that promote or hinder decarbonization.

KSA is considered a 'petrostate' as oil is the cornerstone of economy.

National sectoral mitigation drivers and barriers

Barriers to decarbonisation

Structural context

- KSA is the largest global producer and exporter of petroleum liquids, as well as major consumer of primary energy.[9]
- KSA has an oil-based economy with strong government controls over major economic activities. The petroleum sector accounts for roughly 87% of budget revenues, 42% of GDP, and 90% of export earnings.[10]
- Enormous investments in megaprojects have driven demand for construction materials in recent years. Before, the market was characterised by significant excess capacities for cement production, and several companies took advantage of this to retire outdated manufacturing.[11]
- High dependency on fossil fuels for electricity production. In 2019, KSA produced nearly 100% of electricity with fossil fuels – around 56% with natural gas and 43% with oil.[12]
- Expected growth in energy demand due to population growth (notably the demand for electricity, a rapidly growing manufacturing sector, and a high need for air conditioning systems).[13]
- No significant potential for conventional bioenergy or the use of biomass.[14]

Politics

- Climate action basically non-existent domestically due to strong economic reliance on oil.
- KSA has traditionally approached global climate change mitigation defensively, due to its high reliance of domestic economy on revenues from oil exports.[15] Accordingly, domestic climate policy is basically inexistent.
- Within the international climate change regime KSA has historically represented interests of fossil fuels producing countries and fossil fuels industries and lobbies.[16]

Policy

- Prior to developments around the CCE framework (see below), KSA had no articulated formal domestic climate change policy or plan. Its Saudi Vision 2030 development strategy makes no reference to climate change.[17]

[9] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[10] CIA. (2023, May 26). *Saudi Arabia*. The World Factbook. https://www.cia.gov/the-world-factbook/countries/saudi-arabia/#economy

[11] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[12] Climate Action Tracker. (2021). *Saudi Arabia*. https://climateactiontracker.org/countries/saudi-arabia/

[13] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[14] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

[15] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

[16] Depledge, J. (2008). Striving for No: Saudi Arabia in the Climate Change Regime. *Global Environmental Politics*, 8(4): 9–35.

[17] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

- CAT rated KSA's policy mix as "insufficient", meaning KSA's policy mix does not put the country on a pathway that is compatible with the Paris Agreement's temperature limits. KSA can reach the upper end of its 2030 pledge with its implemented policies, while emissions are expected to increase by around 30% above 2010 levels in 2030.[18]
- High domestic fossil fuel subsidies at nearly USD 30 billion in 2019 (3rd globally), with most subsidies dedicated to oil, followed by subsidies to fossil electricity production and natural gas.[19]

Economics

- Abundant supply of cheap natural gas and oil for EII production.
- KSA has among lowest costs and emissions per barrel of oil produced and has therefore been described as likely 'last man standing' in future global oil markets.[20]

<u>Enablers of decarbonisation of EIIs</u>

Structural context

- High potential for renewable energy production, including the production of green hydrogen.
- Potential need to diversify economy away from dependency on oil revenues, assuming a growing likely hood of peak in global oil demand.[21]
- KSA is pursuing economic diversification through activities and programs that have co-benefits, such as GHG emissions reduction and adaptation impacts.[22]

Paradigms & discourses

- Ambition/vision of national economic diversification away from reliance on revenues of oil (and gas) exports. KSA's NDC is driven by the aim to implement measures that accelerate the economic diversification process, and estimates and ambitions will be adjusted depending on the level of development and progress toward economic diversification.[23]
- KSA has adopted (and internationally championed) a Circular Carbon Economy (CCE) approach to manage and reduce GHG emissions and drive economic diversification. While this entails a continued exploitation and use of fossil fuels, the adoption of the concept signals a stronger level of engagement on climate policy – and could help reconcile domestic interests with efforts to achieve PA-compatible emissions pathway. However, a meaningful operationalisation of the CCE will require (1) a stronger CO2 accounting framework, and (2) intensified efforts to support CCUS and hydrogen, along with continued support for EE and RE.[24]

Politics

- New growth strategies focus on achieving low carbon transition and economic growth.
- Strong domestic desire to actively increase RE sources and energy efficiency.[25]
- Growing interest in potential of hydrogen and ammonia to supplement oil revenues, both for blue (with CCS) and green hydrogen.[26] Including plans to become mayor player in global green hydrogen markets.[27]
- KSA is member and active participant of international initiatives relevant to industrial decarbonisation such as the Global Methane Initiative, Mission Innovation, Clean Energy Ministerial, and Net-Zero Producers Forum.[28]

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[18] Climate Action Tracker. (2021). *Saudi Arabia*.

[19] Ibid.

[20] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

[21] Ibid.

[22] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[23] Kingdom of Saudi Arabia. 2021. *Updated first nationally determined contribution*.

[24] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

[25] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[26] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

[27] Climate Action Tracker. (2021). *Saudi Arabia*

[28] Kingdom of Saudi Arabia. 2021. *Updated first nationally determined contribution*.

- The 2020 G20 presidency by KSA provided an international platform for the country to strengthen its profile in area of climate policy through concept of CCE.[29]

Policy

- Despite the absence of specific mitigation policies (see above), the government has set various targets and implemented initiatives and projects with mitigation-relevant aims and outcomes over the past decade. The focus is on restricting an increase in GHG emissions while retaining a certain level of output growth.[30]
- The CCE represents a potential game changer in terms of the profile of Saudi Arabia's domestic climate policy.
- The 2021 Green Saudi initiative includes targets for economy wide 2060 net-zero emissions; a reduction of 278 mpta CO2 emissions by 2030, and 50% of energy from renewables by 2030 (and 50% from gas). Emissions reductions are to be achieved through investments in new energy sources, improving energy efficiency, and developing CCS program.[31]
- Target of 50% of electricity to be generated with renewable energy and 50% with natural gas in 2030 under the Vision 2030. However, the government will need to vastly increase the pace of renewable energy development to meet the targets. In 2020, the installed renewable energy generating well less than 1% of electricity.[32]

Economics

- Due its high-yield solar and wind resources, KSA is uniquely positioned to become a global leader in green hydrogen production. Flagship giga-projects in this regard are underway.[33]
- KSA has been highly successful in capturing turning fugitive CH4 emissions from oil and gas production into the foundation of highly successful petrochemical industry. This experience has informed attitudes to what might be possible with CCUS action in climate policy context.[34]

Current status of national-sectoral climate policy

KSA had not articulated formal domestic climate change policy or plans, prior to the recent developments around the CCE framework. Nevertheless, over the past decade KSA has set various targets and implemented initiatives and projects with mitigation-relevant aims and outcome.[35]

Governance and Planning instruments

Saudi Arabia's Vision 2030 set's out government's long-term strategy to diversify the economy and reduce the dependence on oil but does not make any reference to climate change.[36] Includes 96 strategic objectives of Vision 2030 and 13 Vision Realization Programs, including a **National Industrial Development and Logistics Program**.[37]

The 2021 **Saudi Green Initiative (SGI)** aims at offsetting and reducing emissions, increasing the use of clean energy and addressing climate change. It comprises an economy wide 2060 net-zero emissions target; reduction of CO2 emissions by 278 mpta by 2030, target to generate 50% of energy from renewables by 2030 (and 50% from gas). Emissions reductions are to be achieved through investments in new energy sources, improving energy efficiency, and developing CCS program.[38]

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[29] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

[30] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[31] Saudi Arabia. (n.d.). *Saudi Green Initiative*. https://www.greeninitiatives.gov.sa/about-sgi/sgi-targets/reducing-emissions/reduce-carbon-emissions/

[32] Climate Action Tracker. (2021). *Saudi Arabia*

[33] Kingdom of Saudi Arabia. 2021. *Updated first nationally determined contribution*. UNFCCC.

[34] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

[35] Ibid.

[36] Ibid.

[37] Kindgom of Saudi Arabia. (2022). *Fourth National Communication*.

[38] Saudi Arabia. (n.d.). *Saudi Green Initiative*.

- Increasing energy efficiency by enhancing KSA's Energy Efficiency Program (SEEP), but without focus on industry.
- Implementing CCE framework: accelerating broad implementation of Circular carbon economy national program to reduce, reuse, recycle, and remove CO2 emission.
- Ambition to become world's leading hydrogen producer and exporter of clean hydrogen (green and blue hydrogen).
- Use of captured carbon to produce chemicals and synthetic fuels.

Circular carbon economy action plan: program and accompanying framework aiming at enabling circular economy features in Saudi Arabia. It follows the 4 Rs logic: reduce (the production of CO2 and GHGs as by-products), reuse, recycle and remove. It focuses on the use of innovative technology.

Middle East Green Initiative (MGI): aims to bring together regional stakeholders to achieve more than a 60% reduction in emissions from regional hydrocarbon production. Through 'scaling up carbon capture, invest in the green economy and encourage innovation and growth in renewables.'[39]

KSA Updated NDC (2021) aims at reducing, avoiding, and removing GHG emissions by 278 million tons of CO2eq annually by 2030, when compared to 2019 as base year. Relevant measures for industry include:[40]

- Energy Efficiency Program targeting industry, building and land transportation sectors (combined 90% of the national energy demand), including progressively stringent efficiency standards, improving the efficiency of feedstock utilization in key strategic sectors such as petrochemicals and improving the thermal efficiency of power generation, transmission, and distribution.
- Green Hydroge production through flagship giga-project, NEOM, by 2025. It is expected to produce 650 tons per day of green hydrogen by electrolysis and 1.2 million tons per year of green ammonia.
- CCUS hubs (in Jubail and Yanbu - homes to petrochemicals, steel and other heavy industries) to advance the uptake of CCUS technologies and scale up its deployment, leverage the concentration of the manufacturing industry, proximity to sinks and transport infrastructures.
- Blue Hydrogen production, which can be utilized domestically in various industrial sectors. Pilots, research and demonstrations will be prioritized to improve technology maturity and lower costs in the aviation, shipping, petrochemicals, and steel industries.

National Industrial Development and Logistics Program (2019): aims to transform Saudi Arabia into a leading industrial powerhouse and a global logistics hub through economic transformation in the energy, mining, industry and logistics sector through infrastructure investments and new policies and regulations. Includes goals for the industry sector, but does not focus on decarbonisation.[41]

National hydrogen strategy – pathway to become leading global producer and exporter of hydrogen (including blue and green hydrogen)

<u>Economic instruments</u>

The Public Investment Fund (PIF) is envisioned to play a central developmental role in the countries transformation away from the reliance on ail investing SAR 150 billion (USD40 bio) annually into the domestic economy. But it is unclear if this includes specific financing for EIIs.

General interest in funding research and development (R&D) for technologies to fix CO2 into products or use it as a feedstock.[42] Ongoing investments into CCU pilot projects by state owned enterprise Saudi Aramco, but no structural policies could be identified.

<u>Regulatory and 'non-economic' instruments</u>

Saudi Energy Efficiency Program: umbrella for energy efficiency initiatives in buildings, industry and transport sector (combined 90% of energy demand). The policy's overall aim is to increase energy efficiency

[39] Saudi Arabia. (n.d.). *Middle Eastern Green Initiative*. https://www.greeninitiatives.gov.sa/about-mgi/mgi-targets/reducing-emissions/reduce-and-eliminate-emissions/

[40] Kingdom of Saudi Arabia. 2021. *Updated first nationally determined contribution*.

[41] Kindgom of Saudi Arabia. (2022). *National Industrial Development and Logistics Program*. Vision 2023. https://www.vision2030.gov.sa/v2030/vrps/nidlp/

[42] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

(electricity) by 30 percent from 2005 levels by 2030. Also, the NEEP contains provisions to reduce state subsidies on electricity prices. So far over 35 initiatives that focus on governance and capacity building, energy efficiency standards, specifications and benchmarks, and public awareness.[43]

- For the industrial sector, the Saudi Energy Efficiency Center aims to improve overall energy intensity by 1% per year. It has set **specific improvement targets** of 3.2% for steel, 4.7% for cement, and 7% for petrochemicals in 2020–2025 relative to the 2019 baseline.
- Further includes introduction of energy audits, energy efficiency labels, standards for appliances and a construction code.

Assessment of KSA policy framework to advance the decarbonization of EIIs

This table assesses the extent to which the national policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + 2060 net-zero target; 2030 target communicated + general vision of economic diversification through decarbonisation - strong focus on CCS and reducing CO2 emissions instead of avoiding - no EII specific sectoral plans - no real mitigation policy in general
	Long term finance	→ medium exploitation + high financial resources + public investment fund for economic diversification - unclear if finance for EII will be sufficient - high reliance on FF for government revenues
Innovation, Demonstration & Deployment	Enhance public RD&D	→ medium exploitation + RD&D support in place for CCU, but limited to pilot projects - no structural support mechanisms in place - focus on CCU not switching away from fossil-fuels
	Accelerate early commercialisation, deployment	→ medium exploitation + ongoing pilot projects focus on implementation of CUU - unclear if policies beyond that are in place
(Re)-shaping markets	Creation of demand	→ weak exploitation: no policies could be identified
	Reshaping of existing markets	→ weak exploitation: - no policies could be identified - high domestic reliance on fossil fuel revenues and no plans to curb production
	Transparency and information	No information available
Policy coherence and integration	Reducing of demand.	→ weak exploitation: no policies could be identified - demand growth for basic materials expected driven by strong investments in infrastructure
	Infrastructure & energy supply	→ medium exploitation + industrial energy efficiency programmes policies + targets and support for RE development and CCS infrastructure + strong support for green and blue hydrogen production - strong-risk of fossil fuel lock-in - high domestic fossil fuel subsidies
	International coherence	→ medium exploitation + production of green hydrogen for export + involvement in international cooperation - no policies to address carbon leakage
	Socio-economic implications	No information available
	Regulatory environment.	→ medium exploitation + regulatory environment generally stable - no specific policies in place - strong influence of vested interests (oil)

[43] Ibid.

Knowledge & Capacity	Public managerial & bureaucratic capacity.	→ medium exploitation + general capacity for governance
	Monitoring and evaluation	→ medium exploitation + general emissions monitoring

How to strengthen national-sectoral climate policy

- Following through with the speedy implementation of existing plans and measures regarding industrial decarbonisation.
- An increase in the use of renewable energy presents an opportunity to significantly reduce GHG emissions from the IPPU sector.[44]
- Achieving a 2°C consistent emissions pathway requires significantly more policy support for carbon capture and storage (CCS) and hydrogen in particular, along with a continued emphasis on renewable energy and energy efficiency.[45]
- Enhance and strengthen sectoral decarbonisation visions to clarify guidance for the sector.
- Implement policies to increase material efficiency and exploit the purchasing power of the public sector for basic materials such as cement and steel through green public procurement.

[44] Rahman et al. (2022). Greenhouse Gas Emissions in the Industrial Processes and Product Use Sector of Saudi Arabia—An Emerging Challenge.

[45] Shehri et al. (2022). Saudi Arabia's Climate Change Policy and the Circular Carbon Economy Approach.

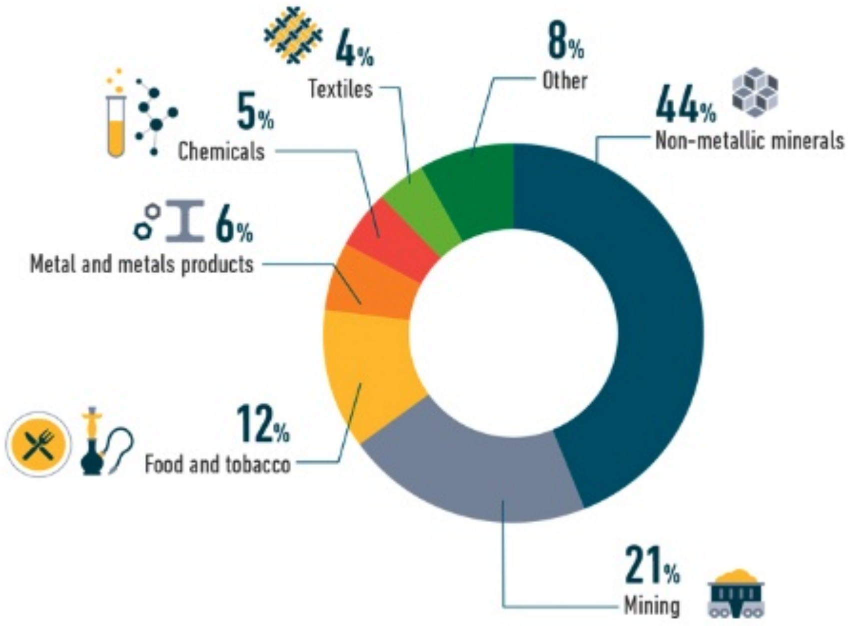
Morocco

Annika Tönjes (Wuppertal Institute for Climate, Environment and Energy), With support from Stefanie Lill (Wuppertal Institute for Climate, Environment and Energy). 6 June 2023.

Big picture: Current EIIs-sector decarbonisation status and prospects

Sectoral GHG emissions:

IEA: Industry is the 3rd highest CO2-emitting sector in Morocco; in 2020, it emitted 7 Mt CO2 (~11% of overall CO2 emissions); Industry is also the 3rd biggest sector by total final energy consumption, and the biggest by electricity consumption; the largest energy-consuming industrial sub-sector by far is non-metallic minerals (61 PJ in 2019), followed by basic metals (8.3 PJ), chemicals & chemical products (7.2 PJ), and paper, pulp & print (2.7 PJ) (*Morocco*, n.d.).



Industrial energy consumption in Morocco, 2016 (source: IEA World Energy Balances 2018)

Direct & indirect energy emissions: "In Morocco, industry accounts for 30% of CO2 "energy" emissions, including 50% of direct emissions from the combustion of fossil fuels and 50% of indirect emissions related mainly to electricity use." (Smouh et al., 2022)

Sub-sector GHG emissions: Among the industrial sectors with high GHG emissions are cement and phosphates, which alone account for more than three-quarters of total emissions from Moroccan industry. The remainder comes from more diffuse sources (construction and public works, agro-food industries, textiles and leather, paper, capital goods, mining, etc.) using mainly fossil fuels (fuel oil, diesel, LPG, natural gas) (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021).

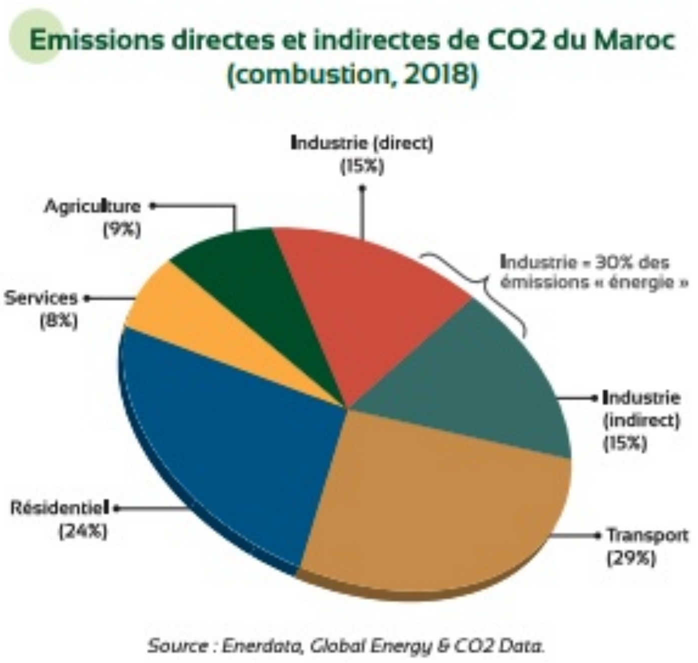


Image Source: https://unfccc.int/sites/default/files/resource/MAR_LTS_Dec2021.pdf

Sub-sector energy consumption: "The majority of Moroccan industrial energy consumption comes from the cement industry which consumes the lion's share with about 30%, while steel industry represents 22%; and chemistry has shown 16%" (Fellaou & Buounahmidi, 2017)

Sub-sector relevance for national economy

History and past struggles of Moroccan manufacturing (1960s–mid-2010s): "The manufacturing sector in Morocco emerged in the sixties and early seventies with the support of import substitution policies. Manufacturing firms took advantage of the high protection rates as well as non-tariff barriers. Since the early eighties, Morocco's policymakers, faced by internal and external macro-economic imbalances, gradually shifted to trade openness and privatization. The process of market-oriented economic reforms accelerated in the nineties with the aim of putting the economy on a higher efficiency track through exposure to stronger domestic and international competition. Three decades later, Morocco's economy had not achieved the expected progress. Morocco's manufacturing sector continues to suffer from structural weaknesses stemming from its excessive specialization in a few industries that are either natural resource based or use intensive unskilled labor. Exports remain mostly undiversified, exhibit low technological content and depend heavily on a few markets." (Lahcen, 2013). Both the share in GDP of the manufacturing sector and employment shares of the industrial sector remained largely stable at around 20% between 1998 and 2016 despite industrial policy efforts to grow the sector (Hahn & Auktor, 2018).

Development and diversification of the industry sector (mid-2010s–now): **"**Before the 2000s, industry accounted for about 15% of GDP and employed only about 10% of the population. It now accounts for almost 30% of GDP and 21% of employment [...]. Prior to the new reforms, production was directed towards textile manufacturing and agri-food. Morocco has since launched several development plans for the sector, the latest of which (Industrial Acceleration Plan 2014-2020 and its update in 2016) seeks to create industrial ecosystems and unite small and medium-sized enterprises around industrial clusters locomotives (offshoring, automotive, aeronautics, electronics, etc.)." (Berahab et al., 2021). In 2021, the industry sector contributed 26% to Morocco's GDP (52% came from services and 12% from agriculture) (O'Neill, 2023). Recently, Moroccan industrial exports have reached record levels, with higher value-added industries (automotive and aeronautics) achieving significant increases in exports value (Machloukh, 2023).

Heavy industry in Morocco: Mineral resources have traditionally played a big role for Morocco's economy. Key segments of the mineral sector are phosphate and cement, both of which are expected to grow further in future. Morocco is home to the world's largest known reserves of phosphates; extracting and processing phosphate ore into fertilizers and phosphoric acid for export is a major economic activity. Morocco's steel industry is small but provides a significant share of the country's domestic needs. Heavy industry in Morocco largely consists of petroleum refining, fertilizers, automobile/tractor assembly, foundry work, asphalt, and cement (*Economy of Morocco*, 2023) (Iysaouy et al., 2019) (*Industry & Mining*, 2020) (Terrapon-Pfaff & Amroune, 2018)

Transition phase:

Morocco's economy is best described as being somewhere between the lock-in and destabilization phase. While renewables (especially solar/CSP) are beginning to gain traction in the electricity sector and could help tackle scope 2 emissions in already electricity-based industrial processes, there is no evidence that the industry sector is moving beyond fossil-based production methods to address process emissions.

National sectoral mitigation drivers and barriers

Drivers

Structural context: excellent conditions for solar energy (Medina et al., 2015) (and existing policies to fulfil this potential, i.e. Moroccan Solar Plan, Moroccan Integrated Wind Program), advantageous geographical position for trade and connecting energy infrastructure with developed as well as emerging economies in Europe and Africa (Hahn & Auktor, 2018); Morocco has no fossil fuels of its own, making it highly import-dependant, thus increasing the attractiveness of renewables

Paradigms/Discourse: Morocco wants to make energy a lever for attractiveness and development (Smouh et al., 2022).

Policies: previous NDC already covered all sectors, but latest NDC has incorporated additional industry subsectors (cement and phosphate production, two key sectors in Morocco) and now covers HFCs

Economy: prospect of EU CBAM and its potential effect on Morocco's exports to the EU (Smouh et al., 2022); geographical location and political stability relative to other countries in the region make it attractive for green investors (Hahn & Auktor, 2018)

Technology: untapped EE potential: "While some advances have been made, vast amounts of untapped energy savings potential still exist in Morocco's industrial sectors. According to the results from national energy audits, more than 15 per cent of the baseline industrial energy use could be saved." (*Morocco*, n.d.b) "Energy is the second-largest cost item for industrial enterprises." (O'Neill, 2023)

Barriers & Challenges:

Structural context: The new NDC plans building up additional natural gas infrastructure with a potential to lead to a lock-in of emissions or stranded assets (CAT 2022). Corruption remains an important issue in the country (Hahn & Auktor, 2018). Rapid urbanisation and continuing infrastructure developments are expected to lead to an increase in demand for basic materials (Terrapon-Pfaff & Amroune, 2018). Another barrier lies in Morocco's "constrained domestic budget resources and competing national priorities" (Houzir et al., 2016).

Paradigms/Discourse: lack of awareness about energy efficiency (*Morocco*, n.d.b); focus on growing industry contribution to GDP (Hahn & Auktor, 2018)

Polity: "limited capacity to formulate and implement industrial energy efficiency measures and limited regulatory oversight" (*Morocco*, n.d.b)

Politics: A major constraint is the reluctance of manufacturers to share information and data that is otherwise essential to the implementation of the transition. There is therefore a need to change mentalities on this point and to establish a climate of trust (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021).

Policies: Morocco has no net-zero target; 1st biennial update report considers targets for the industry sector but excludes large energy consuming industries. At this stage, there is no ambition or quantified objective for the target level of decarbonisation of the Moroccan industry sector considered as a whole by 2050 (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021). Residual subsidies for some oil products (butane) are a barrier to EE investment (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021).

Economy: Morocco struggles with education / lack of skilled labour (Hahn & Auktor, 2018); business climate considered not yet sufficiently attractive for the private sector to take investment initiative (state remains main investor in economy) (Machloukh, 2023); complexity of financing efficiency projects (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable , 2021)

Technology: Techno-economic trajectories for decarbonisation of industry are still uncertain (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable , 2021). The small size of energy efficiency projects, the multiplicity of actors and their low visibility compared to renewable energy projects are barriers for improved EE (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021).

Current status of national-sectoral climate policy

Governance and Planning instruments:

Morocco's Third Biennial Report submitted to the UNFCCC:

- It says that the state-owned OCP group (world's largest producer of phosphate and phosphate-based products) has set itself the following goals (*3ème Rapport Biennal Actualisé Du Maroc Dans Le Cadre de La CCNUCC*, 2022):
    - "Covering all electricity needs of the industry with renewable energy sources and cogeneration
    - Substituting 30% of the fuel oil used for phosphate drying by solar energy (starting in 2028)
    - Implementing a carbon capture and utilisation project from phosphate stacks in 2024 (with a capture rate of 20% to reach 100% in 2028)" (*Morocco. Policies & Action.*, n.d.).
- For cement, energy recovery measures (co-incineration) for waste used as an alternative fuel to petroleum coke are considered:
    - Recovery of used tyres
    - Recovery of wastewater treatment plant sludge
    - Recovery of household waste
    - Recovery of olive pomace
    - A fifth measure to recover fly ash as an additive to clinker is also mentioned.
- For other industry:
    - Energy efficiency programme in industry: reducing energy consumption by consumption by 17% by 2030
    - Natural gas in the industrial sector by 2030: use of 500 million m3 between 2021 and 2030 to replace fuel oil in thermal processes
    - Programme to promote the use of biomass in industry: industrial use of biomass to replace fuel oil, with a total capacity of 300 kt between 2021 and 2030
    - Self-consumption PV installation programme with a total capacity of 1,500 MWp in industry (*3ème Rapport Biennal Actualisé Du Maroc Dans Le Cadre de La CCNUCC*, 2022).

2021 Long-Term Low-Carbon Strategy Morocco 2050 (LT-LEDS): refers mostly to objectives laid out already in SNDD, existing roadmaps related to specific aspects of industry transition, the planned sectoral roadmap for industry and planned development of regulatory and economic instruments (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021)

2021 Morocco Vision 2050: developed in parallel to its 2019 NDC revision; aims to support national/sectoral strategy alignment; foundation for the development of LT-LEDS (*Morocco submits enhanced NDC, raising ambition to 45.5 Percent by 2030,* 2021). (*Morocco 2050 Vision*, 2021)

2019 National Climate Plan (PCN 2030): industry as one of seven areas; two industry measures, one focused on energy efficiency and the other one on import and use of liquefied petroleum gas, use of biomass and implementation of energy management systems and ISO 50001 (Secrétariat d'Etat auprès du Ministre de l'Energie, des Mines et du Développement Durable, chargé du Développement Durable , n.d.)

- Prior version: 2009 plan (PCN 2020)

2017 National Sustainable Development Strategy (SNDD): Strategic focus 10: Availability of a sustainable mining sector: GHG emissions are mentioned as one factor in an integrated approach for sustainable mining development; no other industrial sectors are mentioned (based on Executive Summary in English language) (*National Sustainable Development Strategy (NSDS) - Executive Summary,* n.d.)

- Axis 2 – Green economy: The main objectives stated at this stage are: (i) improving the competitiveness of Moroccan industrialists, (ii) anticipating a carbon tax at the borders of client countries, (iii) strengthening the rate of industrial integration and (iv) identifying and developing new green industrial sectors (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021).
- A recent decree entrusts the Ministry of Industry, Trade and the Green and Digital Economy with setting up, within the framework of the SNDD, the national action programme for the transition to a green economy and ensuring its implementation. This decree also organises the transfer of the State's supervision of the Moroccan Agency for Energy Efficiency (AMEE) to this same ministry. The AMEE's prerogatives have been extended to the green economy, which includes, in addition to energy efficiency, sustainable mobility and clean production in industry. The decarbonisation of industry is therefore an important mission for AMEE. (ibid.)

2009 National Energy Strategy: "Faced with rising energy and resource prices, the Government of Morocco developed a **national energy strategy** to control energy consumption in different sectors with the goal of saving 12% in 2020 and 15% in 2030" (Fellaou & Bounahmidi, 2017). However, the industrial energy efficiency programme excludes large energy-consuming industries (*Morocco. Policies & Action.*, n.d.).

Sectoral roadmap industry: Morocco's LT-LEDS states the goal of establishing a technological and R&D roadmap for the industry sector adapted to the industrial and innovation-research reality in Morocco (to be broken down by sub-sector) (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable , 2021). Industry roadmap could not be found at time of writing; similar roadmaps exist, e.g. for hydrogen (Ministère de l'Énergie des Mines et de l'Environment, 2021a) or biomass (Ministère de l'Énergie des Mines et de l'Environment, 2021b).

Economic instruments:

2021 "Tatwir Vert" as part of the Industrial Recovery Plan 2021–2023: "sets up grants to support enterprise investment. In addition to reducing industrial pollution, «Tatwir green growth» aims to support the emergence of new green industrial sectors and is a tool to support industrials in their process development operations and low-carbon products. This program provides financial support of around one billion MAD for the investment of industrial SMEs in the field of the green economy." (Smouh et al., 2022) EcF

Green Value Chain (GVC) & **Green Economy Financial Facility**, "set up by European partners with partner financing institutions" (ibid.)

MorSEFF (Morocco-Sustainable Energy Financing Facility): helped fund a number of energy efficiency projects (*Morocco—Sustainable Energy Financing Facility (MorSEFF)*, n.d.); Other funds are already in preparation both at the international level (the Green Value Chain Credit Line and more recently the Green Economy Financial Facility) and at the national level with the AMEE (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable , 2021).

The Moroccan LT-LEDS sets the goal of identifying and proposing the implementation of a tax system and incentives favourable to business investments in tools and technologies allowing advanced decarbonisation: eco-taxes, CO_2 market and price, targeted subsidies for investment and R&D, etc. (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021). Evidence of the development of such instruments could not be found at the time of writing.

Regulatory and 'non-economic' instruments

From LT-LEDS: the regulatory framework for energy efficiency and energy intensity reduction has been strengthened over the past two years by the adoption of three decrees relating to the mandatory energy audit and the creation of auditing bodies; the definition of the specifications of energy service companies (ESCOs); and the control of minimum energy performance of appliances and equipment on the import and national market (Ministère de la Transition Energétique et du Développement Durable Département du Développement Durable, 2021).

Law No. 47-09 on energy efficiency (passed in 2009): setting criteria of minimum energy performance for appliances and electrical equipment powered by natural gas, liquid or gaseous petroleum products, coal and RE; mandatory audits for companies and institutions in production, transmission and distribution of energy; energy impact study for new construction and urban projects (*Law 47-09 on energy efficiency*, 2009) "Requiring companies to declare their installed capacity and energy use, as well as to carry out mandatory energy audits, if the use exceeded 1500 tons of oil equivalent (toe) per year." (Iysaouy et al., 2019)

2009 Framework Law 99-12 on the National Charter for the Environment and Sustainable Development: lays the ground for a national policy for environmental protection & sustainable development; considers industry as one of the sectors "having a high potential for sustainability, and a priority in terms of achieving sustainable development. To this end, the government authorities and relevant institutions in charge of these sectors and activities are required to ensure the adoption of concrete sustainability measures in their management and wide dissemination of these measures." (*Framework Law 99-12 on the National Charter for the Environment and Sustainable Development*, 2009)

Educational, Informational, 'soft' instruments

"Furthermore, to remain competitive, Morocco plans to implement a Moroccan standard recognized at the European level to assess the carbon footprint of national companies." (Smouh et al., 2022)

Assessment of Morocco's policy framework to advance the decarbonization of EIIs

This table assesses the extent to which the existing national policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + 2030 mitigation target (BAU) + several economy wide economic development and decarbonisation plans [LT-LEDs] + industry specific sustainable development plans & visions (being updated) + plans for technology & R&D roadmap for the industry sector + NDC incorporated industry subsectors - no sector specific targets - no net-zero target
	Long term finance	→ medium exploitation + financial support for decarbonisation of economy, incl. sustainable energy + financial support for the investment of industrial SMEs in the field of the green economy ["Tatwir Growth Plan"] + Morocco-Sustainable Energy Financing Facility [MorSEFF] + offsetting of decarbonisation costs for industries + receptionist of international support + Green Value Chain (GVC) & Green Economy Financial Facility (set up by European partners with partner fi-nancing institutions) - specificities on policies not clear, potentially insufficient
Innovation, Demonstration & Deployment	Enhance public RD&D	→ weak exploitation: no policies could be identified *+ plans for investment for R&D*
	Accelerate early commercialisation, deployment	→ medium exploitation + financial support for investments in industry SME for green economy + Green Value Chain & Green Economy Financial Facility
(Re)-shaping markets	Creation of demand	→ weak exploitation: no policies could be identified
	Reshaping of existing markets	→ medium exploitation + plans for relevant policies (e.g. carbon tax) - no signs industry sector is moving away from FFs
	Transparency and information	→ medium exploitation + energy audits, energy impact assessment *+ plans for carbon footprint assessment at national level (based on EU standard)* - no further policies, unclear of implemented
Policy coherence and integration	Reducing of demand.	→ weak exploitation: no policies could be identified
	Infrastructure & energy supply	→ medium exploitation + excellent conditions and policies for solar energy [e.g. Moroccan Solar Plan, Moroccan Integrated Wind Program]

		+ industrial energy efficiency policies [Law No. 47-09] - large consumers excluded from EE programmes
	International coherence	→ strong exploitation + reception of international decarbonisation finance + international cooperation on industrial decarbonisation + potentially positive impact of EU CBAM
	Socio-economic implications	No information available
	Regulatory environment	→ weak exploitation - enforcement issues - corruption remains an important issue
Knowledge & Capacity	Public managerial & bureaucratic capacity	→ medium exploitation + proactive climate governance - limited public sector capacity
	Monitoring and evaluation	→ medium exploitation + carbon footprint tracing + national GHG monitoring

How to strengthen national-sectoral climate policy

In order to strengthen its climate policy related to the industry sector, Morocco may

- Set a net-zero target and sector-specific targets for industry
- Phase out fossil fuel subsidies
- Pay particularly close attention to its two highest emitting industrial sub-sectors, cement and phosphate mining/processing
    - planned phosphate sector measures already look quite promising but Morocco should look beyond natural gas and develop policies for H2
    - for cement, Morocco should look past co-incineration of waste and develop measures for deep decarbonisation, including CCS
    - although the steel industry is smaller, its decarbonisation requirements (incl. H2) should not be ignored; the same goes for other heavy industry
- Develop policies for renewable energy that go beyond electricity generation
- Develop policies to exploit its considerable energy efficiency potential to reduce pressure on energy supply; a first step would be to include large energy-consuming industries like cement and phosphates in the industrial energy efficiency programme
- Invest in strengthening governance capacity, tackling corruption and increasing regulatory oversight to enforce, e.g., energy performance and pollution standards
- Implement material efficiency policies to reduce pressure from projected demand increase
- Invest in education and training for the green economy
- Develop strategies to improve the business climate for private sector investment
- Invest in net-zero industry R&D where possible and engage in partnerships with industrialized countries
- Follow up on the goal set in its LT-LEDS of identifying and proposing the implementation of a tax system and incentives favourable to business investments in tools and technologies allowing advanced decarbonisation: eco-taxes, CO_2 market and price, targeted subsidies for investment and R&D, etc.

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Nigeria

Annika Tönjes (Wuppertal Institute for Climate, Environment and Energy), With support from Stefanie Lill (Wuppertal Institute for Climate, Environment and Energy). 6 June 2023.

Big picture: Current EIIs-sector decarbonisation status and prospects

Sectoral GHG emissions

The industry sector represents about 16% of in-scope emissions. In 2020, it emitted 29 Mt CO2, of which: 50% cement production, 36% industrial heat emissions, 7% ammonia production, 7% other industrial processes (*Industry – Nigeria Energy Transition Plan*, n.d.); "Industry-related emissions make up 12% of direct CO2 emissions in Nigeria and 2% of electricity-related CO2 emissions. Nigeria has only managed to reduce emissions from this sector slightly" (*Nigeria Climate Transparency Report*, 2020). "The NDC sectoral analysis for industry indicates that the sector's GHG emissions could increase from 4.2 Mt CO2e in 2010 to 14.8 Mt CO2e in 2030 if no measures to improve energy efficiency are implemented" (*2050 Long-Term Vision for Nigeria (LTV-2050)*, 2021).

Sub-sector relevance for national economy

Underdeveloped industrial sector: "History suggests that industrialization is essential for economic development. Industry is also a means to economic diversification that can boost employment opportunities for relatively unskilled labour, however this approach is yet to be constructively pursued in Nigeria. The GHG emissions inventory serves as a good indicator of the lack of industrial activity, with the sector producing just 10 MtCO2 annually. By comparison, Africa's other leading economies—South Africa, Egypt and Algeria—produce 22, 16, and 28 MtCO2, respectively" (Daggash, 2018). "the economy is mono-cultural, as it depends up to 70% on crude oil as a source of foreign exchange earnings and government revenue, dependence has varied from about 90 % in the 1980s to the current figure. […] the industrial base is fragile, back ward, underdeveloped and extremely foreign-oriented both in terms of capital goods, spares and raw materials. Furthermore, the value-added sector is low while the inter-sectoral linkages are weak. This implies that a boom in one activity rarely affects another in the sector, but will rather impact on the foreign economy from where imports were sourced" (Adetula & Marindoti, 2019). "The primary sector - agriculture, mining and quarrying, including crude oil and gas - accounts for over half of the gross domestic product (GDP). This structure is typical of an underdeveloped economy [1]. The secondary sector comprising manufacturing, construction and building contributes least to the GDP. From 1960 to 2000, the average contribution of manufacturing to Nigerian GDP was 5.8% compared to 6.3%, 10.6%, 15.6%, 23.9% and 33.5% for Botswana, Ghana, India, Korea and China respectively [2]. This lack of industrial development translated to persistent poverty" (Fasakin, n.d.). "The sector's contributions to foreign exchange earnings, employment and government revenue remain relatively low, in particular in comparison to the oil sector. The contribution of non-oil sectors to the economy has consistently grown in the last fifteen years, though at a relatively slower rate since the 2016 recession" (Yetano Roche, 2020) and (after a dip in 2020) recovered to above pre-pandemic levels in 2022 (*Nigerian Gross Domestic Product Report Q1 2023*, 2023).

Steel and nonferrous metals: Historically, establishing a strong national steel industry has been key for economic development. For this reason, Nigeria has invested heavily in building up the industry since the 1970s, including the construction of two publicly owned large integrated steel mills. However, for various reasons, these investments were unsuccessful. Today, Nigeria still does not produce crude steel. Instead, the country's rolling mills are dependent on expensive imports of billets and recycling of scrap sourced largely from municipal solid waste, often working at low capacity. The Nigerian primary steel sector is "comatose" in spite of an abundance of mineral resources. This contributes to a stressed national economy and impedes infrastructure build-up (Adetula & Marindoti, 2019).

Cement: Nigeria is one of Africa's top clinker and cement producers "and could be on course to be one of the top ten producers globally. Over the last two decades, the country's cement industry has grown from being a net importer to a net exporter and is currently booming. […] Within the manufacturing sector, the cement sector is one of the main contributors to growth in GDP terms" (Yetano Roche, 2020). Emblematic of the Nigerian cement industry's economic significance is Africa's richest man, Aliko Dangote, CEO of Dangote Cement, the continent's largest cement producer (Dunne, 2023).

Chemicals: Similar to steel, a national chemical industry is also a strong driver for industrialisation. However, unlike the (ultimately unsuccessful) investments into the steel sector, the country has largely ignored the chemical industry in its National Development Plans over the past decades. Today, the country's demand for chemicals far exceeds its production. There is no basic chemicals industry to speak of. Instead, Nigeria's chemical sector is made up of secondary industries (e.g., paint manufacturers), which are (similar to the steel rolling mills) highly dependent on imports. However, among the countries' manufacturing industries, the chemical sector is comparatively high up on the list when comparing value added (Fasakin, n.d.) (*Nigeria's Agrochemical Industry Is Worth $120 Million*, 2013). Recently, Nigeria has made strides in the production of fertilizer components like ammonia and urea (Busari, 2022).

Transition phase: Nigeria's industry sector is underdeveloped and thus difficult to describe in terms of transition phases. Because of the country's high dependence on fossil fuels, low level of renewables development and continued growth in conventional industrial production (especially in the cement sector), it is perhaps best categorized as being in a lock-in phase. However, because a lot of industrial production capacity is yet to be developed, there is also still (at least theoretical) potential for technological leapfrogging and avoiding the build-up of additional conventional industrial infrastructure with long equipment lifetimes further locking the industry into fossil fuel dependence.

Current general national trends that promote or hinder decarbonization:

Population growth: Nigeria is Africa's most populous country. The population of 216 million (in 2021) is projected to continue increasing significantly, reaching 375 million by 2050 (*World Population Prospects 2022: Summary of Results*, 2022). By the end of the 21st century, Nigeria's population is expected to surpass China's, becoming the second largest after India (Vollset et al., 2020).

Urbanisation: Nigeria is urbanizing rapidly, with 53% living in urban areas as of 2021 (*Urban Population (% of Total Population) – Nigeria*, n.d.). This is projected to increase to 70% by 2050 (*World Urbanization Prospects. Country Profiles: Nigeria*, n.d.).

Poverty: Nigeria is among the countries with the highest number of people living below the poverty line (if not the highest, depending on how it is measured) (World Bank, 2022) (*World Poverty Clock*, n.d.).

High exposure to the effects of climate change: "climate change is taking a major toll on the country — and without international support, could hit the economy hard. Extreme heat episodes, of ever-growing frequency, are affecting millions of people without access to air conditioning or electricity" (Owen-Burge, 2022). "Nigeria's burgeoning population and tropical climate—where temperature is expected to increase faster than the global average—leave its local ecosystems vulnerable to climate change. These ecosystems provide direct and indirect services to the population, including nutrient cycling to maintain the fertility of soils, waste decomposition, and pest and disease control" (Daggash, 2018). However, there appears to be a lack of awareness/ political narrative of how everything is tied together (food insecurity, regional conflicts, extreme disasters like 2023 floods, all linked to climate change).

High dependence on fossil fuels: "The dependence on oil rents for 90 per cent of export revenues also leave the economy vulnerable to climate policies that seek to wean the world off fossil fuels. The policies that the government implements in the coming years will determine Nigeria's competitiveness in an increasingly carbon-constrained world. […] In 2016, Nigeria experienced its first recession in a decade due to low oil prices. With 70 per cent of government revenues generated from oil and gas exports, the plummeting of oil prices from 100 to 30 dollars per barrel resulted in a scarcity of foreign exchange, and the country could not satisfy its hefty import bill." (ibid.) "By Q2 2021, economic growth exceeded pre-pandemic levels (National Bureau of Statistics, 2021)." Phasing out fossil fuel subsidies has proven challenging in the past: The government's heavy gasoline subsidies were lifted by past administrations at the beginning of their respective terms, and later reinstated due to negative socioeconomic effects and social unrest. The new president, Bola Tinubu, has again removed these subsidies upon taking office; it remains to be seen whether this time the measure is permanent (Brnic, 2023).

Political priorities: "Security, health and governance challenges are viewed as more imminent and having more potential for devastation" (Daggash, 2018) than climate change. Nigeria's net-zero plans are seen mainly as a way for the country to attract finance in order to combat poverty as well as climate change. As a poor and populous country, both historic and per-capita emissions are small; the country thus aims to peak emissions later than richer countries, as per Article 4.1 of the Paris Agreement (United Nations Framework Convention on Climate Change (UNFCCC), 2016). It plans to use natural gas to foster development in the meantime. The former administration was vocal about developed countries' responsibilities and the hypocrisy of not supporting developing nations' use of natural gas. "Wealthy countries have contributed the most to climate change, and they cannot demand more stringent actions than they will commit to themselves" (Osinbajo, 2022).

Poor governance (corruption, ineffective coordination & lack of climate mainstreaming): "Pervasive corruption, particularly in the oil and gas sector, is a risk to the transition and impedes the government's ability to respond to climate change. Effective coordination across Nigerian ministries and agencies at all levels of government is currently limited. As a result, climate change is not consistently mainstreamed into policy plans and targets. Meetings of the Inter-Ministerial Committee on Climate Change (ICCC), a key coordinating mechanism established to promote engagement on Nigeria's climate response across sectors, have been intermittent and ad hoc. The creation of the National Council on Climate Change under the 2021 Climate Change Act is expected to improve coordination." (ibid.) Nigeria's 2022 score on Transparency International's Corruption Perceptions Index was 24/100 and it ranked 150th out of 180 countries, indicating a high level of corruption (*Nigeria*, 2023).

National sectoral mitigation drivers and barriers

Drivers:

Structural context: Nigeria holds significant **human and natural resource capital** (Yetano Roche, 2020); "Nigeria enjoys some of the **highest capacity factors for solar** photovoltaics in the world, so intermittency issues are minimal. Furthermore, gas generation can provide flexible back-up capacity and pumped hydroelectric power, which is abundant, can provide energy storage services during periods of low solar insolation" (Daggash, 2018). "It is important to note that, as in the whole of the Nigerian manufacturing sector, the lack of sufficient power from the grid drives all cement plants to install their own **power generation plants on site**. This is potentially a significant opportunity for increasing the electrification of cement making process" (Yetano Roche, 2020).

Policies: Nigeria's "updated NDC has an unconditional contribution of 20% below business-as-usual by 2030 and now has a 47% contribution conditional on international support" (*Nigeria's First Nationally Determined Contribution – 2021 Update*, 2021). "At COP26, President Buhari further committed to achieving net zero emissions by 2060 (the Act itself aims for the 2050-2070 period)" (*Climate Governance. Assessment of the Government's Ability and Readiness to Transform Nigeria into a Zero Emissions Society*, 2022).

Economy: "Cost of energy is a strong driver for energy efficiency in Nigeria, with energy costs being the single largest variable production cost at a cement plant (Oni et al., 2017). Despite efforts to lower energy needs for heat and electricity, there is still a large room for improvement" (Yetano Roche, 2020).

Barriers

Structural context

Lack of (renewable) electricity generation, lack of necessary infrastructure: Nigerian electricity sector is still developing, renewables are underdeveloped, grid is unreliable, 85 million Nigerians (43% of the population) not connected to the grid (*Nigeria to Improve Electricity Access and Services to Citizens*, 2021), demand for electricity far exceeds generation and is rising fast, further build-out of (renewable) electricity generation and infrastructure is hindered by many factors (lack of political will, corruption, fossil fuel subsidies, high investment costs, restricted access to capital, vandalism and militant infrastructure destruction (e.g., at the hands of Boko Haram)) (Adeyanju et al., 2020). "A lack of reliable and affordable electricity supply has been a hindrance to industrialization, albeit one of many. Businesses often rely on private diesel generators for expensive power, which cuts into competitiveness" (Daggash, 2018). Disruptions in power supply affecting industrial production stated to be among the problems for continued industrialisation/build-up of the steel sector ('Resuscitation of DSC Is on Course, Says Premium Steel', 2021). Inadequate transport infrastructure adds to problems and increases the cost of basic materials (Yetano Roche, 2020).

increased demand for basic materials, especially for housing and infrastructure (roughly 81% of Nigeria's road network is unpaved) in Nigeria/Sub-Saharan Africa & incentives to meet this demand with **Nigerian cement production**: "Given population and urbanisation rates, rapid ramping up of investment and capacity [for cement production] is foreseen. There are strong risks of locking-in outdated technology into long-term investments" (ibid.) Nigeria has abundant limestone deposits, policies promoting the build-up of domestic cement production capacity and ambitious infrastructure investment targets (ibid.).

- ~~**Exiting**~~**Entering coal:** "cement manufacturers in Nigeria have been **increasing the use of locally-mined coal** in the last years. This is because LPFO (Low Pour Fuel Oil – a by-product of crude oil) and gas have proven to be more expensive and, in the case of gas, susceptible to foreign exchange volatility and supply disruptions (United Capital, 2019). Moreover, the shortage of natural gas supply in the northern part of the country has restricted its use to plants located in this region (Ohunakin et al., 2013)." (ibid.)
- "enforcement of any standard is often challenging in the country" (ibid.)

Paradigms/discourses: lack of attention?: not a lot of studies on decarbonisation of EIIs in Nigeria (ibid.); because of comparatively low overall emissions, the industry sector has not been one of the focus sectors for Nigerian climate policy; focus on growing the sector, not on decarbonising it; limited public pressure to decarbonise EIIs (however, some focus on environmental pollution); lack of awareness of the opportunities/co-benefits of low-carbon industry (e.g., mitigation of environmental health risks (Etim et al., 2021))

Policies: "The government is attempting to fast-track the renaissance of Nigerian manufacturing as a key source of growth, jobs and food security. The country's comprehensive industrial policy is set out in the Nigeria Industrial Revolution Plan (2014)" (*National Climate Change Policy for Nigeria 2021 – 2030*, 2021).

Economy: high cost of green technologies, low demand for green basic products; 2016 national recession & impact of COVID-19 (Yetano Roche, 2020); "One study on cement did find that the current **investment and costs of carbon capture in Nigeria** (regardless of whether it is combined with carbon use or carbon storage) were high (Yavini et al., 2015), which suggests that demonstration projects are very unlikely to start in the next ten years." (ibid.) Fluctuating exchange rate (affecting critical imports) ('Resuscitation of DSC Is on Course, Says Premium Steel', 2021); **limited access to finance** (Yetano Roche, 2020)

Current status of national-sectoral climate policy

<u>Governance & Planning:</u>

2022 Nigeria Energy Transition Plan (ETP):

- "The oil and gas and industrial sectors: Emissions reduction will be enhanced by the global response to climate change mitigation using technologies such as carbon capture and storage (CCS), direct air capture, hydrogen fuel, etc;" (*Decarbonising Nigeria's Economy*, n.d.)
- 2030 targets: 20% clinker substitute in cement production; 33% hydrogen (blue) in ammonia production
- 2060 targets: 50% clinker substitute in cement production and 100% hydrogen (blue and green) in ammonia production by 2060; ~100% electricity for low/mid temp heating by 2060; ~100% hydrogen for high temp heating by 2060 (*Industry – Nigeria Energy Transition Plan*, n.d.)

2021 2050 Long-Term Vision for Nigeria: "The national vision for the industry sector is that by 2050 Nigeria will have a low carbon industrial sector with enhanced energy efficiency that seizes the opportunities that comes with global transition towards climate resilience and circular economy" (*2050 Long-Term Vision for Nigeria (LTV-2050)*, 2021).

2021 NDC update: HFCs now included in covered GHGs (Nigeria's First Nationally Determined Contribution – 2021 Update, 2021)

"The **Covid-19 recovery plan** also laid out a new framework for boosting solar power in Nigeria. It aims to bring solar power to 5m households by 2023. The project is aimed at "rural communities that have little or no access to the national grid" and will create 250,000 jobs, says the government" (Dunne, 2023).

2017 NDC: included a sectoral action plan for industry but this document is not publicly available (Climate Governance. Assessment of the Government's Ability and Readiness to Transform Nigeria into a Zero Emissions Society, 2022)

Previously strong focus on energy efficiency:

- **2016 National Energy Efficiency Action Plan (NEEAP):** "The Nigerian market and policy environment for industrial energy efficiency is still in its infancy. However, in the last ten years, there have been significant developments. In particular, the development and formal adoption of the NEEAP (National Energy Efficiency Action Plan) which sets the target of **improving on 2015 energy consumption levels by 50 % by 2030 through energy efficiency**" (cross-sectoral target; there is no specific target for the industrial sector) (Yetano Roche, 2020) (*National Energy Efficiency Action Plans (NEEAP) (2015 – 2030)*, 2016) (*Nigeria Climate Transparency Report*, 2020).
- **2015 National Renewable Energy and Energy Efficiency Policy (NREEEP):** "aims to save 20% energy by 2020 in the transport, power and industry sectors, and 50% by 2030 by increasing energy efficiency" (*Nigeria Climate Transparency Report*, 2020) (unclear as to how successful this has been to date)
- **2012 Nigeria Climate Change Policy Response and Strategy:** "promote low-carbon emissions and to respond effectively to the impacts of climate change, such as extreme weather events, food insecurity etc." (*Decarbonising Nigeria's Economy*, n.d.) "The NCCPRS sets **broad strategic objectives** that cover mitigation, adaptation, climate-related science and technology development, public awareness and private sector participation and strengthening institutions and mechanisms to address climate change" (ibid.).

<u>Economic instruments:</u>

2019 Carbon Tax Act: taxes all primary emitters (*THE CARBON TAX ACT*, n.d.) however, seems to not have been put into action; for a new attempt at developing a mechanism for carbon tax see "2021 Climate Change Act"/"Under development"

<u>Regulatory:</u>

To date, it appears that there are no specific regulatory instruments for industrial decarbonisation in use

<u>Key legislation for the development of industry-specific economic/regulatory instruments:</u>

2021 Climate Change Act:

- Implementation of National Council on Climate Change (NCCC), made up of high-level government officials (among others, the Minister of Mines and Steel Developments is a council member) as well as private sector and civil society representatives; the NCCC will
- coordinate and implement **sectoral targets and strategies** for the regulation of GHG emissions and implement the National Climate Change Action Plan (*Decarbonising Nigeria's Economy*, n.d.)
    - collaborate with the Federal Inland Tax Revenue Service to develop a mechanism for **carbon tax**; "The proceeds from the carbon tax, as well as **emissions trading** among other sources of funds, will be used to fund the Climate Change Fund (the Fund) proposed by the Act […] to be disbursed towards funding climate change mitigation initiatives, **incentivizing private and public entities** that meet their GHG emission reduction targets, conducting climate change impact assessments, and running the NCCC" (ibid.).
    - "in conjunction with the Ministries in charge of Environment, Budget and National Planning, will be responsible for formulating Nigeria's National Climate Change Action Plan (Action Plan) going forward. The Action Plan would include […] **GHG emission profile for sectors** of the economy; **incentives for private and public entities** that achieve their GHG emission reduction targets; the level of Nigeria's compliance with its international climate change commitments etc." (ibid.).
- The Climate Change Act requires private entities with 50+ employees "to **put in place measures to achieve the annual carbon emission reduction targets** specified in the Action Plan. The Act also requires private entities to **designate a Climate Change Officer** or an Environmental Sustainability Officer, who would be responsible for submitting an **annual report** that shows the status of the

entity's carbon emission reduction efforts during the relevant period. **Failure to comply with this obligation will result in fines** determined by the NCCC, based on Environment Economic Accounting. The Act also empowers the NCCC to issue notices via gazette with respect to obligations and fines for non-compliance." Fines will feed into the Climate Change Fund. (ibid.).

- "While there are several necessary measures needed to operationalize Nigeria's 2021 Climate Change Act, it demonstrates the seriousness with which the country is approaching climate action. Being the **first stand-alone comprehensive climate change legislation in West Africa** and among few both globally and regionally, it has the potential to become a strategic tool for climate change advocacy" ('A Review of Nigeria's 2021 Climate Change Act', 2022).
- The Climate Change Act provides "a sound **legal foundation for potential climate litigation**. The Act makes it actionable to bring a claim for the potential failure of the Council to regulate offenses and penalties from non-compliance with the climate obligations imposed by the new law on any person, private or public entity that acts in a manner that negatively affects efforts towards mitigation and adaptation measures made under the Act." (ibid.)

2021 Revised National Climate Change Policy (NCCP): "In 2021, the Federal Ministry of Environment, through the Department of Climate Change introduced the National Climate Change Policy (NCCP) for the 2021 to 2030 period. The NCCP sets out Nigeria's climate change policy direction, addresses conditions required to attain Nigeria's vision to be a climate resilient economy, and **sectoral measures** for mitigating the effects for climate change in Nigeria" (ibid.) Programmes for implementing NCCP are included in the **National Climate Change Programmes** for Nigeria, details of which could not be found at the time of writing (*Climate Governance. Assessment of the Government's Ability and Readiness to Transform Nigeria into a Zero Emissions Society*, 2022)

- Industry-related policies include: "i. Pursue an alternative and sustainable path to industrialisation that takes advantage of innovations, technologies and business models for improved energy efficiency in the industrial sector ii. Create and adopt green technology in industry and support low emission manufacturing systems iii. Pursue greening of industry to continuously improve environmental performance of industry iv. Accelerate industrial development utilizing energy mix with emphasis on renewables v. Promote energy efficiency networks for industrial enterprises vi. Set efficiency benchmarks for manufacturing and businesses against international best practice for industrial energy usage vii. Support local research and development of ICT capabilities to promote energy "smart technologies" viii. Promote appropriate financing mechanisms for climate-friendly and energy efficient investment projects" (*National Climate Change Policy for Nigeria 2021 – 2030*, 2021)

<u>Educational/Informational:</u>

2016 National Energy Efficiency Action Plan (NEEAP): "making energy audits compulsory to all energy-intensive sectors (FGN, 2016). The technical assistance programme NESP has facilitated the adoption of the ISO 50001 standard in Nigeria, set up of industrial energy efficiency networks and run a series of capacity building programmes and energy audits (GIZ, 2020). A survey of energy consumption in large-scale firms, including cement, is however still lacking. As a result of recent efforts, awareness on energy efficiency in industry has risen among policy makers and industry" (Yetano Roche, 2020) (*National Energy Efficiency Action Plans (NEEAP) (2015 – 2030)*, 2016).

<u>Under development:</u>

Carbon tax/ETS: "The Nigerian Climate Change Act provides for the Council to collaborate with the Federal Inland Revenue Service to develop a mechanism for carbon tax in Nigeria. A Climate Change Fund will also be established and maintained by the Council into which shall be paid carbon tax and emissions trading" (*Decarbonising Nigeria's Economy*, n.d.) In August 2022, the Federal Government of Nigeria "commenced activities that would lead to the establishment of the Nigeria Emissions Trading Scheme (ETS)" (Uwaegbulam, 2022) (*Nigerian Government Launches Emission Trading Scheme, ETS*, 2022).

Carbon market: "The International Finance Corporation (IFC) and the World Bank have begun to work with the Government of Nigeria to develop a domestic market for carbon capture, utilization, and storage for industrial emissions - an area that could accelerate the energy transition and help Nigeria reach its emissions targets" (*IFC and World Bank to Help Nigeria Pave the Way for Domestic Carbon Storage*, 2022).

Assessment of Nigeria's policy framework to advance the decarbonization of EIIs

This table assesses the extent to which the existing national policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + 2030 reduction target (BAU), net zero target + economic development visions + long term vision for EIIs mitigation + annual carbon emissions reduction targets - focus mainly on economic growth
	Long term finance	→ weak exploitation + policies/funding for sector development nut not focused on decarbonisation + plans for climate change fund, appropriate finance mechanisms for investment - limited access to finance, low investments - high investment costs
Innovation, Demonstration & Deployment	Enhance public RD&D	→ weak exploitation + limited support for local RD&D
	Accelerate early commercialisation, deployment	→ medium exploitation + focus on adoption of innovation and low carbon manufacturing + policies planned for mitigation incentives
(Re)-shaping markets	Creation of demand	→ weak exploitation: no measures could be identified
	Reshaping of existing markets	→ weak exploitation + carbon tax in policy, but so far not implemented
	Transparency and information	→ medium exploitation + annual reporting, energy audits - no product specific policies
Policy coherence and integration	Reducing of demand.	→ weak exploitation: no measures could be identified
	Infrastructure & energy supply	→ medium exploitation + general development of infrastructure and energy supply, incl solar + industrial energy efficiency policies *+ Under development: domestic market for carbon capture, utilization, and storage for industrial emissions* - strong focus on CCUS (Lock-in) - problems with implementation of plans
	International coherence	→ weak exploitation
	Socio-economic implications	→ weak exploitation
	Regulatory environment	→ weak exploitation - lack of enforcement of existing rules
Knowledge & Capacity	Public managerial & bureaucratic capacity	→ medium exploitation + national climate change committee + capacity building projects ongoing - ineffective coordination - lack of climate mainstreaming - corruption
	Monitoring and evaluation	→ medium exploitation + NEEAP making energy audits compulsory to all energy-intensive sectors

How to strengthen national-sectoral climate policy

In order to strengthen its climate policy related to the industry sector, Nigeria may

- Set sector-specific mitigation targets for industry
- Permanently phase out fossil fuel subsidies
- Implement policies to reach the targets for cement and ammonia production set out in Nigeria's 2022 Energy Transition Plan (renewable electricity, H2, electrification of heat, clinker substitution)
- Develop policies to build up renewables, especially exploiting the country's huge solar potential, and to build out the grid, stabilizing electricity supply for people and businesses alike

- Develop policies to implement its energy efficiency targets for the industry sector, exploit its considerable energy efficiency potential, thus reducing pressure on energy supply
- Invest in strengthening governance capacity, improving coordination within the government, tackling corruption and increasing regulatory oversight to enforce, e.g., reporting obligations for businesses resulting from the Climate Change Act
- Implement material efficiency and circular economy policies to reduce pressure from projected demand increase
- Develop strategies to improve the business climate for private sector investment
- Invest in net-zero industry R&D where possible and engage in partnerships with industrialized countries
- Avoid neglecting climate change in policymaking by integrating it with Nigeria's political priorities of security, health, industrialization and economic reform, e.g., by
    - Developing policies to diversify the economy, reduce dependency on crude oil exports and mitigate health risks posed by local pollution while also avoiding carbon lock-in (e.g., by incentivising the building of smaller scale DRI/EAF capacity instead of trying to revive the failed blast furnaces)
    - Exploring the potential for technological leapfrogging in building up its industry sector
- Develop and implement ETS or carbon tax, as stated in the 2021 Climate Change Act to feed into the proposed Climate Change Fund, or other suitable economic or regulatory instruments to promote industry decarbonisation
- Increase awareness among policy makers about synergies between decarbonisation and industrialisation, e.g., opportunity to attract climate finance

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Norway

Simon Otto (VUB), 26 June 2023. Reviewed by national sectoral expert.

Big picture: Current EIIs-sector decarbonisation status and prospects

Current, past, and projected future GHG emissions in the energy-intensive industry sector

In 2020, process emissions from industry contributed 18% of overall emissions. In comparison, in 1990 the industry sector accounted for 45% of overall emissions. Emissions from industrial energy use were about 5% in 2020. In 2020, CO2 emissions from industrial processes were 8.3 million tonnes, an increase of 0.6 million tonnes since 1990.

About 61% of these emissions were from metal production, primarily from the use of coal, coke and charcoal as a reducing agent. Mineral production accounted for 12.2% of industrial CO2 process emissions and Manufacturing of chemicals accounted for 22.5%.[1]

In 2021, manufacturing industries and mining contributed 23,92% of overall GHG emissions. This amounts to 11 mio. t/CO2e, a reduction of 40,8% from 1990-2021, but an increase of 3% when compared to 2020.[2]

Relevance of iron & steel, cement, chemicals and aluminium industry for national economy

Norway has a large energy-intensive manufacturing sector, with a considerable part of manufacturing being based on natural resources. Hence, industry has a high share of production of raw materials and semi-manufactured goods, including iron and steel, non-ferrous metals, chemicals, fertilisers, pulp and paper, mineral industries, food processing industries, building and construction industry.[3]

Nonetheless, the majority of Norway's GDP is based on the production and export of oil and natural gas. In 2021, the manufacturing sector merely accounted for 6% of GDP and 8% of overall employment.[4]

Phase of the zero-emission transition of the EII sector

Norway's EII sector can be considered to be transitioning from the destabilisation towards the reconfiguration phase. Several industrial climate policies are in place that incentive the implementation of deep decarbonisation options and EII emissions are covered under the EU ETS (see EU case study). Several deep decarbonisation pilot projects are under way, but have recently been delated due to cost increases, e.g. the Klemetsrud project did not get funding in the budget, thus decision was postponed [expert review].

Current general national trends that promote or hinder decarbonization.

According to Climate Action Tracker, the continued exploration and production of oil and gas poses a potential risk to global efforts to achieve net zero emissions by 2050. Norway's 2050 target does not include a commitment to ramp down the oil and gas industry. This could also lead to the lock-in of fossil-fuel based basic material production, or the strong reliance on CCS options.[5]

[1] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the Framework Convention on Climate Change.* UNFCCC. https://unfccc.int/sites/default/files/resource/Norway%20NC8_BR5.pdf

[2] Statistics Norway. (2022). *Emissions to air*. https://www.ssb.no/en/natur-og-miljo/forurensning-og-klima/statistikk/utslipp-til-luft

[3] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the Framework Convention on Climate Change*

[4] Ibid.

[5] Climate Action Tracker. (2022). *Norway*. https://climateactiontracker.org/countries/norway/

National sectoral mitigation drivers and barriers

Barriers & challenges to the decarbonisation of EIIs

Structural context

- Norway holds the biggest hydrocarbon reserves in Europe and is the 5th largest exporter of crude oil globally. In 2021, the production of crude oil and natural gas accounted for 25% of GDP as well as 60% of exports. Overall exports accounted for 46% of GDP.[6]
- This heavy reliance on fossil fuel exports places Norway's economy at risk in a decarbonizing world.[7]

Paradigms & discourses

- Industry itself must be at the forefront to seize the opportunities and solve challenges of transition.[8]
- Strong discourse of how petroleum sector should be "developed, not decommissioned" to legitimise further development of the sector, using the argument that new (green industries) can benefit from the skills and knowhow of existing ones [expert review].
- Political controversy around RES expansion (onshore due to low legitimacy of onshore wind; offshore wind controversial due to potential interconnections to other countries via wind farms). RE share high as assessed under EU RES-D, otherwise calculated at around 50% (big impact of how accounts for energy use in energy production due to big petroleum sector) [expert review].

Polity – none identified

Politics

- Strong emphasis on retaining competitiveness of Norwegian business and industry as well as surplus in electrical power balance.[9]

Policy

- There is a gap between policies and actual emissions currently in Norway. Current policies are only 'almost sufficient' to meet the 2030 emission reduction targets.[10] The continued production of fossil fuels undermines the achievement of Norway's targets in particular.

Economics

- Expected shortage of skilled labor in general, which could undermine the green transition (challenge not only specific to EIIs).[11]
- Oil and gas production constitutes a large proportion of Norway's export economy and overall GDP. While this creates potential long-time pressures on the economy (if global decarbonisation continues), it also creates incentives to diversify the economy.
- Norway has increased its oil and gas output and exports to the EU throughout 2022, as a reaction of the energy crisis caused by the invasion of Ukraine by Russia.

Decarbonisation enablers & drivers

Structural Context

- Norway's industrial sector is based on clean and reasonably priced renewable energy, and industrial companies that manage to develop and utilise high-tech solutions in many areas.[12]

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[6] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

[7] Climate Action Tracker. (2022). *Norway*. https://climateactiontracker.org/countries/norway/

[8] Ministry of Trade, Industry and Fisheries. (2022). *The Green Industrial Initiative*. https://www.regjeringen.no/contentassets/1c3d3319e6a946f2b57633c0c5fcc25b/roadmap_the-green-industrial-initiative_spreads_web.pdf

[9] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

[10] Climate Analytics. (2021). *Ambition gap: What is Norway's pathway to limit global warming to 1.5°C?* https://1p5ndc-pathways.climateanalytics.org/countries/norway/ambition-gap/

[11] Ministry of Trade, Industry and Fisheries. (2022). *The Green Industrial Initiative*.

[12] Ministry of Trade, Industry and Fisheries. (2022). *The Green Industrial Initiative*.

- High RE supply: nearly 98% electricity is based on renewable energy sources, with hydropower constituting 89%, enabling cheap and reliable access to clean energy.[13] The RE share of all energy use varies around 50-60%, given the high use of energy to produce oil and gas [expert review].[14]
- Significant potential for the storage of carbon in the North Sea. The Utsira formation (an offshore saline formation) in Norway is considered the largest potential sink for CO2 in Europe, with a storage capacity up to 16 GtCO2. Other Norwegian offshore saline aquifers and depleted oil and gas fields might be able store as much as 40 Gt.[15]

Paradigms & discourses

- Emerging paradigm of economic diversification through green industrialisation.

Polity

- Part of European Economic Area since 1994. Accordingly, the EU Single Market's four freedoms, as well as non-discrimination and equal rules of competition apply in Norway. The EEA cooperates in areas such as research and development, education, social policy, the environment, consumer protection, tourism and culture as well as in energy (for issues relevant for the internal market).[16]
- Agreement with EU to cooperate on fulfilment of respective climate targets in 2019. Accordingly, Norway will take part in EU climate legislation from 2021-2030. Norway had taken part in EU climate legislation beforehand.

Domestic Politics

- Concerning carbon pricing, there is broad political consensus on increasing the taxes on ESR emissions to above USD 200 in 2030, and to continue the participation in the EU-ETS.[17]
- Strong political discussion on use of CCS technologies for decarbonisation.

International Politics

- On CCS Norway collaborates with relevant countries on a bilateral basis, the European Commission, and various regional and international fora, e.g. North Sea Basin Task Force, Clean Energy Ministerial, Mission Innovation and The Carbon Sequestration Leadership Forum.
- Norway provides funding for CCS projects abroad in cooperation with other countries and through existing programmes and institutions.
- 2023 German-Norwegian Partnership on Climate, Renewable Energy and Green Industry, including Climate Policy, Hydrogen, Renewable Energy (Offshore Wind), Negative emissions (CCS), Raw & Processed Materials and Batteries.[18]

Policy

- Norway aspires to be climate neutral from 2030 onwards and reduce emissions by 90-95% by 2050 when compared to 1990. Norway has 2030 emission reduction target of at least 55% compared to 1990, to be fulfilled jointly with the EU.
- A comprehensive climate policy framework covering almost all GHG emissions is in place. In result, emissions have fallen by 2.2% annually from 1990 to 2021.[19]

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[13] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

[14] See Fornybar Norge. (n.d.). Status fornybarandelen i Norge. https://www.fornybarnorge.no/publikasjoner/rapport/2021/fornybarometeret-host-2021/status-fornybarandelen-i-norge/

[15] IEA (2020). *CCUS in Clean Energy Transitions*. IEA, Paris. P. 138. https://www.iea.org/reports/ccus-in-clean-energy-transitions

[16] Mission of Norway to the EU. (2022). *The EEA Agreement*. https://www.norway.no/en/missions/eu/areas-of-cooperation/the-eea-agreement/

[17] Climate Action Tracker. (2022). *Norway*.; Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

[18] Government of Norway. (2023, Jan 5). *Joint Declaration - German-Norwegian Partnership on Climate, Renewable Energy and Green Industry.* https://www.regjeringen.no/en/whatsnew/dep/smk/press-releases/2023/closer-cooperation-between-norway-and-germany-to-develop-green-industry/joint-declaration-german-norwegian-partnership-on-climate-renewable-energy-and-green-industry/id2958104/

[19] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

- About 85% of emissions are subject to carbon taxes or emissions trading, including EII emissions. The level of carbon pricing is among the highest in the world, with over 80%of emissions being priced at or above approximately USD 80 in 2022.[20]
- Most of the EU's 2030 energy and framework applies in Norway (i.e. 40% reduction target). Once the 'fit for 55' framework is adopted by the EU, Norway will consider whether and under what condition this should be applicable in Norway.
- Carbon capture and storage (CCS) is one of the priority areas for enhanced national climate action, and to reach its climate targets. Norway's CCS strategy spans activities from research, development and demonstration to large-scale projects and international work promoting CCS.[21]

Economics

- Long-lasting experience with CCS. Since 1996, CO2 from natural gas production has been captured and reinjected into sub-seabed formations. Currently, a full-scale CCS demonstration projects are under development, including for cement (see below). However, there has been intense political discussions on Norwegian CCS polices in the past, including a rethink of policy. Policy ambitious have resurfaced, but currently some controversies and delays due to cost increases [expert review].
- Norway is developing the storage of CO2 for other countries as business model. Similarly, Norway intends to export blue and green hydrogen to Europe.
- The historic availability of low-cost hydro power created the basis for establishment of metal and fertilizer production, while the availability of petroleum resources enabled some chemical production.[22]

Current status of national-sectoral climate policy

Norway has a comprehensive set of climate policies, that cover emissions from EII installations. As member of the EEA, it closely cooperates with the EU on climate policy, being a member of the EU ETS, the Effort Sharing Regulation and the LULUCF framework. Norway's climate policy is underpinned by the polluter pays principle and focuses on general and cross-sectoral economic policy instruments.

<u>Governance and Planning instruments</u>

The 2017 Climate Change Act (Lov om klimamål): establishes in law Norway's emission reduction targets for 2030 and 2050, introduces a 5-yearly review cycle, and an annual reporting mechanism for the government.[23]

2030 NDC:[24] Conditional target of at least 55% emission reduction by 2030 compared to 1990, to be fulfilled jointly with the EU.

Green Industrial Initiative (2022):[25] Roadmap to 'make Norway a green industrial and energy giant' to help accelerate its 'transition, create jobs throughout the country, strengthen investment on the mainland, increase exports and cut greenhouse gas emissions'. It outlines several priorities relevant to the decarbonization of EIIs:

- Development of offshore wind production
- Development of value chain for production of zero- or low emission hydrogen, also to supply the European market
- Development of CCS solutions
- Development of 'world's cleanest and most modern and energy-efficient process industry'
- As well as to increase available finance for industrial decarbonization.

[20] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*
[21] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*
[22] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*
[23] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*
[24] Norway. (2022). *Update of Norway's nationally determined contribution*. UNFCCC. https://unfccc.int/sites/default/files/NDC/2022-11/NDC%20Norway_second%20update.pdf
[25] Ministry of Trade, Industry and Fisheries. (2022). *The Green Industrial Initiative*.

Economic instruments

Emissions pricing is the cornerstone of Norway's climate policy. Accordingly, close to 85% of Norway's GHG emissions are covered either by carbon taxes or emissions trading, either under the EU ETS or national carbon taxes. CO2 taxes were first introduced in 1991. In 2008 Norway joined the EU ETS (which covers around 50% of Norway's emissions). The level of carbon pricing is also among the highest in the world, with over 80% of emissions being priced at or above approximately 80 USD in 2022.

EU Emissions Trading System (participation since 2008):[26] During ETS phase IV (2021-2030) around 50% of Norway's emissions are covered under the ETS, including most emissions from EIIs. Norwegian installations represent about 1% of the total emissions under ETS. The legal basis for emissions trading in Norway is the **Greenhouse Gas Emissions Trading Act** adopted in 2005 and amended in 2007, 2009 and 2012. Installations in sectors at risk of carbon leakage receive some or all of their allowances free of charge, following the harmonised EU methodology. In 2021, total free allocation to Norwegian installations represented about 60% of their emissions for the same year.[27]

CO2 compensation scheme for the manufacturing industry: established in 2013, to prevent carbon leakage resulting from increased electricity prices due to EU ETS. The scheme includes all 15 sectors listed in the EU Guidelines, among others aluminium, ferro alloys, chemicals and pulp and paper.

C02 tax is in place since 2000 for must uses of mineral oils, petrol and diesel, natural gas, LPG and HFC/PFC (exemption of road transport, aviation, shipping and fishing). In 2022, the standard tax rate on non-ETS emissions is 766 NOK per tonne CO2. A reduced rate applies to the pulp and paper industry and dyes and pigment industry. If natural gas and LPG is used in land-based manufacturing covered under EU ETS, the tax is reduced, or activities may be exempted. This includes chemical reduction or electrolyses, metallurgical and mineralogical processes.[28] Tax exemptions are subject to EU state-aid rules.

Electricity tax was introduced in 1951. However, electricity used in chemical reduction and in electrolytic, metallurgical and mineralogical processes is exempted from the tax. Electricity used in other manufacturing industries, mining and quarrying, (...) is subject to a reduced rate, which in 2022 is NOK 0.00546 per kWh.

Norway invests in research, development, and innovation of climate forward technologies, including EIIs. Multiple public sector funding instruments have been put in place:[29]

- **Enova**:[30] government owned enterprise, provides funding and advice for climate and energy projects, supporting companies, households, and local and regional governments. Funding for projects is drawn from the Climate and Energy Fund, which was provided NOK 4.1 billion (EUR 382 mio) in 2022. Activities focus on late-phase technology development and early-stage market introduction. Relevant project examples include projects on production of ammonia from natural gas with CCS, electrification of industrial processes in petrochemical industry, and clean hydrogen production.[31]
- **Environmental Technology Scheme**: established in 2010, provides grants and other support for development and investments in pilot and demonstration projects for environmentally friendly products, including metallurgic industry, bio-refinery, renewable energy, etc. In 2021, NOK 677 mio (ca. EUR 63 mio) were granted to 110 projects, the total investment in these projects (including the companies' own funds) being NOK 2.3 billion (~ EUR 220 mio).
- **Nysnø Klimainvesteringer AS (Nysnø):** state-owned investment company (through Ministry of Trade, Industry and Fisheries) focused on early-stage companies. Invests primarily in the transition from technology development to commercialisation. So far received NOK 2 925 million in capital.

In addition, Norway finances several technology development instruments, schemes and projects related to **CCS technology**. Often in cooperation with industry stakeholders.

[26] See EU Industry Sector Sheet.

[27] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

[28] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

[29] See Ministry of Trade, Industry and Fisheries. (2022). *The Green Industrial Initiative*.

[30] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

[31] See also Climate Action Tracker. (2022). *Norway*

- **Longship**: Full-scale CCS demonstration project under development in Norway, consisting of two CO2 capture facilities, for cement (Norcem) and waste incineration, as well as a CO2 transport and storage project (Northern Lights) on the Norwegian continental shelf.[32]
- **Technology Centre Mongstad (TCM):** world's largest facility for testing and improving CO2 capture technologies on an industrial scale. Collaborative project between the Norwegian Government, Equinor (formerly Statoil), Shell and Total.
- **CLIMIT programme**: national RD&D programme for technologies for CO2 capture, transport and storage from fossil- based power production and industry. The programme supports projects in all stages of the development chain, from long-term basic research to build expertise to demonstration projects for CCS technologies. Projects under the CLIMIT programme have yielded important results for the development of CCS in Norway and internationally.
- **Centre for Environment-friendly Energy Research for CCS** (NCCS), co-financed by the Research Council of Norway (governmental agency), industry and research partners.
- Additionally, Norway strives to disseminate information and lessons learned from projects in operation in the petroleum sector, new large-scale projects under planning and from research, development and demonstration projects.

Voluntary agreements

Prior to the inclusion of process emissions from manufacturing industries in the EU ETS in 2013, several agreements concerning emissions reductions have been concluded between the industry and the Government, including with aluminium production.[33]

Assessment of Norway's policy framework to advance the decarbonization of EIIs

This table assesses the extent to which Norway's policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ high exploitation + net-zero target; 2030 mitigation target + EII specific target (under EU ETS) + industrial decarbonisation roadmap - no EII specific target for after 2030 (yet) - strong reliance on CCS for decarbonisation
	Long term finance	→ high exploitation + high public resources + several funding mechanisms for EIIs available
Innovation, Demonstration & Deployment	Enhance public RD&D	→ high exploitation + several national RD&D support schemes + participation in EU RD&D support schemes (Innovation Fund) + several pilot projects already ongoing
	Accelerate early commercialisation, deployment	→ high exploitation + several national early commercialisation schemes + specific funding for CCS infrastructure
(Re)-shaping markets	Creation of demand	→ weak exploitation: no specific measures identified
	Reshaping of existing markets	→ strong exploitation + GHG pricing for EIIs under ETS (with free allowances until 2034) + national carbon tax on energy fuels (with exemptions for EIIs) - CO2 price compensation scheme to prevent carbon leakage - free allowances (until 2034)
	Transparency and information	→ medium exploitation + some legislation in place
Policy coherence and integration	Reducing of demand.	→ Weak exploitation: no specific measures identified
	Infrastructure & energy supply	→ strong exploitation + support for RE development (already high RE share), although some political controversies exist on expansion of wind power.

[32] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*
[33] Norwegian Ministry of Climate and Environment. (2022). *Norway's Eighth National Communication Under the UNFCCC.*

		+ strong support for low-emission hydrogen development (and export) + strong support for CCS infrastructure - potential lock-in of fossil-fuel use and overreliance on CCS
	International coherence	→ strong exploitation + engagement in international cooperation + export of low-emission hydrogen (in particular to Eu) + import and storage of captured CO2 - CBAM might have negative implications for other countries
	Socio-economic implications	→ medium exploitation + some policies and social support mechanisms in place
	Regulatory environment.	→ strong exploitation + stable economic and regulatory environment + high regulatory enforcement - high regulatory requirements
Knowledge & Capacity	Public managerial & bureaucratic capacity.	→ strong exploitation + high public capacity and expertise + stakeholder engagement in place
	Monitoring and evaluation	→ strong exploitation + national GHG monitoring system in place + national review systems in place

Potential to strengthen national industrial climate policy

- Implement policies focused on fostering demand for green basic materials, i.e. green public procurement
- End fossil fuel subsidies
- Policies focused on fostering demand reduction of primary through material efficiency and enhancing circularity
- Adopt carbon footprint accounting for basic materials
- Expand existing financing for R&D and early commercialisation

Russia

Simon Otto, Vrije Universiteit Brussels (VUB), 3 July 2023. Reviewed by Yana Zabanova, RIFS Potsdam.

Big picture: Current EIIs-sector decarbonisation status and prospects

Current, past, and projected future GHG emissions in the energy-intensive industry sector

In 2019, Russia was the worlds 6th largest emitter, responsible for a share of 3.87% of global emissions.[1] Total GHG emissions decreased by 32.4% from 1990 to 2019, mainly due to emissions reductions in the 1990s due to the economic collapse after the fall of the Soviet Union. However, since the 2000s, emissions from all sectors except agriculture have increased, and by 2019, total emissions (excl. LULUCF) were 13% higher than 2000 levels.[2]

The majority of emissions stems from the energy sector (89.18%), while the IPPU sector is responsible for 2.18% (53.91 MtCO2e).[3] In 2019 the steel industry was responsible for 50% of IPPU emissions, followed by the chemical industry with 24%, Cement production with 11% (16% when including lime production), aluminium production (3%), and ferroalloys (2%). In 2019 industrial processes were responsible for 24.1% of direct and 10.2% of indirect energy-related CO2 emissions (Climate Transparency, 2022). The iron and steel industry was responsible for 3% and the chemicals industry for 1% of energy related emissions in 2019.[4]

Russia's industry is very emissions intensive. In 2018, its industry emissions intensity was at 1.4 kgCO2e/USD2015 GVA, almost double the G20 average of 0.7, and +34.4% higher than in 2013 (G20 average -10.5%). The carbon intensity of steel production was 2,756.1 kgCO2/tonne in 2019 (average 1,515.3).[5]

Relevance of EIIs for the national economy

The value added of the industry sector (including construction) is around 30% of GDP for the years 2018-2021. In 2019 around 26.5% of total employment was in the industry sector.[6]

Under its LTS-Scenario Russia expects the share in the structure of the economy of 'traditional industries' to decline by 9.4% in 2050 compared to 2020 (almost twice as much as in the business-as-usual scenario).[7]

Phase of the zero-emission transition of EII sector

The Russian EII sector remains in the lock-in phase of the zero-emissions transition. Russia's industry emission intensity has been growing over the past years and almost no to little sectoral decarbonisation policies are in place.

Current general national trends that promote or hinder decarbonization

Russia's economy is heavily reliant on fossil-fuels and not seeking to reduce or transit away from it.

Following the Russian invasion of Ukraine in 2022, Russia has been internationally isolated and subject to far-reaching sanctions by the G7 and the EU, which has had substantial impacts on the Russian economy.

Prior to the Ukraine war, EU policies and access to the EU market were the main drivers of Russian climate policy, both in public policy but also within private sector (i.e. export-oriented industries). However, due to EU sanctions this driver is mainly gone. While Russia is reorienting towards other markets, with different climate policies, it remains to be seen how this will impact Russian policies and discourses.

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[1] Climate Watch. (2022). *Russia Climate Change Data*. Accessed Dec 14, 2022. https://www.climatewatchdata.org/countries/RUS?end_year=2019&start_year=1990#ghg-emissions
[2] Climate Transparency. (2022). Russian Federation. In *Climate Transparency Report: Comparing G20 Climate Action*. https://www.climate-transparency.org/wp-content/uploads/2022/10/CT2022-Russia-web.pdf
[3] Climate Watch. (2022). *Russia Climate Change Data*.
[4] Russian Federation (2022). *STRATEGY of socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050*. UNFCCC. https://unfccc.int/sites/default/files/resource/Strategy%20of%20Socio-Economic%20Development%20of%20the%20Russian%20Federation%20with%20Low%20GHG%20Emissions%20EN.pdf
[5] Climate Transparency. (2022). Russian Federation.
[6] World Bank. World Development Indicators. https://databank.worldbank.org/reports.aspx?source=2&series=NV.IND.TOTL.ZS&country=#
[7] Russian Federation (2022). *STRATEGY of socio-economic development of the Russian Federation.*

National sectoral mitigation drivers and barriers

Barriers to decarbonisation

Structural context

- Russian economy is heavily dependent on fossil fuels, the oil and gas sector contributed 17.4% of GDP in 2021.[8]
- Russia is among the 20 countries with the largest developed oil and gas reserves and plans to increase its gas and oil production by above 5% by 2030.[9]
- As a result of current international sanctions, Russia is likely facing an economic recession and decline in revenues from fossil fuel exports (which contributed 45% of the Government Budget in 2022).[10]

Paradigms & discourses

- An active debate about decarbonisation and environmental and social governance (ESG) was taking place in Russia prior to the Ukraine war, in reaction to the EU CBAM and global climate policy trends. This encompassed a support mechanism for RE uptake, although this mainly focused on building technological capacity and less on climate action. Russia has also been interested in promoting nuclear power, including through international cooperation. However, this discussion is only in addition to the hydrocarbon model the Russian economy is based on.[11]
- Following February 2022, the discourse of compliance with ESG was not abandoned, given that also new potential partners for (economic) cooperation in Asia and the Middle East have or are developing climate regulations.[12]

Polity

- Societal and political suppression leads to absence of critical views on federal decisions, also inside the administration.[13]
- Environmental NGOs in Russia have been largely closed or silenced through administrative and criminal prosecution for criticizing government decisions.[14]

Politics

- Historically, climate policy is not a domestic political concern but rather a concern related to international reputation and administrative interests.
- High influence of fossil fuel lobby on policy making.[15]
- Due to international sanctions access to international environmental funds and donors is unavailable for Russia. National institutions for green financing have not been created.
- The unlawful invasion of and war in Ukraine have suspended international environmental cooperation with Russia for an indeterminate period.
- Under sanctions and lack of global dialogue, Russian businesses increased pressure on authorities to lower environmental limitations and standards.
- Russian EII exports to the EU will be heavily affected by the EU's CBAM, given that the EU was Russia's largest trading partner prior to the invasion of Ukraine. It remains to be seen how Russia-

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[8] Climate Transparency. (2022). Russian Federation.

[9] Climate Change Performance Index. (2023). Russian Federation. https://ccpi.org/country/rus/

[10] Victor, J. (2023, Jan 6). Morning Energy and Climate: Russia's budgetary blow — Green public procurement — Chinese LNG demand. *Politico*. https://pro.politico.eu/news/158358

[11] Zabanova, Y. (2021). *Navigating Un-charted Waters – Russia's Evolving Reactions to the CBAM and the European Green Deal.* Heinrich Böll Stiftung. https://www.boell.de/sites/default/files/2021-12/E-Paper%20%23171Navigating%20Uncharted%20Waters%23187.pdf

[12] Zabanova, Y. (2022). War, Sanctions and Russia's Energy and Climate Policy: A HIGHLY UNCERTAIN FUTURE. *LibMod Policy Paper.* Zentrum Liberale Moderne. https://libmod.de/wp-content/uploads/libmod_PolicyPaper_RU_UncertainFuture_final36.pdf

[13] Korppoo, A. & A. Alisson (2023). *Russian Climate Strategy: Imitating Leadership*. Climate Strategies. https://climatestrategies.org/wp-content/uploads/2023/04/Russian-Climate-Strategy-Imitating-Leadership.pdf

[14] Korppoo, A. & A. Alisson (2023). *Russian Climate Strategy: Imitating Leadership*.

[15] Safonov, G. (2021). *Back to the Future? Russia's Climate Policy Evolution*. Center for Strategic and International Studies. https://www.csis.org/analysis/back-future-russias-climate-policy-evolution

EU trade flows will develop in the coming years, but without implementing substantial measures to decarbonize the Russian industry sector, the economic costs of any future trade with the EU are likely to climb over time.[16]

Policy

- Overall, efforts to tackle climate change remain low. Few relevant policies are in place, which are unambitious or have an unclear expected effect on emissions and indicate no real commitment to curb emissions, with emissions likely to increase until 2030 under current policies.[17]
- While policies exist in principle, they are seldom implemented.[18]
- Russia lacks effective policies to increase the energy efficiency of its industry sector, nor any effective policies to decarbonize the sector.[19]
- Russia does not have a national carbon tax nor an ETS, albeit there was some talk about introducing a carbon tax in 2019, which did not materialise. However, a pilot-ETS in far-east island of Sakhalin is being planned, potentially paving the way for further developments countrywide.[20]
- Due to international sanctions, easing of emission control rules is in discussion. The Ministry of Energy is considering the possibility of revising the targets of the strategy for the socio-economic development of the Russian federation with low GHG until 2050.
- Russia's energy policy to 2035 (adopted in 2021) focuses primarily on promoting fossil fuel extraction, consumption, and export. The 2020 Energy Strategy 2035 envisions a substantial increase of Russian fossil fuel production, combustion and exports within next 15 years.[21]
- Limited policy on renewable energy. The RE support mechanisms has existed since 2013 and was prolonged in 2021 for the period of 2025-2023. It has played a non-insignificant role in Russia, but nonetheless Russia only received 3.06% of its energy from renewable sources in 2020.[22]
- Russia continues to finance fossil fuel subsidies: In 2020, Russia spent more than USD 9bn on fossil fuel subsidies, with petroleum production receiving the largest share. Approximately USD 5.4bn per year in public finance has been invested in energy projects in Russia, 59% of it supporting fossil fuel projects.[23]

Economy

- Due to international sanctions, Russia is faced with oversupply of oil products and lack of storage capacity, which may lead to shutdown of oil refineries.
- In 2021, Russia was the world's largest exporter of fossil gas—with 23.6% of global exports—and the second largest exporter of oil (12.3% of total) (BP, 2022). Since Russia invaded Ukraine on 24 February 2022, the global demand for Russian fossil fuels has declined as many governments, including the EU, have imposed economic sanctions.[24]
- Russia expects a decrease in energy exports due to decarbonization tendencies elsewhere.[25]

Decarbonisation drivers & enablers

Structural Context

- Russia has valuable resources for almost all types of green energy. Technical potential is 35 times higher than annual production of primary energy.
- Climate change is expected to have strong negative impacts on Russia, including increase in natural hazards and shifts in climatic zones will have largely negative impacts on human life and health,

[16] Climate Action Tracker. (2022). Russian Federation – Policies & Action. https://climateactiontracker.org/countries/russian-federation/policies-action/
[17] Climate Action Tracker. (2022); Climate Change Performance Index. (2023). Russian Federation.
[18] Korppoo, A. & A. Alisson (2023). *Russian Climate Strategy: Imitating Leadership*.
[19] Climate Transparency. (2022). Russian Federation.
[20] Climate Transparency. (2022). Russian Federation.
[21] Safonov, G. (2021). *Back to the Future? Russia's Climate Policy Evolution*. Center for Strategic and International Studies. https://www.csis.org/analysis/back-future-russias-climate-policy-evolution
[22] Climate Action Tracker. (2022); Climate Change Performance Index. (2023). Russian Federation.
[23] Climate Transparency. (2022). Russian Federation.
[24] Climate Action Tracker. (2022). Russian Federation – Policies & Action.
[25] Russian Federation (2022).

due to heat and cold waves, infections and declining food security.[26] Similarly, much of Russia's critical infrastructure is located within permafrost areas and thus seriously threatened by global warming
- Russia holds significant potential for carbon storage.[27]

Paradigms & Discourses

- Narrative that climate change could be net-positive for the country.

Politics

- In the past Russia has participated in international climate action programmes.
- Prior to the Ukraine war EU policies and access to the EU market were the main drivers of Russian climate policy, both in public policy but also within private sector (i.e. export-oriented industries). However, due to EU sanctions this driver is mainly gone. While Russia is reorienting towards other markets, that in large part also have ESG and climate policies, it remains to be seen how this will impact Russian policies and discourses.

Policy

- In Oct 2021, Russia announced to achieve net-zero emissions no later than 2060. This target is part of the 'Strategy of socio-economic development of the Russian Federation with low greenhouse gas emissions by 2050,' which was submitted as LTS to the UNFCCC in 2022.[28]
- 'Russia has taken some steps toward greening its financial system. In July 2021, the Central Bank of Russia (CBR) recommended that public joint stock companies disclose environmental, social and governance (ESG) information, in line with the recommendations of the Task Force on Climate-Related Financial Disclosure (TCFD). [29]

National trade-offs and synergies with SDGs

- LTS scenario allows high level of technological development and increased competitiveness of the Russian economy, including the emergence of new industries (including hydrogen).[30]
- Due to global trends in decline of fossil fuel demand, potential loss of jobs in fossil fuel sector.[31]

Current status of national-sectoral climate policy

Governance and Planning instruments

Strategy of socio-economic development of the Russian Federation with low greenhouse gas emissions by 2050:[32] includes net-zero target for no later than 2060 and GHG reduction targets for 2030 (below 30% of 1990 levels) and 2050 (80% below 1990 levels). The 2050 target relies heavily on negative emissions from LULUCF sector, hence other emissions only need to be cut in half to reach net zero target.[33]

Russia's 2030 NDC contains a GHG emission reduction of at least 30% below 1990 levels by 2030. It was updated in 2020, but ambition was not increased.[34] CAT estimates that Russia can easily reach the 2030 target with current policies.[35]

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[26] Korppoo, A. & A. Alisson (2023). *Russian Climate Strategy: Imitating Leadership*.
[27] IEA (2020). CCUS in Clean Energy Transitions. IEA, Paris. P. 113. https://www.iea.org/reports/ccus-in-clean-energy-transitions
[28] Russian Federation (2022).
[29] Climate Transparency. (2022). Russian Federation.
[30] Russian Federation (2022).
[31] Climate Transparency (2022).
[32] Russian Federation (2022).
[33] Climate Action Tracker. (2022). *Russian Federation – Net zero targets*. https://climateactiontracker.org/countries/russian-federation/net-zero-targets/
[34] Russian Federation. (2020). *Nationally Determined Contribution of the Russian Federation*. UNFCCC. https://unfccc.int/sites/default/files/NDC/2022-06/NDC_RF_eng.pdf
[35] Climate Action Tracker. (2022). *Russian Federation – Policies & Action*. https://climateactiontracker.org/countries/russian-federation/policies-action/

Under the LTS, key planned (but so far not implemented) measures outlined include creation of economic incentives to reduce emissions, sectoral GHG reduction targets, systematic replacement of inefficient technologies, creating conditions to ensure competitiveness in low-carbon markets. However, measures lack detail on how or when they will be implemented, or what their projected impact on emissions would be. Currently little to no actions are undertaken.[36]

For **energy-intensive industry** the strategy foresees several measures but does not contain information on implementation thereof:[37]

- *General*: energy and resource efficiency; material efficiency; better recycling (circular economy); CCS technologies (CO2 & methane); new energy carriers (hydrogen, green ammonia) in iron and steel and chemicals production.
- *Steel*: better quality of iron ore; increasing share of electric steel production, share of DRI production; replacing natural gas with hydrogen (research & creation of necessary infrastructure);
- *Aluminium*: increase use of electrolyzers; transition to electrolysis technology with an inert anode (requires R&D); maximizing the use of recycled water.
- *Chemicals*: energy and resource efficiency; fuel-switching (towards blue hydrogen & green ammonia).
- *Cement*: resource efficiency ('wet' method); fuel-switching; clinker substitution (industrial waste, ash, slag)

Russian government plans a roadmap for the development of hydrogen energy in the Russian Federation.

<u>Economic instruments</u>

Russia's LTS foresees the introduction of industry-wide "financial and tax policy measures to stimulate the reduction of […] emissions in the most inefficient carbon-intensive sectors of the economy."[38]

A carbon trading system was launched in the Governance of Sakhalin in September 2022, as a pilot project.[39] Despite only covering one region, this could potentially pave the way for a more large-scale carbon trading system. Additionally, the first Russian carbon units were traded in September 2022.[40]

The LTS further foresees "state support measures for the introduction, replication and scaling of carbon-free technologies and technologies with low emissions" in EIIs, in particular metallurgical and chemical industries.[41] However, so far this seemed to have not been implemented.

Russia adopted a green taxonomy, that includes categories for industry. Green bonds are traded on the Moscow Stock Exchange.[42] The taxonomy largely draws on the EU taxonomy.

Several relevant R&D projects are ongoing, including:

- Developments of nanotechnologies to improve the properties of basic materials (Rosnano).
- Carbon-free hydrogen energy research project with Arctic Council for phasing out emissions-intensive local fuels and transitioning to hydrogen-based power.[43] Following the suspension of Arctic cooperation with Russia, the project is currently claimed to be continued "without international support". The station is planned to be launched in 2024 (postponed from 2022).
- Hydrogen technologies are being introduced in metallurgy and the chemical industry.
- Russia companies seem to show interest in methane emissions monitoring and some state-funded R&D is ongoing.

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[36] Climate Action Tracker. (2022). *Russian Federation – Net zero target*.
[37] Russian Federation (2022). Pp. 28-29.
[38] Russian Federation (2022).
[39] See https://rg.ru/2022/12/22/zaslon-dlia-ugleroda.html
[40] See https://www.eprussia.ru/epr/447/4956548.htm
[41] Russian Federation (2022).
[42] See https://hpb-s.com/news/chto-takoe-zelenoe-finansirovanie/; https://www.moex.com/n54097
[43] Digges, C. (2020, Nov 3). *Snowflake research center will offer sustainable solutions to Arctic energy questions.* Bellona. https://bellona.org/news/arctic/2020-11-snowflake-research-center-will-offer-sustainable-solutions-to-arctic-energy-questions

Regulatory and 'non-economic' instruments

Federal Climate Law (No. 296-FZ; 2021) commits larger companies (150,000tCO_2e/y, 50,000 from 2025) to report GHG emissions from 2023 onward. The law does **not establish emission quotas or penalties**.[44]

Federal Law on environmental protection (adopted 2002, amended 2021). General Russian climate law. In March 2022, amendments to the Federal Law on Environmental Protection were adopted by the Duma that **postponed the creation of enterprise-level emissions monitoring systems** and the requirement to apply for environmental permits to 2024, further undermining already weak climate-related laws.[45]

Russia's draft 2020 Energy Efficiency Action Plan: outlines timelines for the development of numerous national standards and requirements to improve the energy efficiency of the Russian industry sector. However, none of these have been released, despite a number of scheduled release dates since early 2021. The draft action plan targets a slight improvement to the energy intensity of cast iron (-0.3%) and a moderate improvement in cement and clinker production (-17%) by 2030.

Federal Law on Saving Energy and Increasing Energy Efficiency (No. 261-F3; 2009): introduced ban on the circulation of energy-wasting goods, prescribed requirements for the installation of measuring devices for used energy resources, requirements for buildings and structures, measures to improve energy efficiency in the housing stock, and measures to improve the energy efficiency of the public sector. The law provides for the development of regional and municipal programs for energy saving and energy efficiency, the implementation of measures to improve energy efficiency in the field of tariff regulation, as well as the introduction of measures aimed at improving energy efficiency in the private sector of the economy**.** The law does not define either qualitative or quantitative indicators for assessing energy efficiency.

Educational, Informational, 'soft' instruments

LTS foresees 'finalization of information and technical guides on the best available technologies, taking into account indicators of energy efficiency and resource efficiency.[46]

Assessment of Russian policy framework to advance the decarbonization of EIIs

This table assesses the extent to which Russia's policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium Exploitation + 2060 net-zero emission target; general 2030 & 2040 target in place; general vision for EII decarbonization under LTS - targets are regarded as unambitious and not in line with PA; targets are not in law - no specific targets in place for EIIs
	Long term finance	→ weak exploitation + green taxonomy
Innovation, Demonstration & Deployment	Enhance public RD&D	→ medium exploitation + limited RD&D measures and pilot projects are planned/in place - no further specific policies in place
	Accelerate early commercialisation, deployment	→ weak exploitation: no measures could be identified
(Re)-shaping markets	Creation of demand	→ weak exploitation: no measures could be identified
	Reshaping of existing markets	→ weak exploitation + regional pilot ETS - strong dependency on fossil fuels for EIIs and no policy change in sight
	Transparency and information	→ medium exploitation + GHG reporting requirements foreseen for large companies, but not yet implemented. No verification of data required, however. + voluntary ESG reporting by Russian companies
	Reducing of demand.	→ weak exploitation: no measures could be identified

44 Climate Action Tracker (2022). *Russian Federation – Policies & Action.*

45 Climate Transparency (2022). Russian Federation.

46 Russian Federation (2022).

Policy coherence and integration	Infrastructure & energy supply	→ weak exploitation + industrial energy efficiency policy + RE support mechanism - high fossil-fuel lock-in of national energy supply
	International coherence	→ weak exploitation - international isolation - no engagement in international cooperation on industrial decarbonisation
	Socio-economic implications	no measures could be identified.
	Regulatory environment	→ weak exploitation - lack of implementation and enforcement
Knowledge & Capacity	Public managerial & bureaucratic capacity	no measures could be identified, but likely very weak exploitation. - high corruption and influence of vested interests
	Monitoring and evaluation	→ medium exploitation + in principle GHG reporting requirement for large companies, but lacking implementation, + GHG monitoring

How to strengthen national-sectoral climate policy

Recommendations to advance national (climate) policy on industry decarbonisation based on existing literature.

- Make use of potential for renewables to replace fossil fuels for domestic needs and exports.[47]
- Implement carbon pricing scheme, following the lead of its eastern region Sakhalin.[48]
- Russia lacks effective policies to increase the energy efficiency of the industry sector, nor any effective policies to reduce emissions and to decarbonise the sector.[49]

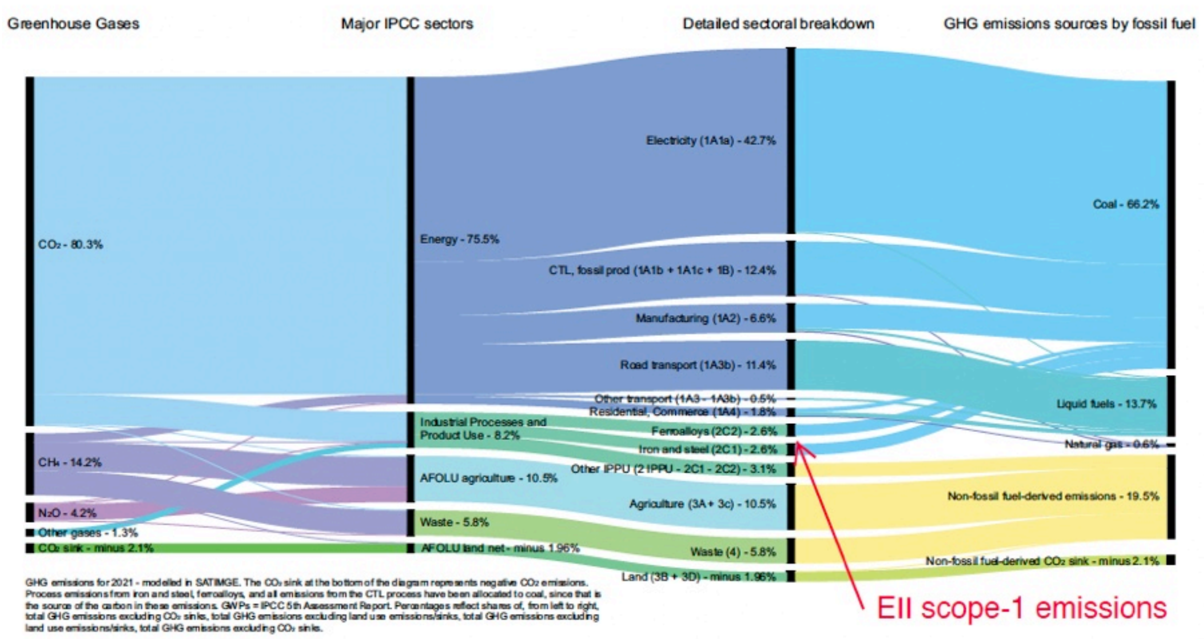
[47] Climate Transparency (2022). Russian Federation.
[48] Ibid.
[49] Ibid.

South Africa

Hilton Trollip (University of Cape Town), Spring 2023

Big picture: Current EIIs-sector decarbonisation status and prospects

Figure 13. South Africa's current (2021) GHG emissions, classified by GHG, IPCC sectors, major emissions categories, and sources by fossil fuel



Source: *JETP-IP Secretariat, 2022*

Important note: There are large differences between figures derived from bottom-up ESRG statistics and aggregate DFFE (South African National Department of Forestry, 2022) statistics. ESRG not available over holidays to check with – This is painstaking effort-intensive work. The DFFE Inventory has text such as, for the ferroalloys industry (pages 180,1) (South African National Department of Forestry, 2022: 180,1).

Overall quantum of EII emissions in the economy: The total emissions for EIIs using bottom up calculations is some 39.5Mt scope 1 (9.5% of total 2017 emissions of 414Mt); and 34.2Mt Scope 2[1] (8.5% of total 2017 emissions of 414Mt, from electricity with a grid factor of about 1Mt/GWh.

Note: these are only CO2 emissions as in rest of this paper unless otherwise stated. Other GHG emissions for EIIs are negligible compared with CO2.

Electricity production from coal fired power stations dominates emissions in South Africa. Electricity production emissions in 2017 were 214Mt and have been declining since 2007 owing to a crisis in the supply industry mainly caused by poor coal plant reliability performance caused in turn by policy and governance crises.

[1] Does not include upstream emissions especially for coke/reductant production.

TABLE 1 – Output of South African EIIs

	2017 Production [Mt]*	2050 production [Mt]**	2017 GVA [US$m2015]*	2017 CO2 emissions [Mt CO2]* Scope 1
Iron and Steel	6.4	15.5	6,370	13.5
Cement production	14.8	29.0	208	8.1
Chemicals production	7.2	14.1	6,661	4.3
Aluminium	0.7	1.7	351	1.5
Other EII***, consisting of:				0
Ferrochrome	3.3	8.0	2,227	10.6
Ferromanganese	0.6	1.5	1,500	0.8
(Ferrosilicon)	0.2	0.5	0	0.7
Total	33.2	70.3	11,843	39.5
Total [%]				
GDP / total emissions			250,000	414
%				

* Only CO2 - from DDP 2022 Pathways / Ferroalloys: calculations based on Production and emissions intensities from 2020 ESRG Modelling Input Report for SA NDC internal draft advance version and from (South African National Department of Forestry, 2022).

** Rough projections / estimates – these could vary widely but variations within a wide range don't affect this policy analysis

Table 2 – GHG Emissions from South African EIIs

2017 Heavy industry sub-sector	Total [%]	scope 1 [%]	scope 2 [%]	Production [Mt]	GVA [USm2015]
Iron and Steel production	21.1	34.3	5.9[2]	6.4	6 370.0
Ferrochrome	31.8	26.8	37.5	3.3	2 227.5
Ferromanganese	4.2	2.0	6.8	0.6	1 500
Ferrosilicon	2.0	1.8	2.3	0.2	0.0
Chemicals production	11.2	10.8	11.7	7.2	6 660.6
Aluminum	18.6	3.8	35.8	0.7	350.6
Cement production	11.0	20.5	0.0	14.8	207.5
Scope 1 and scope 2 %	100	53.6	46.4		
TOTAL	**100.0**	**100.0**	**100.0**		
…Ferroalloys	38.0	30.6	46.6		

[2] This number needs special attention: need to find out amounts of coke that goes into heat/reduction and amounts of electricity in EAFs. Also, by 2022 no DRI which is a substantial change from the year in this table.

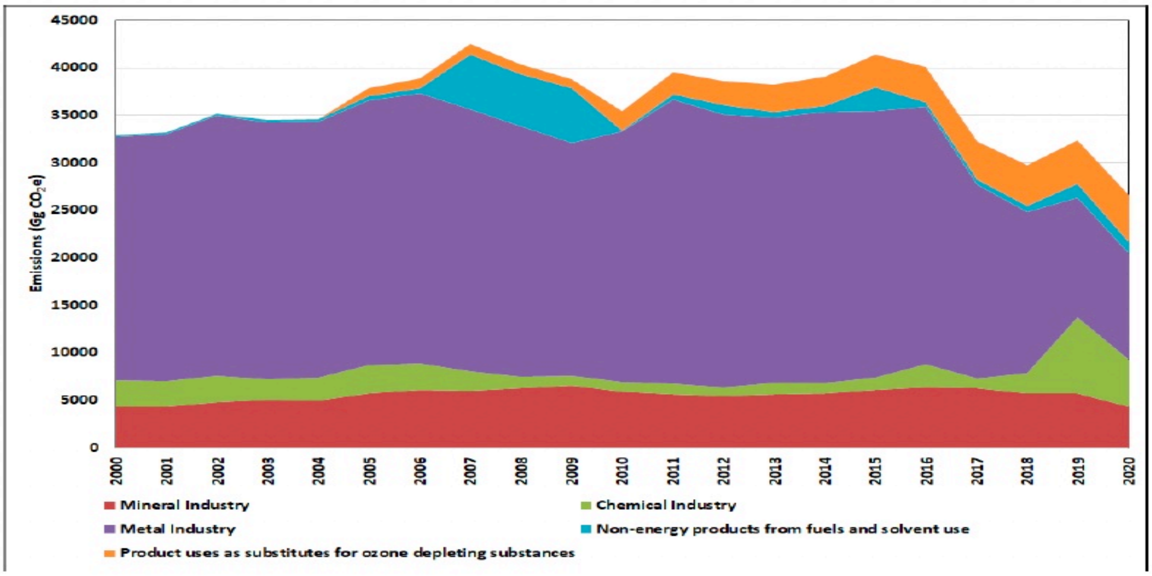


Figure 4.1: Trend in South Africa's IPPU sector emissions, 2000 – 2020.

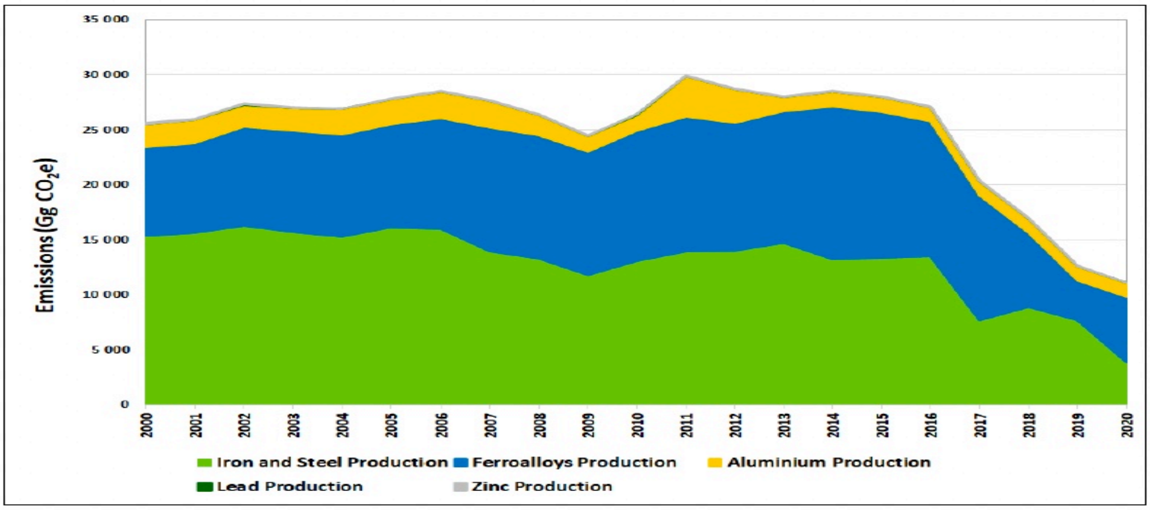


Figure 4. 3: Trend and category contribution to emissions from the metal industries, 2000 – 2020.

Current and past emissions

From the two tables and the two figures above we can make the following observations.

1. Scope-1 emissions from EIIs are about 10% of total emissions and scope to emissions are some 8% making very roughly 20% of total emissions of some 414Mt in 2017.
2. There has been a substantial decrease in EII emissions from 2016 to 2019.
    a. The metal industry was the major contributor to this decline in emissions : both ferroalloys and iron and steel.
    b. The substantial decreases in emissions are largely not owing to decreases in emissions intensity is in these industries. However it is problematic to access details of local emissions factors.
    c. The reason for the decrease in emissions has been almost solely decrease in production.
        i. **Manganese and iron and steel production are down around 50% from their highs in 2010.**
        ii. **Ferrochrome production has dropped sharply over the last few years[3] .**

[3] https://www.miningweekly.com/article/minerals-council-south-africa-should-now-publish-national-chrome-strategy-as-platinum-strategy-follow-on-2019-03-22

d. This is largely owing to factors exogenous to the industries:
   i. Substantially increased electricity tariffs
   ii. International markets and conditions in other productions centres especially China, where lower costs make essay production un-competitive
   iii. Highly volatile global prices.
   iv. Increasingly severe local and national logistics problems: reduced capacity, disruptions in service, security problems and high prices.

The other EIIs in the table, namely chemicals, cement and aluminium have fundamentally different features from ferroalloys from a decarbonization perspective, especially in their South African contexts. So, for the rest of this sector sheet" each of the questions/topics will largely be presented under EII headings.

Future emissions

Iron and steel

This sector can be possibly fully decarbonised. Many major global steelmakers have announced net zero targets for 2050. This includes dominant South African still maker, ArcelorMittal South Africa (AMSA), which operates South Africa's only blast furnaces and accounts for most emissions in the sector. DRI EAF using green H2 (possibly with natural gas as an intermediate pathway to lower carbon steel) or retrofitting of BF BOF with CCUS are main potential technologies

However, there are large uncertainties around international supply chains and the extent to which decarbonisation support being offered an industrialised countries can be offered in South Africa. Needs of the South African government nor South African industry is in a position to offer such support. Thus the future of the South African iron steel production industry will depend on international agreements.

The subsector could decarbonise by 2050 by shutting down all my being integrated into global supply chains with the support being offered in regions with iron steel production takes place being extended to South Africa.

Ferroalloys

New process technologies such as those being commercialised in the iron and steel sector are not yet available for ferroalloys production. If/ when these technologies become available it is possible that these industries will follow in the steps of iron and steel sector.

Until then, substantial emissions reduction is possible in these industries through reducing scope-2 emissions which are substantially larger than scope-1 emissions.

In the short term the sector is likely to continue to decline so emissions will decline.

In the medium term if the sector has revived omissions might well decline because essential element of rescuing the sector will be access to new electricity generation and very low emissions renewables office least costly option thus scope-2 emissions will be substantially reduced.

In the long term it is highly likely that new processes will be substituted for old (manganese already has some promising prospects in the laboratory) and along with zero emissions electricity by 2050 it is highly possible the sector will be fully decarbonised.

Chemicals

This sector is huge and entangled with synthetic fuels manufacturing, the latter accounting for sun 40% of South African liquid fuels supply. Sasol Ltd., South Africa's largest industrial company owns and operates the liquid fuels manufacturing and most of the chemicals manufacturing.

In the past two or three years they have been dynamic developments much of which involve substituting hydrogen for carbon in Sasol processes.

It is starting to become plausible that Sasol would be able transform its chemical operations to net-zero by 2050. However, in the short to medium term it will still be South Africa second biggest emitter after Eskom.

Aluminium

South Africa produces aluminium at the Hillside smelter with capacity of some 0.7Mt from imported bauxite and electricity off the national grid mainly for export. It essentially exports South African electricity embedded in imported aluminium. It closed the Bayside smelter in 2014. Similarly to iron and steel and ferroalloys prices vary widely over time for e.g over the past years the price has varied between ZAR20k-50k/t. Exports are worth some US$ 1.7Bn.[4]

If low-emissions electricity costs can compete with other sites South African production can be decarbonised and continue.

Future success of this industry in South Africa will rely on shifting completely to renewable energy electricity.

Cement

This remains the hardest to abate sector. Even in the medium term emissions are likely to be achieved through a variety of measures along the supply chain and interventions in usage.

The sector is likely to continue production rates and us omissions trajectories at this stage are projected to reduce slowly.

In the medium to long-term it is possible that breakthrough technologies both in supply of cement, usages of cement such as in concrete mixing, and finally usage methods and construction alternatives will be able to fully decarbonise the sector. However these technologies are yet to be discovered.

Thus this sector will not be focused on in this paper as, excepting well-worn ideas such as reducing cement usage, are largely speculative in South Africa. Reducing cement usage to achieve emissions reduction goals, beyond efficient usage as practised by formal construction companies already driven by financial and economic drivers is highly complex in developing countries.

Relevance of iron & steel, cement, chemicals and aluminium and non-ferrous metals industry for the national economy

Iron & Steel: Socio-economic role important ~169k direct jobs in steel manufacture, and ~4% of GDP. Significant secondary contribution to jobs in construction, automotive and machinery manufacturing industries Local demand is mostly met through local supply with limited imports and exports. Potential to create jobs and a new export market if green steel can be competitively produced locally SA well positioned given green H2 and renewable energy potential. (NBI, 2022). Major direct and indirect risks if green steel not achieved locally, e.g. automotive manufacturers lose competitiveness as key export markets (Germany) enforce carbon border regulations, forced to import steel or close SA operations"

Ferroalloys: South Africa has 75% of world manganese and 82% of chrome (ore) resources. Much of the chrome ore production in South Africa is a by-product of platinum mining and as a result lower cost that other reserves; *"South Africa has a long-standing chrome value chain that sustains 200,000 jobs and contributes R42-billion a year to gross domestic product(GDP), but could shed 60 000 to 80 000 of those jobs. The contribution of the ferrochrome industry to South Africa's GDP could plunge to R23-billion, and chrome ore prices could collapse because of oversupply precipitated by South Africa's upper-group-two(UG2) platinum mining sector, which exports the chrome ore by-product."*[5]

South Africa also has excellent world least cost renewable energy resources. As such exports of beneficiated ferro-manganese and ferro-chrome Office huge potential for export earnings. However, these industries are in rapid decline and face an existential threat (see above).

Currently exports are some 3,300Mt and 600Mt respectively accounting for some 0.9% and 0.6% of GDP. This is a substantial amount and could be substantially higher if effectively developed.

Chemicals: See info re Sasol above

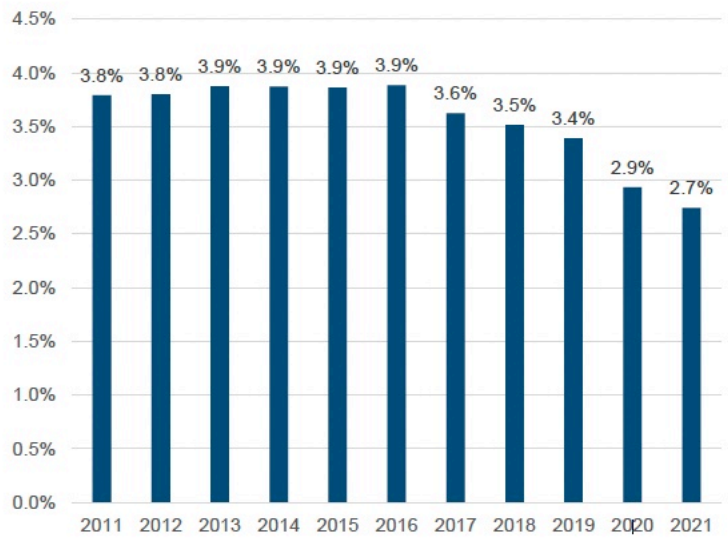
[4] https://www.indexmundi.com/commodities/?commodity=aluminum&months=120&currency=zar

[5] https://www.miningweekly.com/article/south-african-ferrochrome-profitability-down-to-zero-danko-konchar-2012-09-06; https://www.businesslive.co.za/bd/companies/energy/2020-08-20-record-production-at-hillside-smelter-despite-increased-load-shedding/

Aluminium: See above

Cement: Local cement production is integral to the construction sector which has been decline with the general economy.

Figure 5 – Percentage contribution of the construction industry to total value added (current prices), 2011–2021



Source: P0441

Between the two survey years of 2017 and 2020, the contribution of the construction industry to total value added decreased from 3,6% to 2,9%. The decline of 1,1 percentage points between 2011 (3,8%) and 2021 (2,7%) was steeper.

“Between 2011 and 2020, ‘construction of civil engineering structures’ category lost the biggest percentage share of income (-14,1 percentage points) (from a percentage contribution of 43,4% in 2011 to 29,3% in 2020).” Total income for the construction industry is some ZAR440Bn or approx.. 6% of GDP. The South African government has a controlling shareholding in the biggest cement producer and recently place a “banned the use of imported cement on government-funded projects” because imported cement was lower priced and was threatening the sustainability of the local industry.[6]

Phase of the zero-emission transition

Viable iron reduction processes have become available in the past few years and are on the brink of industrial scale commercialization. (see under “future emissions”). Excepting iron and steel the other production processes scope-1 emissions do not have viable decarbonization options. For ferroalloys significant reduction in emissions can be achieved via electricity decarbonization. See under sections above, iron and steel and ferroalloys could be phased out, i.e. continue their decline because production is shifted to other regions/countries.

Current general national trends that promote or hinder decarbonization

South African GHG emissions have been declining since 2007 but this is driven by a decline and electricity production owing to an electricity supply shortage which in turn is directly linked to the performance of the coal fired fleet that provides some 85% of electricity.

The energy intensive industries owing to the volatile features of international markets have in general performed with high volatility in terms of production but in general production is declining having two reasons mentioned above. Thus, emissions have been largely declining.

[6] https://www.dailymaverick.co.za/opinionista/2021-10-18-cementing-south-africas-future-what-could-possibly-go-wrong-with-strategic-economic-localisation/

However, the ongoing decline in the electricity sector and EIIs is not consistent with South Africa achieving core development goals. Whilst the overall economy might be decarbonizing the industries aren't.

It is problematic from socio-economic development and political perspectives to implement many marginal decarbonisation measures in a situation of economic decline. In general, there is large production overcapacity in the EIIs. Covering operating costs is challenging. Unless new investments can compete on the cost basis with returns earned on sunk investments it is difficult for them to be viable.

Large-scale job losses with what is essentially a process of deindustrialization, driven not by policy but by failed policy, create a challenging investment environment generally.

National electricity crisis

The electricity supply shortage, which had its origins in the mid-2000's, has intensified over 15 years and has recently accelerated with national monopoly Eskom in a financial crisis where it cannot even cover interest payments on crippling ZR400Bn debt and the energy availability factor (EAF) of the coal fleet is around 52% and on a steady decline with no objective evidence that this decline is being reversed, or plans to reverse it. National load shedding with power being cut off 8 hours a day, often 4 hours in business hours has become the norm.

Cheap electricity from coal and cheap coal were the foundations of South African EIIs. In the short term (1-3 years) there are no credible prospects of the supply shortage improving. This creates a highly problematic context for EIIs.

However as mentioned above South Africa has potential abundant renewable energy resources. Up until recently legislated Napoli on electricity generation was enforced. Crisis has left this year to lifting of some regulations which creates opportunities for businesses to use renewable energy from privately owned IPPs to begin solving the electricity shortages and also problems caused by electricity prices increasing to levels substantially above countries is hosting competing EII producers.

It is likely that political and institutional dynamics and the electricity system will be central to decarbonisation transitions. The politics around this is highly complex with a responsible ministry the Department and Mineral and Energy Resources (DMRE) essentially taking the position of a fossil fuel promotion agency and (in effect) resisting its legislated mandate to authorize renewable energy for the National Grid.

In short, there is a general decline in the South African economy with factors other than emissions such as electricity prices, electricity reliability and logistics driving the decline. However, underlying mineral and natural resources and techno economics provide structural advantages for EIIs. Major institutional changes will be required to exploit these.

Just Energy Transition (JET)

The JET process driven by the Presidential Climate Commission has created significant expectations around an energy transition. This could potentially address some EII issues.

The Just Energy Transition Investment Plan (JETP-IP) announced at COP26 includes specific mentions of green steel GS production as part of a new large green hydrogen (GH2) programme. However this programme focusses on new industries mainly exports of ammonia and hydrogen. The total GH2 investment is stated as ZAR319Bn with ZAR13.2Bn allocated to GS. This would cover one 1Mt export plant. None of the US$8.5Bn pledged by the JETP international Investor Group (IG) has been allocated.

AMSA and Sasol have announced a joint venture agreement.[7]

> *"Under the JDA, the companies will study two potential projects:*
>
> - *The Saldanha green hydrogen and derivatives study, exploring the region's potential as an export hub for green hydrogen and subsequent products and green steel production.*

[7] https://businesstech.co.za/news/business/635873/sasol-partners-with-arcelormittal-to-develop-a-green-hydrogen-hub-in-south-africa/

- *The Vaal carbon capture and utilisation (CCU) study to use renewable electricity and green hydrogen to convert captured carbon from AMSA's Vanderbijlpark steel plant into sustainable fuels and chemicals, such as ammonia.*
- *"Sasol stated that: The study will gauge whether we can produce green hydrogen to supply the relevant plants, with a key focus on producing ammonia for export… "*

It appears that the focus will be on using the JETP-IP for the new ammonia and hydrogen exports with a secondary interest in decarbonisation of steel production. ZAR150Bn of the estimated ZAR319Bn is allocated to port infrastructure. South Africa already has an idle port for steel exports at Saldanha, where the GS plant is planned,

National sectoral mitigation drivers and barriers (around 1 page)

Structural context: Covered above

Paradigms & Discourses

There are competing paradigms and discourses in South Africa. They aren't only to clearly delineated "sides" to these discourses and these are simplified below to make some key points.

Roughly speaking, on the one side is a paradigm and discourse that prioritizes the use of South Africans substantial call resources and potential gas resources to continue the previous so-called Minerals-Energy-Complex development path. In general this side views development and environmental protection as being at odds. And this is reflected and an oft repeated statement about South Africa deserving emission space to achieve its development before placing limits on emissions. This side launch the looks of the short-term survival of a legacy high missions economy.

On the other side is a paradigm and discourse that starts at position adopting Paris Agreement arguments that unmitigated climate change will be disastrous especially for vulnerable countries and regions and that South Africa is one of them both from the point of view of limited agitation capacity in a country which is struggling to meet basic needs of its population and is in the grips of a protracted economic downturn. The side has adopted scenario-based long-term analysis which shows that decarbonization is possible and economically desirable.

These discourses and paradigms are not only of academic interest because they overlap largely with identifiable alliances which are often at odds politically inside government, inside the ruling party, and in social fractions.

Polity

The South African constitution negotiated in the political settlement at the end of apartheid in 1994 and then finalized in 1998 is regarded as a progressive democratic inclusive constitution which protects human rights and has a number of constitutional safeguards to protect democratic institutions.

Politics

The challenge of politics post-apartheid has been to address centuries of human rights abuses on the majority of the South African population and the resultant deeply unequal society in many dimensions and a severely un-capacitated public sector. South Africa has essentially been a post-conflict society. The African National Congress ANC and alliance with the South African Communist Party (SACP) and organized labour unions began with a large majority in 1994. However two major tendencies, one prioritizing the so-called National Democratic Revolution (NDR) and the other tending towards neoliberalism and market centred economic I've been at loggerheads inside the ruling alliance and increasingly inside government since the 1990s. The ANC majority has steadily reduced and it is facing the very real prospect of not retaining its majority in the 2024 elections.

An additional complication has been the rise of crony capitalism with the so-called radical economic transformation (RET) groupings being involved in widespread state capture which lead to South Africa being on the brink of a failed state in 2017. Since then the group that could be called the Constitutionalists have fought back and at the December 2022 ANC electoral conference reasserted their dominance. This creates more stability is on there has been for many years for government programs. This will potentially favor the second set of discourses paradigms an alliance has mentioned in the section above. However the very influential DMRE remains in control of energy policy and the Department of Trade and Industry (DTI) has yet to demonstrate that it prioritises a low carbon economy except in some statements which are not backed up by solid policy.

Regarding business positions on climate policy there has been a marked swing from a decades long position of resisting climate policy on the side of big emitters and remaining silent among many large corporates to within the last two years business becoming totally supportive of the transition to green economy and in many cases starting to lead government.

Policy – focus on institutional aspects

There are a number of competing centres power competing in policy formulation and implementation related to emissions mitigation and climate change policy. They aren't clear lines drawn or any formal arrangements but the are gross misalignments in policies.

On the one side there are the Department of Forestry, Fisheries and Environment (DFFE), Department of International Relations / Foreign Affairs (DIRCO), Presidential Climate Commission (PCC). On the other side is mainly the DMRE and Department of Trade and Industry (DTI).

Economy: Covered above

<u>National trade-offs and synergies with SDGs</u>

Similar to Economy above. In general decarbonisation of EIIs will be of economic benefit to South Africa within the rapidly evolving international trade regime international cooperation can be secured and accelerated. However there is don't national consensus on this see discourses and paradigms and politics above.

Current status of national-sectoral climate policy

South African climate policy is founded on the 2011 National Climate Change Response White Paper (NCCRWP). There are two pillars of this policy. The first is downward cascading carbon budgets. This starts with a national carbon budget based on the peak plateau decline (PPD) trajectory specified in the NCCRWP. This carbon budget is allocated to various sectors and then downward to sub sectors and industries. It had some success in being applied applied to national electricity generation planning. However when it comes to EIIs it has been problematic. In essence in an area era of deindustrialisation, economic stagnation and decline, state capture, decline of the electricity sector and then crisis in the sector, politically influential and financially concentrated large corporates that generally dominate EIIs I have managed to successfully win a policy argument that "the economy and jobs come first". Given that most of the EIIs emissions largely come from processes that excepting the steel industry have no decarbonised options is easy to understand how difficult the carbon budgets policy has been and will remain to be to implement.

The other pillar has been a carbon tax. Similar arguments to those against carbon budgets have been mounted. Even so a carbon has been implemented albeit at levels that are all bit negligible for the EIIs. Strong technical arguments have been made by the EIIs that the carbon budgets and carbon tax mechanisms are incompatible.

However, in the last few years there has been a large swing, as mentioned above, by EIIs largely owing to the strong intricate integration with global supply chains and the overall success of climate policy internationally.

<u>Governance and planning instruments</u>

This first long section is essentially about how the NDC is translated into carbon budgets for individual companies. to date this is the primary connection between decarbonisation and EIIs.

Overarching guidance

- The South African National Climate Change Response White Paper (CCRWP) specified a national emissions trajectory with upper and lower bounds (Department of Environmental Affairs (DEA), 2011). The current form of this trajectory is defined in the updated NDC submitted to UNFCCC in 2021 as follows.

- "South Africa's first NDC placed mitigation targets in the context of common but differentiated responsibilities and respective capabilities, and "takes the form of a peak, plateau and decline (PPD) GHG emissions trajectory range. South Africa's emissions by 2025 and 2030 will be in a range between 398 and 614 Mt CO2 eq, as defined in national policy, containing mitigation targets for two years (2025 and 2030), corresponding to two periods of implementation (2021-2025, and 2026-2030). The update contains targets for the same two years, corresponding to the same periods of implementation." The updated targets and periods of implementation are as follows:
  - In 2025 South Africa's annual GHG emissions target will be in a range from 398-510 Mt CO2-eq. for implementation in the period 2021-2025.
  - In 2030 South Africa's annual GHG emissions target will be in a range from 398-510 Mt CO2-eq. for implementation in the period 2026-2030. (South Africa, 2021: xx)

Achieving the PPD emissions trajectory range

Overarching Carbon Tax-Carbon Budget –Mitigation System[8] concept

Three primary mitigation measures form critical components of the South African mitigation system **related to EIIs namely:**

- Sectoral Emissions Targets (SETs),
- Carbon Budgets (CBs) and a
- Carbon Tax (C-tax).

→ The NDC→SET→CB→PPP system

- For the purposes of the main EII policy measures the area under the PPD trajectory can be viewed as a national carbon budget (CB).
- The allocation of parts of this budget to EIIs is done by 'cascading it down' firstly to sectoral emissions targets (SETs) and then company carbon budgets (CBs).
- The C-tax and CB systems are integrated and operated using the South African Greenhouse Gas Emissions Reporting System (SAGERS)[9] and Pollution Prevention Plans (PPP). When companies apply for a CB they are required to submit a PPP

Relevant history of SETS and CBs

- The carbon budgets and SETs[10] were first mentioned in NCCRWP (DEA, 2011). An emissions reduction system has been under development since 2011.
- *"The NCCRWP stated that within two years of its publication in 2011 carbon budgets would be allocated and adopted. It also outlined the intention for sector-level DEROS to be cascaded to CBs at company or facility level, and that this would be based on an in-depth mitigation potential analysis (MPA) (DEA, 2011). Since then a stakeholder process to develop the carbon budgets has been ongoing."*
- The apparent simple concept has turned out to be highly complex in practice. The processes of allocating CBs has encountered significant resistance and experienced much delay. (Trollip and Boulle, 2017).
- Following the failure to "allocate and adopt" SETs and CBs in the time period specified in the NCCRWP, DEA decided to implement a phased approach with Phase I involving Voluntary CBs (VCBs) for the period 2016-2020.
- In a trial, voluntary CBs were allocated for a five year period 2016-2020
- A primary reason these were voluntary was that the necessary legislation to enforce them was not yet available. As importantly, it is a complicated system, and to make it workable, learning by doing trials with stakeholders were a necessity.
- Provision for CBs is made in the planned National Climate Change Act (NCA). The National Climate Change Bill was introduced in Parliament in February 2022 and in a public consultation process (April 2023).

[8] This is the current name of the system being used by the DFFE

[9] https://ghgreporting-public.environment.gov.za/GHGLanding/SAGERSHome.html

[10] In the NCCRWP the SETs began their evolution being called desired emission reduction outcomes (DEROs).

- Phase II, Mandatory Carbon Budgets for the period 2021-2025 was meant to begin but owing to delays an extension of the Voluntary Phase from 2021-2022 was announced, called the Transition Period. Phase II was shifted to 2023-2027. The transition period period has now elapsed and SETs and CB's cannot be implemented until the NCA is in force. The transition period will most likely have to be extended until the NCA is promulgated and SETs and CB regulation published and SETs and CBs allocated for the Phase II which will then start.
- Because the time factor is crucial in climate change policy it is relevant to mention this initial history to assess how implementation may proceed. Clearly initial plans were very ambitious and things have turned out to be much, much more complicated than envisaged in the NCCRWP approach. Even so the GOVSA is persisting to make this approach work and more details are provided below

Status and prospects for CB system for EIIs

The national emissions trajectory can be viewed as a yearly and multi-year national carbon budget (CB) which are cascaded down to company CBs. The NCA is still in consultation so the VCBs will likely[11] extended until the first Mandatory Phase of 5 years starts. This will be when:

- the NCA has been promulgated and
- operational details of the "Tiered Approach" that has been proposed in a CB Methodology document (Department of Forestry, 2021) have been finalised
- the tiered approach has been proposed to address challenges with allocating CBs. Three tiers are proposed
    - Bottom Tier - Fixed Target: Budgets are sector-wide fixed reduction
    - Middle Tier - Mitigation Potential: Budget is underpinned by the mitigation potential assessed in the mitigation model
    - Highest Tier - Benchmarking: Budget is/are benchmark intensity/intensities, determined at a company level but underpinned by performance data at facility level.

Operationalising this system is a substantial challenge. One last note is especially relevant. The draft NCA states that: *"In respect of the carbon budgets issued… the Minister [Cabinet Minister responsible for environmental affairs] must follow a fair procedure prior to the issue of the carbon budget including consultation with the person to whom a carbon budget is allocated."* The difficulties experienced from 2011 onwards (see Relevant history of SETS and CBs above) suggests that there still might be some way on what the DFFE calls: "The journey to mandatory carbon budgets". While the government since 2011 has expended substantial efforts and persistence to make the apparently simple CB system work, to date it cannot be said that the prospects are certain.

GUIDANCE/DIRECTION TO EIIS FROM OTHER POLICY

One of the challenges of this section is that the following largely hold true for these policies:

> "A number of broad policy documents, such as the National Development Plan (NDP), the Innovation Plan, and the National Strategy for Sustainable Development and Action Plan (NSSD), have called for the transition to a more sustainable development path in South Africa. Such documents mention and support (at least in principle) a green industrial transition, but they do not constitute a strategic, coherent, green industrial development vision. … South Africa's overall industrial policy vision remains fundamentally entrenched on a business-as usual trajectory from a green economy perspective. It tends to consider the transition to an inclusive green economy as an add-on to other developments in the country." (Montmasson-Clair and Chigumira, 2020).

However, there are very recent initiatives to develop policies that show great potential. The most important for EIIs is policy development around green hydrogen GH.

There have been a number of almost discontinuous step-changes in the clarity and guidance of the direction and speed for South African EIIs since the comments in 2020 by Montmasson-Clair above. These have been driven by the combination of net-zero (NZ) targets by major economies, the recognition that EIIs that had

[11] There have been no publicly announced details of the plans to address the delay. The Carbon Budget Methodology Document A Guideline to Implementing the Tiered Methodological Approach May 2021 (DFFE 2021) indicates a complex system which could require considerable efforts to operationalize.

been identified as hard-to-abate and typically put on the "do later" list now had to be abated to meet NZ targets and very rapid evolutions of renewable energy costs, electrolyser costs and recognition that zero-emissions technologies using hydrogen could plausibly become economic.

The step changes are detailed in the Green Hydrogen Commercialisation Strategy (see below)

The Hydrogen Society Roadmap (HSRM) and Green Hydrogen Commercialisation Strategy (GHCS)

The NDC→SET→CB→PPP system, with SAGERS for monitoring establishes a system for companies to agree on CBs and manage these, with the government being given the powers to ensure the CBs contribute to achieving the NDC (see details below).

However, South Africa's approach to EIIs does not limit decarbonising EIIs to the challenges of reducing and then eliminating energy and process emissions of existing EIIs. Instead, South Africa has recognised that its comparative advantages in potential abundant RE plus mineral resources and existing industrial base provide the potential for creating whole new industries ranging from manufacturing ZE fuels, manufacturing the equipment to make ZE fuels, manufacturing new ZE plant and equipment and using both SA manufacturing and imported technologies to decarbonise existing EIIs. The South African innovation system is a crucial component.

In short, instead of merely substituting ZE fuels and processes in existing EIIs South Africa is putting in place plans to transform the legacy industrial establishment based on cheap coal and minerals relevant to the 20th century with a new industrial ecology based on abundant renewable energy and the minerals relevant to the 21st century.

South Africa has been experiencing de-industrialisation for more than fifteen years as the *'old is dying and the new still cannot be born'.* The legacy coal-based electric power system has deteriorated to the extent that the coal based electricity utility now has a 50% energy availability factor (EAF) on its 80% coal generation fleet and national load shedding of power now only being available for 50% of the day is common. EIIs are in decline and investment has declined. There has been huge push back from fossil interests to an initially very successful renewable energy power procurement programme. Complex politics is at play and the power system transformation probably still has some way to go for the corner to be turned.

However, in parallel, to highly problematic developments in electricity supply, which is the responsibility of the Department and Mineral and Resources and Energy (DMRE), led by an Energy Minister[12] that has publicly opposed the JETP and renewable energy, the Department of Science and Innovation (DSI) (previously Department of Science and Technology), has been investigating and promoting the hydrogen economy, and the Department of Trade, Industry and Competition has taken up policy development with gusto. The DSI launched the Hydrogen South Africa (HySA) in 2008 (www. hysainfrastructure.com).

Subsequently, the German green energy think-tank Agora Energiewende commissioned HIS Markit (now www.spglobal.com) to conduct a very detailed study with DSO as an active client. The presentation of the full report titled A Super H2igh Road Scenario for South Africa, released in June 2021, has 310 slides with detailed information on each. It presents compelling evidence that South Africa has the potential to become a key exporter of green hydrogen and details of how this can be implemented.

The H2igh Road Scenario hydrogen scenario eclipses any previous policies on EII decarbonisation in detail, scope and scale. It presents a future of fundamental transformation involving re-industrialisation and creation of large new industries.

A central feature is that the scenario is initiated by flagship projects and involves demand led investments across the GH value chain starting with primary sectors such as PGM metals for electrolysers and renewable energy extraction. Backward linkages to the latter include mining of primary inputs and then manufacture of inputs such as steel and copper and then renewable energy equipment such as wind-turbine nacelles, electrical gear and electrolysers.

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[12] The implementation of renewable energy electricity generation has been troubled by conflict within the Department of minerals and energy and in government and powerful pro fossil lobbies.

Two core linked features of the scenario is that it is initiated by serving export demand and that scale is critical. Initially, only export markets can provide sufficient scale of demand to kick-start the value chains and local demand has to increase substantially before localisation of many links in the value chain becomes economic.

South Africa's main challenges are unemployment (50%) and inequality (highest Gini in the world and getting worse). Most employment and economic development benefits are in links in the value chain that aren't generation of renewable energy and export of hydrogen, even in ammonia form. Without addressing the entire value chain there is the likelihood of replicating former enclave extraction economics which does not address the main challenges.

The sectors detailed in the scenarios include the decarbonisation of energy intensive industries like iron and steel, chemicals, refining, mining and cement. But other linked sectors such as the heavy-duty transport sector; the decarbonisation of the creation of an export market for green hydrogen and ammonia; and the creation of a manufacturing sector for hydrogen products and components are integral to the scenarios.

Following on the DSI HIS Markit H2igh Road Scenario, the Department of Science and Innovation (DSI) launched the Hydrogen Society Roadmap. This highly detailed 105 pp Roadmap was followed by the 30 November 2022 DTI gazetted (official) issuing of the draft government ***Green Hydrogen Commercialisation Strategy*** for comment consisting of three complimentary documents (Department of Science and Innovation. South Africa., 2021; 2022)

- Green Hydrogen Commercialisation Strategy final report (158pp)
- Green Hydrogen Commercialisation Strategy Executive summary (26pp): A separate and complimentary document to the final report and Panel report.
- Summary of the Green Hydrogen Commercialisation Strategy Panel Report (65 slides): A detailed action-orientated strategy with more than 90 actions for identified actors within short term 2022-2025 and long term (2022-2050) roadmaps.
- This includes details of strategic choices around: Targeted volumes; Market focus and sequencing; Supply Location Archetypes; Spatial focus; Localisation

The essence of the strategy is ***"Demand Driven Commercialisation"***. It states that:

- *"South Africa will have to secure a long term global market share and competitive trade position against competition from other exporters. Export potential is estimated at 2mtpa by 2040 with upside to be as high as 8mtpa in the longer term.*
- *The domestic market mainly follows later with the strategy stating that: "Domestic demand will accelerate as price parity gets closer to fossil fuels. Co-located production projects (e.g. Mining sector) will have accelerated commercial value due to lower infrastructure and supply chain dependencies and hence lower cost. Domestic potential estimated at 2 - 3 mtpa by 2040 with upside as high as 6mtpa"*

The expansion of renewable energy electricity generation from wind and solar for the H2igh Road dwarfs expansion planned for the conventional electricity system and would require a re-think of South African energy futures.

Long-Term Finance

Previously measured climate finance: Of Rbn 62.2 on the tracked private, public and blended finance flows in the South African Landscape in 2017 and 2018 only some 2% could be directly attributed potentially (i.e. at most) to EIIs (the "EE and DSM" category) . (Cassim *et al.*, 2021). This assessment assesses project-level data – understanding in detail the source, disbursement, instrument and use. Evidence of a substantial increase in flows is not accessible (April 2023). → In summary very small amounts recorded to date

The Just Energy Transition Partnership Investment PLAN JETP-IP

The JEP-IP was announced in November 2022. *"At COP 26 in November 2021, the governments of South Africa, France, Germany, the United Kingdom and the United States of America, along with the European Union the International Partners Group (IPG), issued a Political Declaration announcing a new ambitious, long-term Just Energy Transition Partnership (JETP). …on 7 November 2022 November, President Cyril Ramaphosa of the Republic of South Africa launched the new JETP Investment Plan (JETP-IP) prepared by the South African government as envisaged in the Political Declaration. The Plan covers three priority sectors – the energy sector as well as, electric vehicles and green hydrogen – for finance." …*

The Partnership aims to accelerate the decarbonisation of South Africa's economy to help it achieve the ambitious goals set out in South Africa's updated Nationally Determined Contribution emissions goals. …

*The IPG is mobilising **an initial $8.5 billion** to catalyse the first phase of the programme. The funding package will be disbursed through various mechanisms over the five year period including grants, concessional loans and investments and risk sharing instruments.* (European Commission, 2022).

The ZAR 1.5 Tn 2023-2027 budget to meet NDC goal

The JETP-IP states that *"to decarbonise the economy to within the target NDC range by **2030 requires initial funding of ZAR 1.5 trillion (US$ 99 Bn) over five years 2023–2027** in three priority sectors electricity new electric vehicles (NEV) and green hydrogen (GH)"* (Presidential Climate Commission, 2022).

Allocation of 2023-2027 JET-IP ZAR 1.5 Tn budget [%]

Electricity	66
NEVs	9
GH2	22
subtotal	96

Funding of total 2023-2027 budget as at November 2022

Total 2023-2027	ZAR Bn	%
Total	1480	100
IPG	128	8.6
Public (DFI/MDBs)	150	10.1
Private sector	500	33.8
Outstanding	700	47.3

Electricity: Most of the (estimated) budget is allocated to the electricity sector (which indirectly decarbonises EIIs through Scope 2 emissions. These are the 2023-2027 budget estimates referred to above.

Electricity	ZAR Bn	%
Target	1030	100.0
IPG	115	11.2
Public (DFI/MDBs)	500	48.5
Private sector	100	9.7
Un-funded	315	30.6

GH2: ZAR 319 Bn (21%) is allocated to GH2 but just about all of this is allocated to new export industries mainly direct exports of GH and ammonia and construction of a dedicated new export port for these. It is also unclear how this contributes to meeting the NDC by 2030.

GH2	ZAR Bn	%
Target	319	100.0
IPG	10	3.1
Public (DFI/MDBs)	25	7.8
Private sector	0	0.0
Un-funded	284	89.0

NEVs: This is support for the SA vehicle manufacturing industry industrial development and innovation for NEV manufacture and for support of deployment of NEVs. It is un-clear how this contributes to meeting the NDC by 2030.

NEV	ZAR Bn	%
Target	128	100.0
IPG	3	2.3
Public (DFI/MDBs)	25	19.5
Private sector	0	0.0
Un-funded	100	78.1

EIIs: For EIIs in this JETP-IP plan the only budget that appears to be directly attributable to decarbonising EIIs is the GH2 one, and then only a small amount is allocated namely ZAR13 Bn allocated to Green Steel, out of ZAR 319 Bn allocated to GH.

The directly attributable amount is, of the ZAR 1.5 trillion: **ZAR 13Bn (~1%) is directly allocated to decarbonising a specific existing EII, namely green steel production. This is included in the GH budget**

Allocation of the US$ 8.5Bn IPG pledge: The IPG pledge is some 8.6% of the total JETP-IP 2023-2027 budget estimate

IPG pledge vs investment estimate "to decarbonise the economy to within the target NDC range"

		US$ Bn	%
2023-2027 total budget		98.70	100
IPG initial pledge		8.5	8.61

JETP-IP IPG finance to date: France and Germany have each signed loan agreements of Euro 600m (very roughly ZAR[13] 12 Bn) with the South African government[14]. Given the focus on electricity in the JETP-IP it is likely that unless a specific case is made for EIIs very little of the actual finance made available so far will be for EIIs.

13 ZAR Euro is highly volatile ~ZAR20/Euro 14 April 2023)

14 https://www.treasury.gov.za/comm_media/press/2022/2022110901%20Media%20statementFrance%20and%20Germany%20extend%20%E2%82%AC600%20million%20in%20financing%20to%20support%20SAs%20transition%20from%20coal.pdf

Summary

Much detail has been published on the JET-IP. It is complicated to unpack. The amount of detail given above is required to substantiate two conclusions.

- The first is that a minimal amount of climate finance is directly targeted at national emissions reduction (i.e. achieving the NDC in 2030) for specific EIIs.
- **The second is that South Africa is in the process of developing a detailed 'hydrogen economy' strategy which will facilitate decarbonisation of some EIIs over the longer term.**

The Hydrogen Society Roadmap (HSRM) and Green Hydrogen Commercialisation Strategy (GHCS)

New industries that will support global decarbonization are envisaged under the GH programme: upstream RE equipment, electrolysers,

Economic Policies

Carbon Tax: EII companies that are subject to CBs are also subject to a carbon tax (C-tax) (2022 KPMG)

- The Carbon Tax Act No. 15 of 2019 (NCA) was assented to by the President on 23 May 2019. It came into forced on 1 June 2019. The NCA sets out how the tax will be managed for Phase 1 (initially due to end on 31 December2022), it is silent on the specifics of Phase 2. (KPMG, 2022)
- Currently the effective tax is at a rate that is unlikely to have material impact[15].
- The NCA specifies that the initial rate of carbon tax of R120 per tonne will be increased by consumer price inflation plus 2% per year until 31 December 2022. After that the rate of tax will be increased only by CPI.

The World Bank's High Level Commission on Carbon Prices estimated that, in order to drive transformational change, carbon tax should be US$40-80 per tonne of CO2e by 2020, and between US$50-100 per CO2e tonne by 2030 (KPMG 2021). With the initial rate of R120, less than US$ 7.00 at current rates for the foreseeable future the C-tax will have little material impact. However, operationalising the complicated C-tax and CB scheme will be a considerable administrative achievement as a first step.

R&D Policies: South Africa has been a leader in for example the beneficiation of UG-chrome (the chrome mined with platinum group metals). It has also been a leader in manganese smelting technologies. The use of PGM is in electrolyses and South Africa's huge PGM resources have also been the basis of R&D in hydrogen technologies. If corporate's can be convinced that the government is overcoming the policies in sectors including electricity policy (and implementation) and logistics (see Freight paper) and security that have substantially hindered these industries so that they are facing an existential threat, South Africa has shown a history of successfully taking minerals beneficiation technologies through the so-called "Valley of Death" – See sections on chrome and manganese

The steel sector is dominated by transnational ArcelorMittal which is a global leader in technology deployment in GI/GS still manufacture.

Decarbonisation of the metals EIIs will rely on international markets. If these markets are not fair and open and if subsidies and protection that are currently being offered and will plan to be offered to for example European EIIs South Africa will be excluded from decarbonisation of these global industries (Trollip et al., 2022).

Other regulatory policies

The central organizing principles of the just energy transition framework that has been developed by the PCC are the principles and politics required to address the phase out of coal based industries in South Africa.[16]

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[15] "South Africa's carbon tax started at ZAR120 rand ($8.09) per tonne in 2019, and is currently priced at R127. However, with agenerous basic allowance and other available exemptions, companies can easily bring the effective rate down to ZAR6.35 ($ less than US$0.5 /tonne – at current rates - , including through the use of offsets, …" https://carbon-pulse.com/120970/

[16] https://www.climatecommission.org.za/publications/design-addition-and-amendment-to-just-transition-framework-with-dedication-to-pcc-secretary

Assessment of policy framework to advance the decarbonization of EIIs

This table assesses the extent to which the national policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + national emissions trajectory (i.e. target) + sectoral emission targets & carbon budgets for EIIs + development strategies, incl. Green Hydrogen Commercialisation Strategy + economic development through green basic materials production - lack of strategic, coherent green industrial development vision - issues with policy implementation
	Long term finance	→ medium exploitation + international climate finance for economic decarbonisation (JETP), but for EIIs focus is only on green hydrogen - domestic decline of EIIs in decline - investments in decline low climate finance provided to EIIs
Innovation, Demonstration & Deployment	Enhance public RD&D	→ medium exploitation + flagship projects for green hydrogen economy value chain in EIIs
	Accelerate early commercialisation, deployment	→ medium exploitation + JETP contains ltd. allocation of finance for green steel development + flagship projects for green hydrogen economy value chain in EIIs
(Re)-shaping markets	Creation of demand	→ weak exploitation: no measures identified - decarbonisation of basic material production will rely on international markets
	Reshaping of existing markets	→ medium exploitation + carbon tax in place - however, current effective tax rate unlikely to have material impact.
	Transparency and information	→ medium exploitation + pollution prevention plans + facility level performance data - no policies on product level transparency
Policy coherence and integration	Reducing of demand.	→ weak exploitation: no measures identified
	Infrastructure & energy supply	→ medium exploitation + JETP for energy system decarbonisation + political focus on green hydrogen economy - undeveloped power supply - green H2 primarily for export
	International coherence	→ medium exploitation + pot. exporter of green hydrogen + engaged in international cooperation
	Socio-economic implications	→ medium exploitation + Just transition framework with inclusive consultation + specific policies under implementation
	Regulatory environment	→ weak exploitation - difficulties in implementation of existing policies - vested interests
Knowledge & Capacity	Public managerial & bureaucratic capacity	→ weak exploitation - public capacity underdeveloped, but support provided.
	Monitoring and evaluation	→ medium exploitation + GHG monitoring + facility level performance data

How to strengthen national-sectoral climate policy

- In general, there are no specific government policies for the decarbonisation of EIIs beyond overall top-down statements of a commitment to net zero, the NDC, the carbon budgets and carbon tax.
- These are not likely to be sufficient to deal with a very specific challenges that have been presented for EIIs above.

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Türkyie

Simon Otto (VUB), 22 June 2023. Reviewed by sectoral expert.

Big picture: Current EIIs-sector decarbonisation status and prospects

Current, past, and projected future GHG emissions in the energy-intensive industry sector

Total GHG emissions (excl. LULUCF) were 523.9 Mt CO2 eq. in 2020. The energy sector was the main source with 70.2%), while the industrial processes and product use (IPPU) sector share was 12.7%. From 1990-2020 overall emissions increased by 138.4% by 2020, mostly driven by energy sector emissions.[1]

IPPU emissions (12.7% of total emissions) mainly stemmed from the minerals industry (70%), the chemicals industry (4%), and the metal industry (15%). Manufacturing industries accounted for 16.4% of energy sector emissions. IPPU related emissions increased by 190.5% from 1990 to 2020. The main driver behind this increase were emissions from the minerals industry which increased by 350%.[2]

Under Turkey's BAU scenario emissions are expected to increase by around 452% by 2030 compared to 1990. Turkey's mitigation scenario foresees a reduction of GHG emissions by 21% compared to the BAU scenario, which would result in an increase of emissions by 322% by 2030 compared to 1990. IPPU emissions are projected to grow to 169 MtCOeq by 2030 compared to 1990 under the BAU scenario, an increase by more than 600% This would constitute an increase of 154% compared to actual 2020 emissions from the sector. The mitigation scenario does not foresee any emission reductions for the IPPU sector compared to the BAU scenario. However, it is to be noted that the projects underlining the BAU and mitigation scenario are somewhat outdated and do not reflect recent political decisions. The projections had also foreseen IPPU emissions to be 41% higher in 2020 (95 MtCOeq) than reported emissions.[3]

Relevance of EIIs for the national economy

The industry sector (incl. construction) was responsible for around 25-30% of annual value added of GDP over the past two decades, while manufacturing added between 15-22% to GDP annually.[4]

Current phase of the zero-emission transition of the sector

Türkyie's EII sector can best be described to be still in the lock-in phase. Industry emissions are still growing and little to no decarbonisation efforts can be observed. There are little to no policies currently in place that will fundamentally change this. However, recent policy announcements and the updated NDC might suggest a shift towards the destabilisation phase in the medium term.

Current general national trends that promote or hinder decarbonization.

The Turkish economy has been struggling with fundamental structural issues over the past decades that undermine macroeconomic stability and constrain economic growth. These structural underlying issues include, strong reliance of past economic growth on domestic demand funded to large part by debt-creating capital flows resulting in system unsustainable current account, low national savings rate, low technologic level of existing exports and low productivity in manufacturing, and signs of pre-mature deindustrialisation.[5]

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National sectoral mitigation drivers/enablers and barriers

Barriers to decarbonisation of EIIs

Structural context

- Persistent macro-instability and uncertainty due to low national savings rate and slow development of capital markets, resulting in a shortage of long-term funding for industrial development.[6]
- High level of vulnerability to external global shocks (due to current account deficit) that contributes to persistent macro-economic instability and undermine business investment.[7]
- Turkey's primary energy supply is dominated by fossil fuels, which accounted for 83% of domestic energy supply in 2019.[8]

Paradigms & discourses

- Prevalence of paradigm of economic growth in domestic politics, resulting in 'unrealistic' economic development policies based on intensive natural resource exploitation and emphasis on low-technology infrastructure including coal-led energy, road-based transportation, mining and construction.[9]
- Similarly, Modernisation and prestige concerns have always been more instrumental to Turkey's climate policies than rational action and fair share debates.
- Regarding international climate policy Turkey has been insisting to be classified as 'developing' rather than 'developed' country to better reflect its inability to fulfil the obligation developed countries to provide climate finance to third countries and reduce domestic emissions.

Polity

- Member of EU customs union since 1995. EU accession negotiations since 2005, but process has stalled almost entirely since 2018.[10] Nonetheless, compliance with EU policies is regarded as strategic goal and state policy by turkey, especially in the fields of environment, energy and climate and has led to domestic climate policy development.[11]
- The centralisation of authority under the AKP has undermined bureaucratic autonomy, transparency, and public sector accountability.[12]
- Limited overall state capacity reflected in *'reactive' policymaking* by governments. Due to a lack of established institutionalised governance mechanisms for industrial policy, governments resort to *ad- hoc administrative measures* and increased executive control, creating a vicious circle of further de-institutionalisation.[13]
- Concerning climate policy, Turkey conducted a first multi-actor process on climate in 2004 but failed to create a structured dialogue and inclusive policymaking process on climate change in subsequent years. Despite push from civil society.[14]
- Civil society faces continuous pressure and their space to operate freely has continued to diminish limiting their freedom of expression and freedom of association.

Domestic Politics

- For a long time no real interest in climate policy in Turkish government, with the priority being on economic growth and development.

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[6] Ibid.

[7] Ibid.

[8] IEA (2021), *Turkey 2021*, IEA, Paris. Pp. 19, 42. https://www.iea.org/reports/turkey-2021

[9] Turhan, E., Cerit Mazlum, S., Şahin, Ü., Şorman, A. H., & Cem Gündoğan, A. (2016). Beyond special circumstances: Climate change policy in Turkey 1992–2015. *WIREs Climate Change*, *7*(3), 448–460. https://doi.org/10.1002/wcc.390

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[14] Turhan et al. (2016). Beyond special circumstances: Climate change policy in Turkey 1992–2015.

- Increasing political and social volatility (e.g. protests, electrical questions, regional conflicts).[15]
- Turkeys' business elite is fragmented and dependent on state support and thus unable to stem significant investments. Historical legacy of state-business relations established in the early years of the Republic.[16]

International Politics

- Turkey has signalled little enthusiasm for international climate policy over the past decades. Only ratified the UNFCCC in 2004 after having been removed from Annex II.[17]
- Turkey did not ratify the agreement until October 2021, over concerns of obligatory contributions of climate finance, whereas Turkey considers itself as climate finance recipient and not donor.
- EU and US protectionist measures against the Turkish iron & steel industry, as well as the EU's CBAM and other environmental regulations could undermine Turkey's heavy industry and automotive exports.[18]

Policy

- While overall mitigation target exists and several mitigation policies are in place (see below), the implementation of these measures has been lacking.[19]
- Few decarbonisation policies are in place regarding the industry sector (see section 3). Existing measures mainly focusing on increasing industrial energy efficiency, energy reporting and audits,[20] and have not resulted in sufficient incentives to decarbonise EIIs.
- Further existing mitigation policies focus mostly on general climate governance as well as the power and land transport sector. [21]
- National energy policy is predominantly focused on energy security and decreasing dependency on fossil fuel imports, the development of domestic nuclear and coal power generation capacity, but also the increase of RE production and decreasing energy intensity.[22]
- High fossil fuel subsidies, in order to address high energy prices caused by high-import dependency when it comes to fossil fuels and low domestic purchasing power.[23]
- High energy subsidies for EIIs to ensure their international competitiveness (in particular steel and cement industry) amid high energy prices.

Economics

- Long term macroeconomic instability, high inflation and underlying structural economic problems result in investment uncertainty for industrial actors (see above).
- So far Turkey had a global niche as producer and exporter of heavy (polluting) industries (while advanced economies deindustrialised and moved into light industry and high-tech sectors). However, this niche is being threatened with the introduction of EU CBAM.[24]
- Regional geopolitical instability (such as Russian invasion of Ukraine) can amplify the volatility of the economy, resulting in high 'market uncertainty for producers regarding the cost of funds and inputs leading to persistent demand for state support to mitigate the macro- shocks.[25]
- High dependence on private foreign capital for investments in industry.[26]

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[15] Alkan, A., Oğuş Binatlı, A., & Değer, Ç. (2018). Achieving Turkey's INDC Target: Assessments of NCCAP and INDC Documents and Proposing Conceivable Policies. *Sustainability*, *10*(6), Article 6. https://doi.org/10.3390/su10061722

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[24] See Toksoz. (2023). The Return of Industrial Policy in Turkey.

[25] Ibid.

[26] Ibid.

Drivers/Enablers of sectoral decarbonisation

Structural context

- High potential for the production of renewable energy (RE) as well as green hydrogen.[27]

Polity

- As EU accession country, Turkey is closely following EU policies and developing legislation to comply with the EU environmental and climate acquis.[28]
- Existence of domestic climate change institutions.[29]
- Several environmental NGOs are active in Turkey.[30]

Domestic Politics

- Increase in political climate ambition and action in the recent years, manifested in ratification of Paris Agreement, 2053 net-zero target, updated NDC in 2023, and climate action plans (e.g. Green Deal Action Plan). A policy framework for industrial decarbonisation is under development.[31]
- Increasing pollution and degradation of the environment and recent natural disasters—draught widespread fires, landslides – have put public pressure on the AKP.[32]

Politics – international

- Turkey finally ratified the Paris Agreement in 2021, folloowing a MoU with the Green Climate Fund on USD 3.2 billion of funding to support public and private climate projects to meet clean energy goals. This could push climate ambition in Turkey.[33]
- The EU's CBAM will significantly affect Turkish EIIs. This could drive industrial decarbonisation in principle, but the heavily polluting exporting sector might not be able to adapt in time.[34] Turkish EIIs seem to be very aware of the potential effects of CBAM, but are reportedly still waiting to see its actual impact.
- Climate policy diffusion from the EU played certain role in consolidating interest in early period, although national developmental aspirations always overwrote climate policy ambition.[35]

Policy

- A 2053 net zero target was communicated in 2021 and an updated more ambitious NDC submitted in 2023.[36] While this could signal a stronger interests in domestic climate action, it is unclear if this is not merely a response to international pressures.
- Several cross-sectoral climate change strategies are in place that shape the countries mitigation and adaptation efforts, which include several measures regarding industry (see Section 3).[37] The cross sectoral strategies are currently under revision.
- In 2021 the Ministry of Trade presented a *Green Deal Action Plan* in response to the European Green Deal. The plan foresees the development of a carbon pricing scheme for industry, which is

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27 IEA. (2021). *Turkey 2021.*

28 Turkey. (2023). *Updated First Nationally Determined Contribution*. UNFCCC. https://unfccc.int/sites/default/files/NDC/2023-04/TÜRKİYE_UPDATED%201st%20NDC_EN.pdf

29 Turhan et al. (2016). Beyond special circumstances: Climate change policy in Turkey 1992–2015.

30 Monciatti et al. (2022). Policy Vision Roadmap for Civil Society.

31 Turkey. (2023). *Updated First Nationally Determined Contribution*; see also Toksoz. (2023). The Return of Industrial Policy in Turkey.

32 Toksoz. (2023). The Return of Industrial Policy in Turkey.

33 IEA. (2022). *MoU with the Green Climate Fund*. IEA/IRENA Renewables Policies Database. https://www.iea.org/policies/14397-mou-with-the-green-climate-fund

34 Toksoz. (2023). The Return of Industrial Policy in Turkey.

35 Turhan et al. (2016). Beyond special circumstances: Climate change policy in Turkey 1992–2015.

36 Turkey. (2023). Updated First Nationally Determined Contribution.

37 (Climate Policy Database. (n.d.). *Turkey*; IEA. (2021). *Turkey 2021.*

likely to closely mirror or be linked to the EU ETS.[38] A general policy framework for industrial decarbonisation is under development.[39]
- Turkey has a long-standing tradition of state-led industrial policies that could be a driver of decarbonisation, although with strong variation of approaches over time. However, a major barrier to successful industrial policy has been problems with the implementation of industrial policies.[40]
- Supporting infrastructure: various policies regarding the development of RE are in place, including a 2023 target, support schemes, RE resource areas, feed-in tariffs and auctions. The 2023 target of a 38.8% RE share of domestic power generation is likely to be overachieved given that RE accounted for 54% of total domestic energy production in 2019 already.[41]
- Several policies are in place to slow the rate of energy consumption growth through improving energy efficiency. The National Energy Efficiency Action Plan 2017-2023 (NEEAP), aims to reduce primary energy consumption by 14% from BAU levels across several sectors, including industry.[42]
- R&D and innovation supports have focused on combating and adapting to climate change and transitioning to a net zero economy.[43]
- Plans exist to enhance its green finance ecosystem and accelerated policy and regulatory action.[44]

Current status of national-sectoral climate policy

Turkey has few policies in place to decarbonise the industry sector. Existing policies mainly focus on increasing energy efficiency. However, Green Deal Action Plan and updated NDC outline plans for the development of an emission trading system and signals a shift towards more proactive industrial decarbonisation policies. An industrial decarbonisation policy framework is under development.

<u>Governance & planning instruments</u>

2053 Net-zero emissions target: communicated in 2021 but not yet transposed into national legislation.

Turkey's updated 2023 NDC:[45] overall 41% reduction target by 2030 compared to a BAU scenario. Outlines planned mitigation measures for the industry sector up to 2030, with some relevant for EIIs:

- Increase use of biofuels, refuse-derived fuel, alternative fuel, and raw materials in industrial facilities.
- Reduce the carbon footprint of industrial products and increase renewable energy use and resource and energy efficiency in the industry sectors.
- Conduct Green Growth Technology Roadmap studies for the iron-steel, aluminium, cement, chemicals, plastics and fertilizer sectors.
- To support "Green Transition in the industry" by prioritizing certification of industrial facilities that use "Best Available Techniques" as an indicator for clean and green industrial production.

Additionally, several cross-sectoral climate strategies are in place:

Green Deal Action Plan (GDAP, 2021): [46] strategy and roadmap for achieving a green shift in all sectors to project and develop the competitiveness of Turkish exports. It deliberately aims to put Turkey in line with the European Green Deal and includes a total of 32 targets and 81 Actions. Measures (in)directly relevant for the decarbonisation of EIIs:

- carbon regulations at the border (incl. establishment of an ETS);
- green and circular economy; fostering green finance;

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[38] Republic of Turkey. (2021). Green Deal Action Plan 2021. *Ministry of Trade*. https://climate-laws.org/geographies/turkey/policies/green-deal-action-plan-approved-by-presidential-circular-2021-15

[39] Turkey. (2023). *Updated First Nationally Determined Contribution*; see also Toksoz. (2023). The Return of Industrial Policy in Turkey.

[40] Toksoz. (2023). The Return of Industrial Policy in Turkey.

[41] IEA. (2021). *Turkey 2021,* P. 21.

[42] IEA. (2021). *Turkey 2021.* p. 12.

[43] Turkey. (2023). Updated First Nationally Determined Contribution.

[44] Ibid.

[45] Turkey. (2023). Updated First Nationally Determined Contribution.

[46] Republic of Turkey. (2021). *Green Deal Action Plan 2021*. Ministry of Trade.

- clean, affordable and secure energy supply;
- and combatting climate change in general.

National Climate Change Action Plan 2011-2023 (NCCAP):[47] identifies sectoral climate actions for the period 2011-2023, including short, medium and long-term goals under eight topics, including industry. It is currently being reviewed and proposed to be updated by end of 2023, including a long-term review (2030-2050) of policy options.[48]

National Climate Change Strategy 2010-2023 (NCCS):[49] sets out a vision for climate compatible development and includes short, medium and long-term objectives to guide national climate change policies and actions for the energy, transportation, industry, waste, land use, agriculture and forestry sectors for 2010-2020. Currently under revision. For the industry sector it included the following objectives:

- Short term: awareness raising & guidelines; mandatory energy managers for large industrial energy consumers.
- Medium term: voluntary agreements on GHG monitoring; annual energy studies; industrial heat recovery; replace of industrial resources; R&D activities and technology transfer.
- Long term: incentive mechanisms for cleaner production; industrial energy efficiency.

11th Development Plan (2019-2023): plan for economic development but does not include industry specific mitigation measures.

Medium Term Programme (2023-2025): Defines establishment of ETS.

Turkey National Energy Plan (2020-2035)

Hydrogen Roadmap (published)

2023 Industry and Technology Strategy (2019)

Planned governance and planning instruments:[50]

- **Green Growth Technology Roadmap**: identifies technologies needed to increase green production in industry and support R&D studies for the development of determined technologies. The Roadmap focuses on achieving a green transition in iron-steel, aluminum, cement, chemicals, plastics, and fertilizer sectors.
- Road Map for Emission Intensive Industries (under preparation)
- A Zero Carbon Roadmap for the Steel, Aluminum, and Cement Sectors (under preparation)
- CCUS roadmap and implementation plan (under preparation)
- National Circular Economy Action Plan (being drafted)
- 12th Development Plan (2024-2028) (under preparation)
- Long-term low emission development strategy (Long-Term Strategy) (under preparation)
- Climate Law (under preparation)
- Long-Term Climate Change Strategy (under preparation)
- Sustainable Consumption and Production Strategy (under preparation)
- Secondary Legislation for ETS (under preparation)

Economic instruments

Announced: Establishment of Emission Trading System (ETS): Announced in Medium Term Programme (2023-2025) and Green Deal Action Plan; as primary mitigation instrument in industry and energy sector. Planned to include emission-intensive sectors and be designed as cap-and-trade system, based on the existing Turkish MRV System**.** Allocation methods and policies will be determined considering the sectoral abatement costs and mitigation options, among other interrelated policy areas.

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[47] Ministry of Environment and Urbanization. (2012). *National Climate Change Action Plan 2011-2023*. https://webdosya.csb.gov.tr/db/iklim/editordosya/iklim_degisikligi_eylem_plani_EN_2014.pdf

[48] IEA. (2021). *Turkey 2021.*

[49] Ministry of Environment and Urbanization. (2010). *Republic of Turkey Climate Change Strategy 2010-2023*. https://webdosya.csb.gov.tr/db/iklim/editordosya/iklim_degisikligi_stratejisi_EN(2).pdf

[50] See Turkey. (2023). Updated First Nationally Determined Contribution.

Market-based or **economic policies** in the energy, transport and industry sector are in place, including support schemes for RE (RE resource areas, feed-in tariffs and auctions) and energy efficiency in industry.[51]

Efficiency Improvement Support Program (2008): support mechanisms to reduce the energy intensity of industrial installations. Within the scope of the Program, 346 projects were supported in the 2009-2021 period, and 76 thousand TOE energy savings were achieved.[52]

Regulatory and 'non-economic' instruments

National Energy Efficiency Action Plan 2017-2023 (NEEAP) [under revision]: aims to reduce primary energy consumption by 14% from BAU levels across several sectors, including industry. Regarding industry it foresees the scale up of cogeneration systems, a 10% reduction in energy intensity by 2023 for each industry subsector, low-interest loans for energy efficiency projects, and harmonisation of environment-friendly design and product labelling legislation with EU standards.[53]

Energy Efficiency Law (1983, 2007): industrial enterprises with a specific size should commission energy efficiency audits and establish energy management units.

By-law on Fluorinated Gases (2022)

By-law on Substances that Deplete the Ozone Layer (2017)

Monitoring, reporting and verification (MRV) system [By-law on Monitoring of GHG emissions (2012, 2014); Communiqué on Monitoring and Reporting Greenhouse Gas Emissions (2014, 2021); Communiqué on Verification of Greenhouse Gas Emission Reports and Accreditation of Verification Bodies (2017, 2022)]: Covers emissions from combustion of fossil fuels, oil refining, iron and steel, ferrous and non-ferrous metal production, primary aluminium production, mining industry, pulp and paper production, chemical industry, and acid production. More than 700 facilities, accounting for approximately 50% of Türkiye's total GHG emissions, submitted their monitoring plans and have been monitored since 2015. Creates infrastructure for future carbon pricing systems and is in line with EU-ETS.[54]

Environmental Inspection By-law (2008)

By-law on Management of Industrial Emissions with Best Available Techniques (being drafted)

Communiqué on Voluntary Carbon Market Project Registration,

Educational, Informational, 'soft' instruments

Borsa Istanbul (BIST) Sustainability Index & other ESG indexes, sustainability disclosure frameworks and standards, the sustainability and integrated reports made voluntary by the private sector supports measures to mitigate emissions and manage climate change risks.

Assessment of Turkey's policy framework to advance the decarbonization of EIIs

This table assesses the extent to which Turkey's policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + 2053 net-zero target; 2030 target (BAU) + Green Deal Action Plan (outlines industrial decarbonisation measures) *+ EII decarbonisation strategies under development (general guidance)* - general focus on economic development over decarbonisation
	Long term finance	→ weak exploitation: no long-term financial mechanisms exist - macroeconomic instability and lack of investment capabilities in industry
	Enhance public RD&D	→ weak exploitation: no specific measures could be identified

[51] IEA. (2021). *Turkey 2021.* Pp. 31-33.

[52] Turkey. (2023). Updated First Nationally Determined Contribution.

[53] IEA. (2021). *Turkey 2021.* P. 42.

[54] See Turkey. (2023). Updated First Nationally Determined Contribution.

Innovation, Demonstration & Deployment	Accelerate early commercialisation, deployment	→ weak exploitation: no specific measures could be identified
(Re)-shaping markets	Creation of demand	→ weak exploitation: no specific measures could be identified
	Reshaping of existing markets	→ weak exploitation (under current measures *+ announcement of establishment of ETS* - high fossil fuel subsidies
	Transparency and information	→ medium exploitation + GHG monitoring of EIIs + energy audits *+ product requirements under preparation*
Policy coherence and integration	Reducing of demand.	→ weak exploitation: no specific measures could be identified *+ planned circular economy measures*
	Infrastructure & energy supply	→ medium exploitation + RE targets and policies + industrial energy efficiency - high fossil fuel subsidies
	International coherence	→ medium exploitation + close relation to EU - little involvement in international cooperation - high impact of EU CBAM expected
	Socio-economic implications	No information available
	Regulatory environment	→ medium exploitation + frameworks and institutions in place - low implementation of existing policies
Knowledge & Capacity	Public managerial & bureaucratic capacity	→ medium exploitation + national institutions on climate change in place + close engagement with industrial stakeholder engagement - limited public capacity on industrial decarbonisation - limited public capacity overall
	Monitoring and evaluation	→ medium exploitation + GHG monitoring system + annual energy audits for industrial installations

How to strengthen national-sectoral climate policy

- Follow-suit with swift implementation of planned measures (e.g. carbon tax)
- A combination of industrial high-tech and green transition development policies can address the foreign payments problem by reducing the USD 40bn or so hydrocarbon import bill.[55]
- Turkey needs significant international financial support for its climate-friendly technical assistance and investment projects to implement its NDC and realize its increased ambition in mitigation and adaptation actions.[56]
- Phase-out of fossil fuel subsidies
- Provide subsidies for implementation of clean technology.
- Exploitation of green energy potential to create supply of green materials for export.

[55] Toksoz. (2023). The Return of Industrial Policy in Turkey.
[56] Turkey. (2023). Updated First Nationally Determined Contribution.

United States of America (US)

Annika Tönjes (Wuppertal Institute for Climate, Environment and Energy), with support from Stefanie Lill (Wuppertal Institute for Climate, Environment and Energy), 6 June, 2023.

Big picture: Current EIIs-sector decarbonisation status and prospects

Sectoral GHG emissions

Industry accounted for 24% of US GHG emissions in 2020, making it the third highest emitting sector after transportation (27%) and electric power (25%). When including indirect emissions from electricity generation, the share goes up to 30%, making industry the highest emitting sector in the US. Total emissions from industry (incl. electricity) declined by 22% between 1990 and 2020 (*Sources of Greenhouse Gas Emissions*, 2022). As of March 2022, energy-related CO_2 emissions from industry are projected to increase by 8% between 2021 and 2050, assuming no changes to current laws or regulations (*Energy and the environment explained*, 2022).

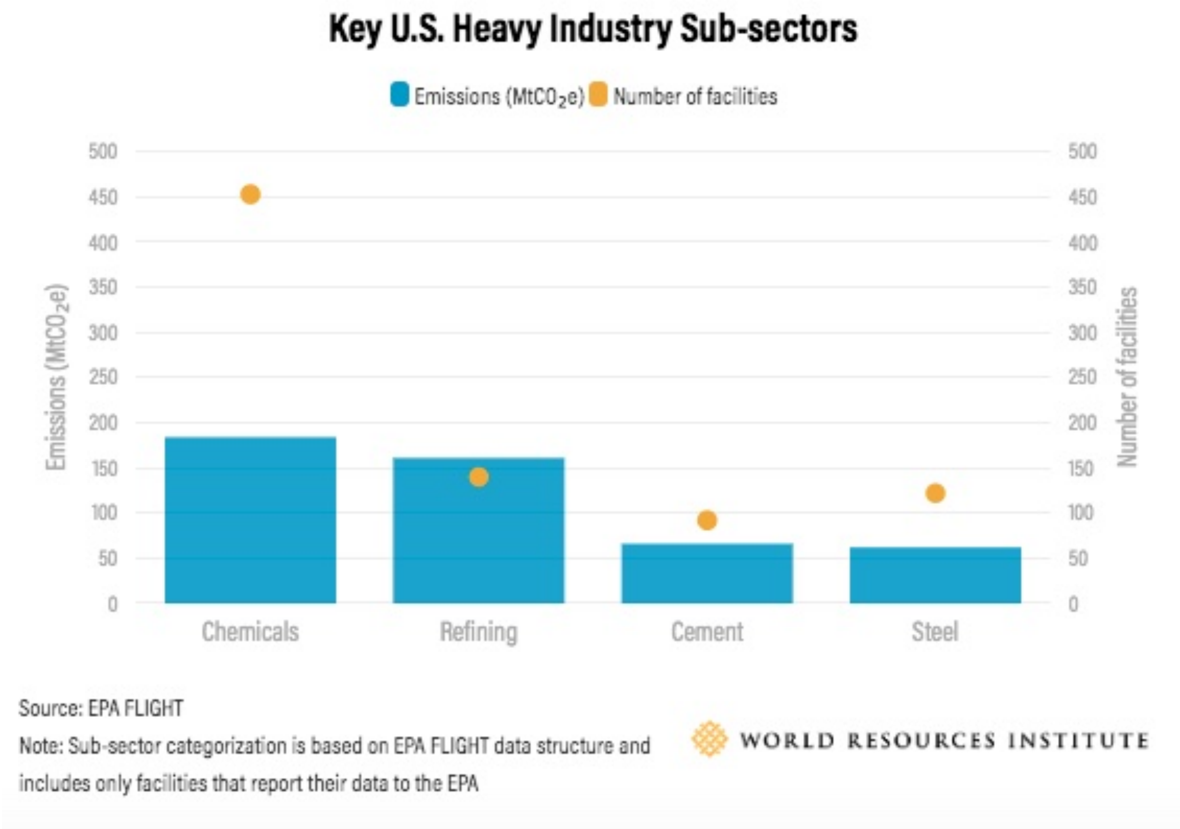


Image source: Anderson et al., 2021

Sub-sector relevance for national economy

The U.S. is a service economy, with the tertiary sector accounting for close to 80% of GDP. The secondary sector (manufacturing/industry) is responsible for less than a fifth of U.S. GDP (Statista Research Department, 2023). Within the manufacturing sector, chemical products account for the largest share (18%) of sectoral value added at 401.5 billion USD. Primary metals and fabricated metal products account for 59.5 bn. USD (3%) and 151.6 bn. USD (7%), respectively. Nonmetallic mineral products account for 67 bn USD (3%) sectoral value added (Statista Research Department, 2022). The US is the world's 3rd largest chemicals producer (after China and the EU – so, 2nd largest if EU is not counted) (Hadhri, 2023), the 4th largest producer of crude steel (after China, India and Japan) (*October 2022 crude steel production*, 2022), the 4th largest cement producer (after China, India and Vietnam) (Garside, 2023), and the 9th largest producer of aluminium (Garside, 2023b).

Transition phase

The US industry sector can be described as being at the cusp of exiting the lock-in phase and entering the destabilisation phase. Accordingly, there is still a strong need for policy support for niche technologies, while at the same time already levelling the playing field by changing taxation polices, demand creation and infrastructure build-up.

Current general national trends that promote or hinder decarbonization

Over the past few years, studies and surveys have indicated that climate denialism (i.e. the belief that the climate is not changing at all, or, that it is changing but humans are not responsible) is comparatively high in the US (as high as 18%, according to a comprehensive 2022 survey) (St. Fleur, 2015). The share of people who view climate change as a minor threat or no threat at all is also particularly high when compared to other countries (as high as 39%). Political affiliation is a major indicator for US Americans' views on climate change, more so than other factors such as religious affiliation, education or ethnicity. Democrats tend to be more concerned about the climate, with concerns rising over the past decade, while Republicans have remained much less concerned, widening the gap between the two parties' views on the topic. This is reflected in elected officials' stance on climate, the most prominent example being President Trump's withdrawal from the Paris Agreement and broad rollback on climate and energy regulation, and President Biden's recommitment to the Paris Agreement and push for more climate ambition. Even when Democrats held both chambers of Congress as well as the White House for the first two years of Biden's presidency, strong climate legislation was difficult to implement, leading, for example, to a major scale-back on climate action within the *Infrastructure Investment and Jobs Act* of 2021. Following the 2022 midterm elections, the split Congress will make legislative action on climate even more difficult. While it is unlikely that the Republican House Majority will be able to block the 2022 Inflation Reduction Act (IRA), the Biden Administration's signature climate law, they are expected to slow down its implementation. Any federal regulatory action implemented under the IRA will be vulnerable to reversal by potential future Republican Administrations. Climate change thus remains a highly partisan issue, often caught in the crossfires of the two-party system in a politically divided America, making future action on climate particularly uncertain (Fagan & Huang, 2019). In the US, it is important to take into account the state as well as the federal level. Ambitious action in a state like California, which by itself is the 5th largest economy in the world and might soon surpass Germany to take 4th place, can be very impactful. Among other steps, the state passed the California Global Warming Solutions Act in 2006, under which it has established a cap-and-trade system. Under the Trump Administration, state-level climate action was crucial to somewhat compensate for federal inaction (*Policies and action rating*, 2022). In many states, the legislature does not face the same issues of dividedness as in the federal government, considering that the majority of states governments are so-called trifectas (i.e. states in which one party holds the governorship as well as both chambers of the state legislature). In the 2022 midterm elections, voters flipped several state legislatures, increasing the number of Democratic trifectas, which could allow for ambitious implementation of federal climate legislation, even as the split Congress may prevent or slow down further federal action.

National sectoral mitigation drivers and barriers

Drivers

Structural context: high RE potential, RE fastest growing energy source in US; rich in natural resources, human, financial, and technological capital (Corb, 2022) (Broekhoff et al., 2021); good conditions for CCS: high concentration of industrial emissions with access to sequestration sites (Corb et al., 2022)

Paradigms/Discourses: green recovery/inflation reduction; USA as green technology leader, net-zero targets are becoming the norm for companies

Politics: Growing international dynamic towards decarbonising EIIs (COP bilateral agreement with EU)

Policies: 2050 net-zero goal (+ halving emissions by 2030); lots of state/regional/city level & company net-zero targets during Trump era (Corb, 2022); IRA as a paradigm shift: RE/H2/CCUS tax incentives, R&D investment, loans

Economy: demand for clean materials through Buy Clean Initative (public), First Movers Coalition (private); collaborations like the Industrial Innovation Initiative (*Industrial Innovation Initiative - Advancing industrial emissions reductions*, n.d.) bringing key industry actors and environmental groups together to identify policy needs

Technology: availability of deep decarbonisation technologies

Barriers & Challenges

Structural context: limited (local) availability of clean energy, lack of infrastructure, expected increase in demand for basic materials (for the transition to a net-zero economy) will put pressure on basic materials companies to grow faster and more cleanly than ever (Azevedo et al., 2022)

Paradigms/Discourses: Decade-long aversion to industrial policy, stronger than in almost any other advanced capitalist country (Gross, 2021); technologies incubated in the US have not historically created a thriving clean-tech manufacturing/export sector (companies having typically migrated to Europe or technologies like solar or EV batteries massively scaled up in China) (Corb et al., 2022)

Politics: carbon leakage prevention, protectionism, e.g. steel tariffs, “buy American” provisions in IRA

Policies: historically absence of ambitious climate policies ⍰ IRA paradigm shift but all-carrots-no-sticks approach may not be sufficient; CCUS incentives may lead to fossil lock-in; procurement criteria/building codes inhibit use of low-carbon materials like cement (Anderson et al., 2021) (Gross, 2021)

Economy: high investment and operational costs (when compared to conventional production technologies based on fossil fuels, which are still heavily subsidised – in the US and elsewhere (*Fossil Fuel Subsidies*, n.d.)), low demand for low-emission materials, long investment cycles, high trade exposure; very low natural gas prices in recent years; recent large capital investment in US chemical industry connected with processing shale gas ⍰ large scale, very efficient, long equipment lifetimes making low-carbon replacements in next few decades challenging (Cresko et al., 2022)

Technology: low TRL of clean production technologies

Current status of national-sectoral climate policy

Governance and Planning instruments

2022 DOE Industrial Decarbonization Roadmap (Cresko et al., 2022)

2021 Executive Order “Tackling the Climate Crisis at Home and Abroad”: “The executive order reaffirms the goal to achieve net zero GHG emissions by 2050, encourages a government-wide approach to tackle climate change, mandates the use of federal purchasing power, property and public lands and waters to support climate action, and establishes high-level interagency groups to facilitate coordination, planning and implementation of climate action at federal level” (*Policies and action rating*, 2022)

2021 Global arrangement on sustainable steel and aluminium, an arrangement between the United States and the European Union to establish collaborative pathways to support and deploy decarbonized steel and aluminium (*Fact Sheet: U.S. - EU Arrangements on Global Steel and Aluminium Excess Capacity and Carbon Intensity*, 2021) (Williams & Bell, 2022)

Economic instruments:

2021 Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability (Biden, 2021), accompanying **Federal Sustainability Plan** (*Federal Sustainability Plan*, n.d.), creating the **Federal Buy Clean Initiative**, which establishes preferential procurement of low-carbon materials (some states are pushing in this direction as well) (*Federal Buy Clean Initiative*, n.d.)

2021 Infrastructure Investment and Jobs Act: provides $8bn in federal funding for hydrogen hubs, which will spur fundamental infrastructure development connecting industry to green H2 projects (Tatarenko & Koch Blank, 2022); provides $500 million for industrial low-emissions demonstration projects in sectors like cement, iron and steel; includes provisions for industrial CCS (Anderson et al., 2021)

2022 Inflation Reduction Act (IRA): key climate law, see box below for more detail because of its size and significance

2022 CHIPS and Science Act: Main focus on semiconductor production, but also includes energy, climate and science provisions, including funding for DOE Office of Science to invest in research to advance the next generation of energy storage, solar, hydrogen, critical materials, fusion energy, manufacturing, carbon removal, and bioenergy technologies, among many other areas (*Chips and Science Act 2022*, n.d.). Authorizes a new DOE program on low-emissions steel manufacturing, focusing on several key technology areas including heat generation, carbon capture, smart manufacturing, resource efficiency, alternative materials, and high-performance computing (Ambrose et al., 2022).

<u>Regulatory and 'non-economic' instruments:</u>

Chemicals: HFC Phasedown under the 2020 American Innovation and Manufacturing (AIM) Act (EPA rules to reduce production & imports of HFCs by 85% until 2036) & subsequent ratification of the Kigali Amendment to the Montreal Protocol

<u>Educational, Informational, 'soft' instruments:</u>

EPA programs to make "companies and workers aware of the steps to reduce or prevent emissions leaks from equipment. EPA has a variety of voluntary programs that provide resources for training and other steps for reducing emissions. EPA supports programs for the aluminum, semiconductor, and magnesium industries" (*Sources of Greenhouse Gas Emissions*, 2022)

<u>Voluntary agreements:</u>

The US-led **First Movers Coalition** secures corporate purchasing commitments for low-carbon materials and technologies (*Fact Sheet: Biden-Harris Administration Advances Cleaner Industrial Sector to Reduce Emissions and Reinvigorate American Manufacturing, 2022*).

DOE voluntary certification schemes/ challenges: **Superior Energy Performance** (SEP) 50001 program (facilities implement an energy management system that meets the ISO 50001 standard and demonstrate improved energy performance) (*Superior Energy Performance*, n.d.); **Better Plants program** (manufacturers set energy, water, waste, and carbon reduction goals and commit to reducing energy intensity by 25%) (*Better Plants*, n.d.).

The Inflation Reduction Act

The Biden Administration's signature climate legislation injects **USD 369bn** in the form of tax credits, grants and loans into clean energy technologies. It is a toned-down version of the more ambitious USD 1.75tn "Build Back Better" bill, which stalled in the US Senate (Policies and action rating, 2022). The IRA is expected to:

- drive demand for low-carbon materials/construction and clean technologies
- spur innovation through R&D of clean technology and low-carbon materials
- create demand for low-carbon products in construction of federal buildings and transportation projects (*The Inflation Reduction Act and your business*, n.d.)

THE MECHANISM OF TAX CREDITS

Importantly, a lot of the tax credits under the IRA are **direct pay tax credits**, meaning that companies that are eligible for these tax credits can treat them as an overpayment of taxes and receive a **cash refund** from the Treasury Department if the credits exceed their tax liability (i.e. the sum of the tax credits received is larger than the amount of taxes owed in a given year). This is opposed to "traditional" tax credits that *exclude* the option of direct pay and thus can only reduce the amount of taxes owed. This distinction is relevant particularly for companies whose tax liability is simply not that large because they do not (yet) generate a lot of profits. Without the option of direct pay, these companies are reliant on the private sector for **tax equity financing**, paying a premium to pass the tax credits along to an investor large enough to realize them. If the demand from potential tax investors is low (e.g., because of a recession), small and medium-sized clean energy developers cannot realize the full savings from the tax credit, potentially making the project economically inviable and hence reducing the subsidy's overall effectiveness. Thus, the option of direct pay has the potential to **significantly boost clean energy projects** that are eligible for tax credits under different Sections of the IRA, as described below (Milko, 2021). It is also important to note that tax credits are **less vulnerable to political change**. Once policies are implemented in the tax code, they are less likely to be reversed by future administrations than, say, regulatory approaches.

ENHANCEMENT OF THE EPA LOAN PROGRAMS OFFICE

Apart from direct pay tax credits, a large portion of the IRA's climate finance will be issued in the form of loans from the EPA. The Agency's Loans Programs Office (LPO) receives $11.7 billion to support *issuing* new loans. The LPO's existing loan authority is increased by approximately $100 billion. This includes $40 billion in loans issued to eligible projects under the **Innovative Clean Energy Loan Guarantee Program**, $40 billion under the **Advanced Technology Vehicles Manufacturing Direct Loan Program** and $20 billion under the **Tribal Energy Loan Guarantee Program**. In addition to this, the IRA authorizes the LPO to issue $250 billion under the newly created **Energy Infrastructure Reinvestment Program**, Altogether, this adds up to a staggering $350 billion in additional loan authority for the LPO (*Inflation Reduction Act of 2022*, n.d.).

ACCESS TO CHEAP GREEN ELECTRICITY

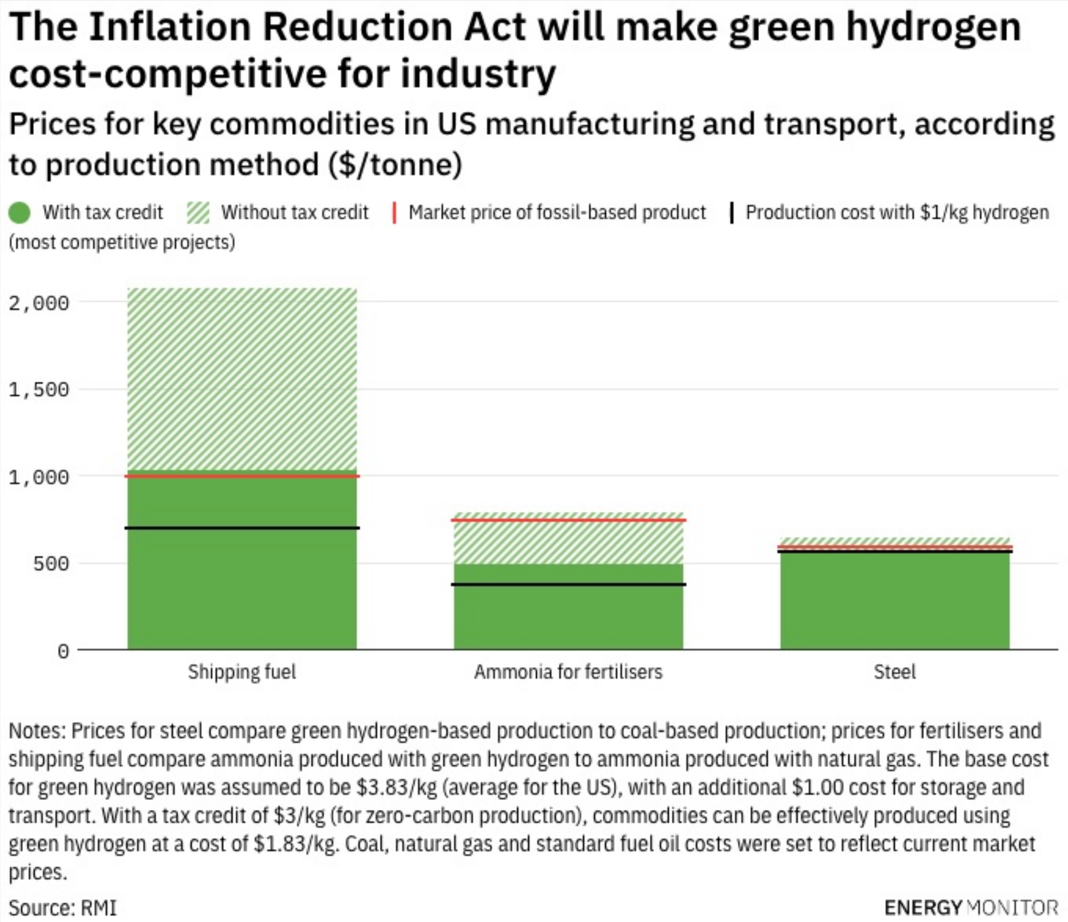
Through the abovementioned enhancement to EPA loan programs as well as different clean energy tax credits, the IRA will further decrease the cost of clean electricity while increasing its availability, thus driving down the cost of electrifying production processes in energy-intensive industries and running them on green electricity (*The Inflation Reduction Act, A big deal for green steel*, 2022).

The IRA modifies and expands the existing **Clean Electricity Production Tax Credit (PTC)** and **Clean Electricity Investment Tax Credit (ITC)** for 10 years, adding the option of **direct pay**. "The PTC is a tax credit primarily provided for the production of wind energy at a qualified facility for its first 10 years in operation. The ITC is a lump sum tax credit claimed by a solar producer or homeowner when a solar array becomes operational. Both credits are currently worth 26 percent of the total installation cost." (Yañez-Barnuevo, 2022)

Thanks to the IRA, producers of wind, solar and battery components are eligible for the **Advanced Manufacturing Tax Credit**. Only taxpayers producing components within the United States qualify. Clean energy producers are eligible to receive the **Section 48C Advanced Energy Project Investment Tax Credit** of up to 30% of investments for purchasing and commissioning property to build a manufacturing facility before 2025. Qualified facilities may choose to claim the investment tax credit in lieu of the Section 45X manufacturing tax credit. "The IRA includes adders for both of these credits if (i) 100% of any **steel or iron** that is a component of the facility was **produced in the United States**, and (ii) 40% of manufactured products that are components of the facility were produced in the United States. These domestic content adders will provide incentive for renewable energy project developers to buy equipment manufactured in the United States." (Atkin & Schurle, 2022)

ACCESS TO CHEAP GREEN HYDROGEN

The IRA also includes a **Green Hydrogen PTC.** "Under the new law, producers of green hydrogen made with renewable electricity will receive a **$3 credit for each kilogram** (kg) of the zero-carbon fuel they can supply for ten years after eligible facilities come online. The production tax credits bring green production of steel, fertilisers and shipping fuel to **cost competitiveness** with current fossil-based commodity prices. **Ammonia** for fertilisers, currently produced with natural gas at around $700 per tonne (/t), can be produced at $500/t with subsidised green hydrogen. **Steel**, produced today with coal at $590/t, can be produced at $560/t with subsidised green hydrogen. **Shipping fuel**, produced with ultra-low-sulphur fuel oil at $1,000/t, can be substituted with green hydrogen-derived ammonia produced at a similar cost with the subsidy. In regions with ideal renewable resources, where green hydrogen can be effectively produced at $1/kg with the tax incentives, green commodity costs will fall even further below fossil-based commodity prices. […] Green steel and green fertiliser will **maintain cost competitiveness** even if global fossil fuel markets were to revert to historical low prices." (Tatarenko & Koch Blank, 2022)



CCUS

The IRA subsidizes (industrial) CCUS by enhancing the existing **Carbon Oxide Sequestration Tax Credit** in a number of ways. Credit values are increased from previously $50 to $85 per ton of carbon captured and sequestered (CCS), and from $35 to $60 per ton of carbon captured and used (CCU). Smaller facilities now qualify for the credit as thresholds for their size are lowered from 100,000 to 12,500 tons of carbon captured per year. Owners of the carbon capture equipment can receive direct pay for the first 5 of the total 12-year duration of the tax credit. All CCUS projects that meet the criteria and commence construction before 2033 qualify (*Inflation Reduction Act of 2022*, 2022) (*The Inflation Reduction Act, A big deal for green steel*, 2022).

LOW-EMISSIONS PROCESS TECHNOLOGY FUNDING

The IRA provides $5.8 billion for a new DOE **Office of Clean Energy Demonstrations**, which will provide financial assistance through a new **Advanced Industrial Facilities Deployment (AID) Program** to key sectors like steel, aluminium and cement for the development and deployment of Advanced Industrial Technologies in the form of loans, cost shares, grants and cooperative agreements, used to cover up to 50% of the cost of deployment of new low-emissions industrial process technologies at eligible facilities (Policies and action rating, 2022) (*Steel Manufacturers Association Comments on the passage of the "Inflation Reduction Act"*, 2022) (*The Inflation Reduction Act Delivers Affordable Clean Energy for Virginia*, 2022) The AID Program will help companies reduce some of the initial risk by supporting early demonstrations at scale and encouraging them to work together in consortia. "Congress also directed the program to support the incorporation of sustainable chemistry and engineering practices and approaches that use materials and energy effectively, decrease health and environment impacts, reduce waste, and make recycling and reuse easier. And the program will fund improvements in the energy and materials efficiency of processes at a more holistic, broader scale, using smart manufacturing, information technology, and high-performance computing approaches." (Rightor, 2022)

LABELING FOR LOW-EMBODIED CARBON PRODUCTS

The IRA provides $100 million for the EPA to identify and label low-embodied carbon construction materials (Gabriel, 2022) (Rightor, 2022).

DEMAND SIDE: GREEN MATERIAL PROCUREMENT

The IRA "provides a boost for the **Federal Buy Clean Initiative** with $4.5 billion in funding for the General Services Administration, Department of Transportation, and Environmental Protection Agency to designate and use **construction materials and products** that produce substantially lower levels of greenhouse gas (GHG) emissions." (*FACT SHEET: Biden-Harris Administration Announces New Buy Clean Actions to Ensure American Manufacturing Leads in the 21st Century*, 2022) "Most notable is **Section 60503, Use of Low-Carbon Materials**. This program allocates a whopping $2.15 billion to construct or modify federal buildings with low-carbon materials. While the legislation does not go into detail about what these materials will be, our guess is that much of it will target embodied carbon from concrete and steel, especially given the size of most federal buildings." (Gabriel, 2022)

DEMAND SIDE: CONSUMER TAX CREDITS

The IRA includes several **consumer tax credits** for solar, energy-efficient appliances, heat pumps, building insulation and electric vehicles (EVs), which will lead to an increase in demand for the materials used in their manufacturing. This includes, for example, aluminium and nonferrous metals for solar panels and EV batteries as well as basic chemicals needed for thermal insulation, sealants, solar panels and plastics used in EVs. In addition to the materials needed for utility-scale solar, wind, energy storage, hydrogen electrolysers, advanced vehicles manufacturing, new or retrofitted industrial facilities and electrical, H2 and CO2 infrastructure, the overall increase in material demand triggered by the IRA will likely be quite significant. While there appear to be no provisions for green material use outside of public procurement, this type of broad demand stimulation is still worth mentioning. While it will pose a significant challenge for basic materials companies, it could also stimulate green growth (Guido et al., 2022) (Sampieri, 2022) (Greenwood, 2022).

GLOBAL SIGNIFICANCE AND INTERNATIONAL RESPONSE

Because of the significance of the US economy and the unprecedented wave of climate financing the IRA is set to unleash, the IRA's impact will reach far beyond US borders. It has the potential to advance innovation, scale key technologies and bring down their costs. While undeniably a win for the climate, the IRA has sparked a wave of criticism around the world. Among others, the EU and China have vocalized fear of unfair competition and potential flight of investment due to the "made in the USA" condition embedded in many of the tax credits. They see a violation of World Trade Organisation (WTO) treaties and have threatened to bring a case to the WTO. Experts have expressed concerns that the IRA's unilateral, protectionist approach will spark a costly subsidy race, pushing the world toward an "every man for himself" mentality and undermining global efforts to tackle climate change (*EU's Breton: EU will not remain passive on U.S. subsidies*, 2022) (Monceyron, 2022) (Wendt Jensen, 2022) (*Rethink rule-breaking Inflation Reduction Act: China daily editorial*, 2022). The EU Commission has since responded with their own Green Deal Industrial Plan, including among other things the proposed Net-Zero Industry Act *(The Net-Zero Industry Act: Accelerating the transition to climate neutrality, n. d.)*

Assessment of policy framework to advance the decarbonization of EIIs

This table assesses the extent to which the national policy framework exploits several policy functions that are relevant to the decarbonization of EIIs on a strong, medium, to weak scale.

Pillar	Policy Function	Exploitation of policy function
Policy Commitment & Pathways design	Clarity and guidance	→ medium exploitation + 2050 net-zero target, 2030 target (not in law) + 2022 DOE Industrial Decarbonization Roadmap + 2021 Executive Order "Tackling the Climate Crisis at Home and Abroad" + A lot of state-level action during Trump, big impact in the case of federal inaction, f.e. California Global Warming Solutions Act in 2006 + 2021 Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, accompanying Federal Sustainability Plan, creating the Federal Buy Clean Initiative (?) - no EII specific reduction targets - federal climate targets and ambition subject to political change
	Long term finance	→ high exploitation + high-scale public finance for decarbonisation (through IRA) + specific large-scale finance for innovation and deployment
Innovation, Demonstration & Deployment	Enhance public RD&D	→ high exploitation + large-scale finance for RD&D (through IRA AID program, also CHIPS Act) + 2022 Inflation Reduction Act: Advanced Industrial Facilities Deployment (AID) Program + specific subsidies for CCUS
	Accelerate early commercialisation, deployment	→ high exploitation + tax credits for implementation of clean technology making clean basic materials cost competitive + advanced industrial facilities deployment program specific to EIIs (2022 IRA: Advanced Industrial Facilities Deployment (AID) Program) + specific support for green hydrogen development
(Re)-shaping markets	Creation of demand	→ strong exploitation + funding for low carbon materials through Federal Buy Clean Initiative + private procurement through First Movers Coalition (FMC)
	Reshaping of existing markets	→ weak exploitation + subsidies and tax credits for clean electricity, green hydrogen - no federal level carbon price in sight to break incumbent markets, - high subsidies for fossil fuels - policy approach might lead to lock-in of CCUS, and continued reliance on fossil fuels
	Transparency and information	→ medium exploitation + 2022 Inflation Reduction Act: provides $100 million for the EPA to identify and label low-embodied carbon construction materials
Policy coherence and integration	Reducing of demand.	→ Weak exploitation: no specific measures identified
	Infrastructure & energy supply	→ strong exploitation + large scale financing and incentives for clean energy development and CCUS (through IRA) + voluntary energy certification programmes + public funding for infrastructure build–up (Infrastructure Investment and Jobs Act)
	International coherence	→ medium exploitation + strong engagement in international cooperation, incl. financing for technology measures + global arrangement on steel and aluminium trade + provides technology leadership through IRA - protectionist tendency, e.g. tariffs focused on competition - carbon leakage is not addressed
	Socio-economic implications	→ medium exploitation + recent measures under IRA can lead to regional growth + just transition provisions focused on coal regions in IRA - no specific policies to address just transition concerns for EII regions could be identified.
	Regulatory environment	→ medium exploitation

		+ stable regulatory environment + low regulatory hurdles - policy uncertainty due to political divide and history of change-of-direction in federal climate policy
Knowledge & Capacity	Public managerial & bureaucratic capacity	→ medium exploitation + general capacity present + specific programmes for training in place + IRA specifically funds capacity build-up in the EPA LPO - agencies can be subject to political influence - historical aversion to strong industrial policies
	Monitoring and evaluation	→ medium exploitation + GHG monitoring

How to strengthen national-sectoral climate policy

In order to strengthen its climate policy related to the industry sector, the United States may

- set sector-specific mitigation targets for industry
- rethink the "all carrots, no sticks" approach of the IRA and implement regulatory instruments where possible, which would also reduce the strain on the federal government's budget
- In the same vein, phase out fossil fuel subsidies incentivising the continued use of fossil fuels (e.g., with CCS, which is covered by IRA tax cuts)
- soften the IRA's protectionist approach and use its power to drive international industry decarbonisation by building up more international partnerships (e.g., through emissions-focused trade agreements (such as GASA), green procurement alignment, and the Industrial Deep Decarbonisation Initiative) (Williams & Bell, Auburn, 2022).
- create "acceptance, and even demand, for low-carbon industrial products throughout the supply chain […] [through] education, changes to industry standards, procurement policies, financial incentives and low-carbon product standards" (Anderson et al., 2021)
- develop policies to address just transition concerns: "Decarbonization will require policymakers to provide adequate time frames for industrial transition and ensure that workers and community advocates are represented early and throughout all stages of policy development and implementation. A fair and equitable process will also require the implementation of new investments and technologies to support new and existing workforces. Where gaps remain, governments should ensure social safety nets, such as unemployment insurance and worker training programs, and provide direct support for any dislocated worker" (Williams & Bell, Auburn, 2022).
- develop policies specifically targeted at heavy industry transition and "focus significant investments on direct support, such as grants, for existing steel and cement production facilities to integrate deep decarbonization technologies and processes […] [and] toward deploying innovative technologies" (Williams & Bell, Auburn, 2022); this includes directing IRA investments from the DOE Office of Clean Energy Demonstrations towards heavy industry and exploring the option of tax credits for clean steel and cement (ibid.)
- "prevent greenwashing by ensuring that investments are targeted toward full decarbonization and not used to perpetually sustain fossil fuel production using gray hydrogen. Marginal efficiency improvements do not constitute meaningful progress toward full decarbonization, nor do vague promises of eventual partial carbon capture" (Williams & Bell, Auburn, 2022).
- develop and implement material efficiency, circular economy and behavioural change policies to reduce demand for basic materials
- update and improve energy efficiency standards (can be done at federal level without requiring new legislation) (*Policies and action rating*, 2022)
- formulate more ambitious decarbonisation policies at state level, reaping the benefits in the IRA (ibid.)

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