STUDY

Towards a Greener Industry Sector

Existing and Potential Approaches to Decarbonisation in Germany and New Zealand

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Disclaimer

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The contents reflect solely the findings and opinions of the authors and do not represent the position of the client or other members and stakeholders of Germany's climate and energy partnerships.

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Abbreviations

BF-BOF	Blast furnace – basic oxygen furnace
CO_2e	Carbon Dioxide Equivalents
CCC	Climate Change Commission [New Zealand]
CCU	Carbon Capture and Utilisation
CEEAG	Guidelines on State aid for climate, environmental protection and energy [EU]
CERF	Climate Emergency Response Fund [New Zealand]
CHP	Combined Heat and Power
CSRD	Corporate Sustainability Reporting Directive [EU]
DRI-EAF	Direct reduction of iron – electric arc furnace
EECA	Energy Efficiency and Conservation Authority [New Zealand]
EEE	Energy and Resource Efficiency in the Economy [EU]
ERF	Energy Reuse Factor
ERP	Emission Reduction Plan [New Zealand]
ESRS	European Sustainability Reporting Standard
ETS	Emissions Trading System
EU	European Union
FEC	Final Energy Consumption
GB	Gigabytes
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIDI	Government Investment in Decarbonising Industry Fund [New Zealand]
GW	Gigawatt
H_2	Hydrogen
HFC	Hydrofluorocarbon
ICT	Information and Communication Technology
IEEN	Initiative for Energy Efficiency Networks
IEEKN	Initiative for Energy Efficiency and Climate Action Networks
IHP	Industrial Heat Pumps
IPCEI	Important Projects of Common European Interest
IMF	International Monetary Fund
IPPUs	Industrial Processes and Product Uses
Kt	Kilotonne
kWh	Kilowatt-hours
LPG	Liquefied Petroleum Gas
MBIE	Ministry of Business, Innovation and Employment [New Zealand]
MEPL	Mandatory Energy Performance Labelling
MEPS	Minimum Energy Performance Standards
Mt	Megatonnes
MW	Megawatt
NAPE	National Action Plan on Energy Efficiency [Germany]
NHS	National Hydrogen Strategy [Germany]
NZAS	New Zealand Aluminium Smelter
NZEECS	NZ Energy Efficiency and Conservation Strategy
NZS	New Zealand Steel
PEC	Primary Energy Consumption
PJ	Petajoules
TWh	Terawatt-hours
UBA	Umweltbundesamt [Germany]
WTO	World Trade Organisation

1 Introduction

The decarbonisation of the industry sector is crucial to the achievement of national climate targets and hence of the Paris climate goal more broadly. Germany seeks to reach carbon neutrality in 2045, New Zealand in 2050. In Germany, the industry sector accounted for 22% of its total emissions in 2022, in New Zealand the industry sector was responsible for 12.25% of total emissions in the same year. This study aims to identify the key levers for accelerating industrial decarbonisation efforts in both countries. For this, it considers the composition of Germany's and New Zealand's respective industry sectors, taking into account country-specific challenges and identifying which measures have already been implemented. Since the regulatory and subsidy environment creates the framework within which companies operate and oftentimes determines the feasibility of technological reform processes, this study also compares policy initiatives targeted at or at least relevant to the decarbonisation of the industry sector. Based on this investigation, the study concludes with recommendations for collaboration activities between Germany and New Zealand to enable knowledge sharing and the joint implementation of solutions.

Germany and New Zealand are both prosperous countries with GDPs per capita of 67,000 EUR and 53,000 EUR, respectively. While in both countries the services sector is the largest contributor to their economy, the industry sector comes second. This means that future-proofing this sector by aligning it with the requirements set by the countries decarbonisation goals is not only relevant in terms of emissions but also with regards to the countries' prosperity and social stability. Consequently, businesses in both countries across sub-sectors are looking for new and innovative ways of production and increasing energy efficiency.

The definition of "industry" is not straightforward and a variety of understandings exist, differing in terms of scope. In this study, the term "industry / industrial sector" is used in the commonly understood sense of the manufacturing of goods. Furthermore, chapter 2 and 3 specifically look at the sub sectors that are responsible for the largest shares of emissions.[1] In Germany, the two largest contributors to emissions in this sector are metal production and processing (28%) as well as chemical and petroleum product manufacturing (28%). Together, these account for 56% of emissions in the industry sector. Meanwhile, in New Zealand food, beverage, and tobacco product manufacturing contributes 28% of industry emissions, followed by metal production and processing (24%) and chemical, petroleum, polymer, and rubber product manufacturing (14%). Since both countries have already implemented various measures for reducing emissions in these sectors, including for instance energy efficiency improvements, the remaining required actions differ and are also influenced by country-specific circumstances, such as the degree of electrification in the industrial sector and the composition of the power grid, the latter being much more renewables-based in New Zealand than in Germany. However, some overlapping approaches include the roll-out of heat pumps, stronger efforts to increase energy efficiency, the ramp-up of green hydrogen, and increased resource efficiency through a switch towards circularity. Moreover, the examination of the policy environment shows that both countries have seen varying levels of success through the implementation of an Emission Trading System (ETS), with Germany achieving far greater emission reductions, and several regulations, particularly in the field of energy efficiency. Both the ETS and regulations are dynamic issues that will require continued attention and adaptations in both countries.

Based on this, this study would like to recommend the following cooperation activities, which will be further elaborated on in chapter 5:

Exchange knowledge on the roll-out of heat pumps and share best practices with regards to Energy Service Companies (ESCOs) in the **Dairy Industry**.

Given the importance of the dairy exporting industry especially in New Zealand, the decarbonisation of the industry even beyond its biogenic emissions is a central challenge to wider industrial

[1] Kirchner, Almut; Piégsa, Alexander, "Emissionsreduktion in der Grundstoffindustrie," 2023, https://www.prognos.com/de/projekt/emissionsreduktion-grundstoffindustrie.

decarbonisation. We therefore suggest bilateral workshops allowing for exchange on the potential application of large-scale heat pumps to decarbonise the industry's energy supply and on the proliferation of Energy Service Companies (ESCOs). The workshops should profit from the inputs of the most recent research and innovative companies from the sector.

Establish sectoral dialogues on the usage of green hydrogen, particularly in the **Steel and Chemical Industries**.

While the sizes of the steel and chemical industries in both countries differ greatly, steel and chemicals production are significant contributors to both countries' emissions. Aside from direct electrification measures, the use of green hydrogen will be central to these industries' decarbonisation. In order to allow for a structured exchange on the build-up of the required supply chains and infrastructure, we suggest the establishment of sectoral dialogues to connect policy makers, industry and academic actors.

Host a workshop to share the concept of **Energy Efficiency and Climate Protection Networks** as successful and business-driven initiative to lower emissions.

With global instability regarding fuel prices and supplies, saving energy and money through energy efficiency has become a central theme in many countries. In an initiative taken by government and business actors, Germany has established the concept of Energy Efficiency Networks in 2014. The initiative, now called called Initiative on Energy Efficiency and Climate Protection Networks (IEEKN), connects companies willing to profit from each other's knowledge on saving energy. Such a business-driven pragmatic approach might be interesting for New Zealand businesses as well. We therefore suggest a workshop format, in which the idea of the IEEKN is presented to interested stakeholders and the process of implementing a similar initiative could be kicked off.

Establish a regular **Policy Dialogue** on new and existing regulations and funding mechanisms for industrial decarbonisation.

The establishment of a regular policy dialogue could benefit both side's understanding of the respective funding and regulatory measures taken to propel industrial decarbonisation. The sharing of experiences and knowledge of novel instruments such as Germany's Carbon Contracts for Difference (CCfDs) as well as on how to increase the efficiency of existing measures like Emissions Trading Systems could further highlight of the most efficient ways to cut emissions. With Germany being embedded in the EU's political institutions, exchanging on relevant topics could benefit New Zealand's knowledge of processes on other EU countries as well.

Exchange on cutting emissions, saving money and ressources and increase resilience through the implementation of **Circular Economic Measures**.

Another possibility for saving energy, emissions and costs pertains to implementing measures from the field of circularity, as studies have shown. We suggest the organisation of a workshop on the current status of a circular economy in both countries, shining light on the political environment and regulatory framework, most recent research, and initiatives undertaken by innovative companies.

2 Industry Composition in Germany

The German economy is the largest in Europe and a major contributor to the global economy. The country has a highly diversified industrial base and is one of the world's leading exporters of goods and services. The industry composition in Germany is characterised by a mix of traditional manufacturing, modern high-tech industries, and an increasing emphasis on the service sector.

2.1 Overview of Germany's Economy

Among the largest economies globally, Germany ranks third, falling behind only the United States and China with a gross domestic product (GDP) exceeding 4 trillion EUR. From 2016 to 2023, Germany's GDP grew from 3.1 trillion EUR to over 4 trillion EUR (see **Fehler! Verweisquelle konnte nicht gefunden werden.**), showcasing steady expansion.[2] Recent crises such as the Covid-19 pandemic and the war in Ukraine with its impact on the global economy, however, slowed down this trend. For 2024, the Institute for the World Economy in Kiel forecasts a growth of merely 0.5%.[3] The driving forces behind Germany's economic growth have been predominantly its exports and the level of domestic consumption. According to the World Trade Organisation (WTO), overall exports exceeded 1.3 trillion EUR[4] in 2021. At the same time, low unemployment rates and increasing wages fostered domestic consumption.[5] [6]

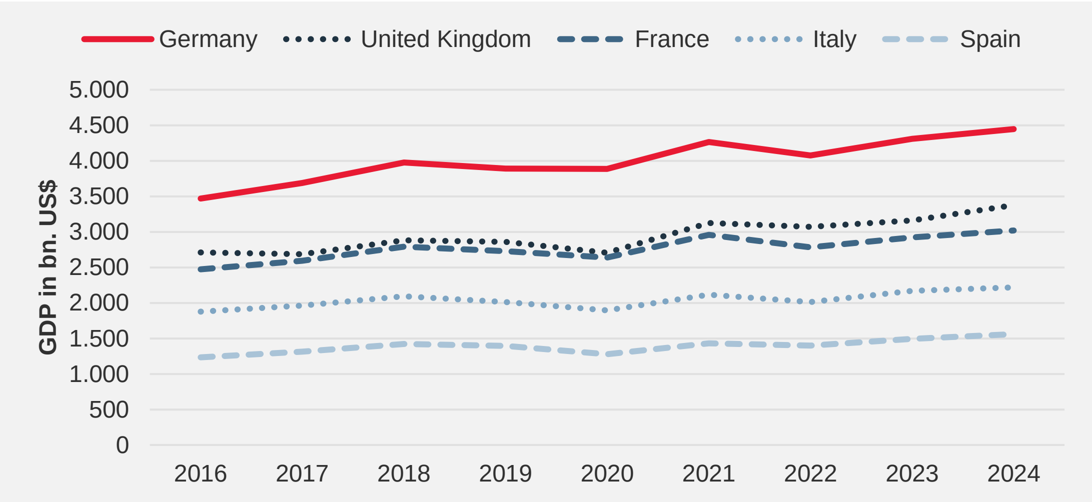

Figure 1: *Economic Development of Selected Economies (2016-2024f.)7*

The Covid-19 pandemic brought significant challenges for Germany's economy, as global trade came to a halt in 2020. In the second quarter of 2020, Germany experienced a sharp decline in economic output, with a contraction of 10.1%. Compared to the same period in the previous year, Germany's GDP shrank by 3.4%. Despite these setbacks, the German economy began recovering in the third year of the pandemic, despite additional challenges such as the war in Ukraine and the energy crisis.[8]

[2] Statistisches Bundesamt, "Volkswirtschaftliche Gesamtrechnungen," 2024, https://www.destatis.de/DE/Themen/Wirtschaft/Volkswirtschaftliche-Gesamtrechnungen-Inlandsprodukt/Tabellen/bip-bubbles.html.

[3] Handelsblatt, "IWF Erwartet Nur 0,5 Prozent Wachstum Für Deutschland," 2024, https://www.handelsblatt.com/politik/konjunktur/deutsche-wirtschaft-2024-iwf-erwartet-nur-05-prozent-wachstum/100009708.html.

[4] Exchange rate : US$ 1 = € 0.9138 (as of 11th March 2024)

[5] WTO, "WTO Stats," 2023, https://stats.wto.org.

[6] KPMG, "Economic Key Facts Germany - as of May 2023," 2023, https://kpmg.com/de/en/home/insights/overview/economic-key-facts-germany.html.

[7] International Monetary Fund (IMF), "World Economic Outlook Database," 2023.

[8] Federal Statistical Office, "Economic Impacts - Statistics Related to Covid-19," 2023, https://www.destatis.de/EN/Themes/Cross-Section/Corona/Economy/context-economy.html.

However, the sharp rise in interest rates and the ongoing reduction in high stock levels in the wake of supply chain disruptions continue to weigh on the industrial economic growth, meaning that low growth rates at best can be expected for 2024.[9]

In its Federal Climate Protection Act and Climate Protection Programme, the German Federal Government has set ambitious goals for reducing greenhouse gas emissions, targeting an 88% reduction by 2040 and achieving neutrality by 2045. This commitment requires significant changes in the industry sector, which is a major contributor to emissions.[10]

Over the next decades, the German industry sector will face the unprecedented challenge of transforming to climate neutral operations by 2045 while retaining industrial operations and global competitiveness. The German Federation of Industry estimates the economy-wide investment necessary to reach the 2030 reduction target to be at 860 billion EUR in total or 2,5% of GDP annually. The industry sector has to invest heavily in reducing fossil fuels as material input, efficient processes, renewable heating and new facilities for steel, cement, and the chemical industries.[11]

2.1.1 Overview of Germany’s Economic Sectors

Despite it being renowned for its manufacturing, Germany’s economy can be described as service-centric. Accounting for almost 70% of the country’s GDP, the services sector is the largest sector in Germany, amounting to 2,431 billion EUR in 2022 (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). This includes, among others, public services, education, the health sector, trade (wholesale and retail), and business services. Following the services sector, the industry sector makes up the second largest sector in Germany, accounting for 24% of GDP or 842 billion EUR. The prominence of the industry sector is underpinned by Germany’s position as a global leader in automobile, industrial equipment, and chemical products manufacturing. The construction sector contributes to 6% of GDP, amounting to 201 billion EUR. Finally, the primary sector, consisting of agriculture, forestry, and fishery, contributes a mere 1% or 36 billion EUR to Germany’s GDP.[12]

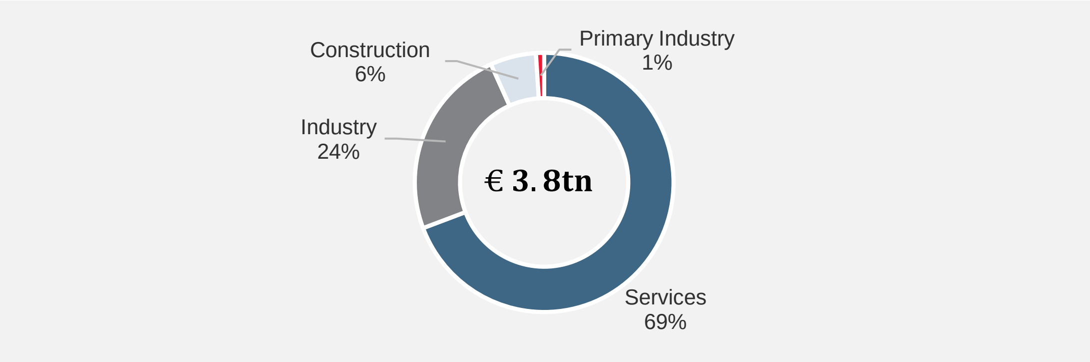

Figure 2: *Composition of Germany’s Economy (2022).13*

2.1.2 Distribution and Development of Emissions in the German Economy

Germany, as the major economy in Europe, carries substantial weight regarding the continent's carbon footprint. According to data from 2021, Germany’s emissions topped those of its European counterparts, producing 750 Megatonnes of CO_2 equivalents (Mt CO_2e). This ranks Germany as the country with the 11th highest greenhouse gas emissions in the world.[14] Emissions are lower in international comparison

[9] Bundesministerium für Wirtschaft und Klimaschutz, “Konjunktur und Wachstum,” 2024, https://www.bmwk.de/Redaktion/DE/Dossier/konjunktur-und-wachstum.html.

[10] Bundesregierung, “Klimaschutzgesetz: Klimaneutralität Bis 2045,” 2022, https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/klimaschutzgesetz-2021-1913672?view=renderNewsletterHtml#.

[11] Bundesverband der Deutschen Industrie, “Klimapfade 2.0: Klima-Studie zur Klimaneutralität in Deutschland bis 2045 | BDI,” BDI, September 22, 2022, https://bdi.eu/themenfelder/energie-und-klima/klimapfade.

[12] Statistisches Bundesamt, “Volkswirtschaftliche Gesamtrechnungen.”

[13] Statistisches Bundesamt, “Volkswirtschaftliche Gesamtrechnungen, Inlandsprodukt,” Statistisches Bundesamt, 2023, https://www.destatis.de/DE/Themen/Wirtschaft/Volkswirtschaftliche-Gesamtrechnungen-Inlandsprodukt/_inhalt.html.

[14] European Commission, “EDGAR - Emissions Database for Global Atmospheric Research,” 2022, https://edgar.jrc.ec.europa.eu/dataset_ghg70.

when looked at on a per capita basis. In this case, Germany's emissions are the 43rd highest globally, with 9.49 tonnes of CO_2e per person in 2022.[15]

In 2022, Germany emitted 743 Mt CO_2e[16], with varying contributions from different sectors. The majority of emissions are attributed to the energy sector, followed by industry and transport (see **Fehler! Verweisquelle konnte nicht gefunden werden.**), highlighting the fossil-intensity of each sector.[17] The buildings and agriculture sectors contributed 15% and 8% of emissions respectively, with the former arising mainly from energy consumption in properties, and the latter from agricultural practices like enteric fermentation in livestock and fertilizer management. The waste sector accounted for 1% of emissions, reflecting emissions from waste management and disposal.[18]

In 2022, Germany witnessed a 2.7% reduction in greenhouse gas emissions compared to 2021.This performance is part of a longer-term trend: comparing the greenhouse gas emissions of 2022 with those in 1990, when emissions stood at 1,287 Mt CO_2e, Germany has achieved a reduction of over 40%.[19]

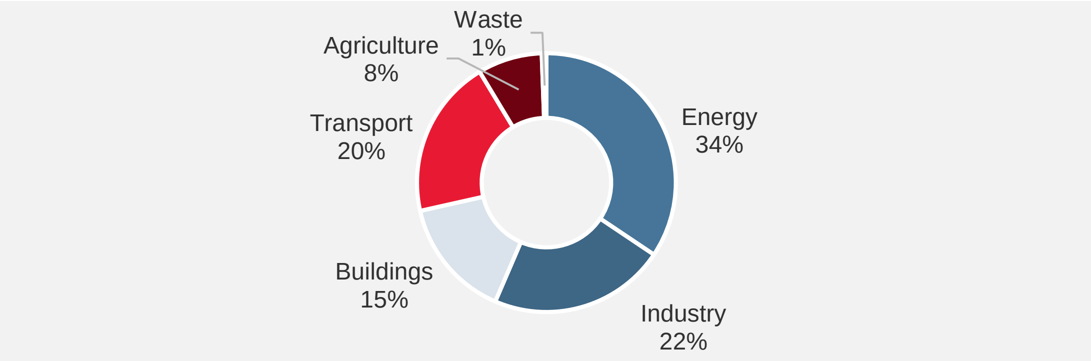

Figure 3: *Carbon Dioxide Equivalent Emissions by Sectors (2022).*[20]

2.2 Distribution of Emissions in the Industry Sector

In 2022, the industry sector was the second-largest emitter in Germany, accounting for 22% of total emissions, just behind the energy sector.[21] Since 1990, this sector has reduced its emissions by 41%.[22] By comparison, emissions from all sectors in Germany except industry, including energy production, transportation, and households, dropped by approximately 40% over the same period. This shows that reductions in industrial emissions are generally in line with overall emissions reductions.[23]

Simultaneously, the industrial sector's gross value added increased by about 37% between 1995 and 2019 when adjusted for price development. This progress can be attributed to several factors, including enhanced efficiency of production processes and the manufacturing of higher quality, resource-efficient

[15] European Commission, "EDGAR - Emissions Database for Global Atmospheric Research," 2023, https://edgar.jrc.ec.europa.eu/dataset_ghg70.

[16] Including Land use, land-use change, and forestry (LULUCF)

[17] Umweltbundesamt, "Emissionsübersichten KSG-Sektoren 1990-2022," 2023, https://www.umweltbundesamt.de/themen/klima-energie/treibhausgas-emissionen.

[18] Umweltbundesamt, "Emissionsübersichten KSG-Sektoren 1990-2022," 2023, https://www.umweltbundesamt.de/themen/klima-energie/treibhausgas-emissionen.

[19] Umweltbundesamt.

[20] Umweltbundesamt.

[21] Umweltbundesamt.

[22] Umweltbundesamt, "Indikator: Emission von Treibhausgasen," Text, Umweltbundesamt (Umweltbundesamt, 2023), https://www.umweltbundesamt.de/daten/umweltindikatoren/indikator-emission-von-treibhausgasen.

[23] Umweltbundesamt.

products. Additionally, a significant shift towards electricity-based production processes has been observed such as an outsourcing of emission-intensive processes to other countries. [24] [25]

Within the industry sector, the chemical and petroleum products sector and the metal production and processing sector are the largest emitters, followed by the non-metallic product manufacturing sector[26], referred to as the cement and lime industry throughout this study (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). The following subchapters provide a detailed breakdown of these sectors within the German industry sector.

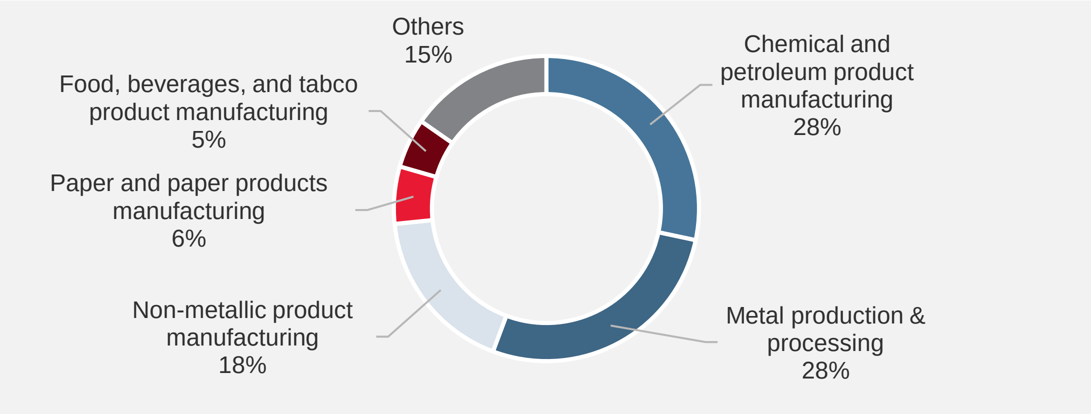

Figure 4: *Emission-Breakdown in the Industry Sector (2021).[27]*

2.2.1 Steel and Metal Production and Processing Sector

The industry sector plays a significant role in addressing global climate change. In the German context, facilities involved in metal production and processing contribute considerably to GHG-emissions, resulting in significant environmental impacts throughout the value chain. In 2021, the German metal industry emitted 60.2 Mt CO_2e, representing 28% of total emissions from the industry sector. This industry includes key sectors such as iron and steel production, non-ferrous metal extraction, foundry industry, and the wider metal processing industry.[28]

Among these sub-sectors, iron and steel production is the largest contributor to emissions, representing over 90% of total CO_2e emissions in the metal industry.[29] As the leading steel producer in Europe and the seventh largest globally, Germany produced approximately 40 Mt of crude steel in 2019. Steel production is very carbon-intensive due to the dominance of primary production methods,[30] which contribute to around 70% of total production. Furthermore, significant emissions stem from the use of fossil fuel-generated electricity, enhancing the overall climate impact of the sector.[31] [32]

Steel's unique properties make it indispensable across various industries, positioning the steel sector as central to achieving a climate-neutral economy. Decarbonising this industry is vital yet complex,

[24] Umweltbundesamt, "Indikator: Treibhausgas-Emissionen der Industrie," Text, Umweltbundesamt (Umweltbundesamt, 2022), https://www.umweltbundesamt.de/daten/umweltindikatoren/indikator-treibhausgas-emissionen-der-industrie.

[25] Deutsche Gesellschaft für Auswärtige Politik, "Carbon Leakage in Zeiten Der Energiekrise | DGAP," 2023, https://dgap.org/de/forschung/publikationen/carbon-leakage-zeiten-der-energiekrise. Deutsche Gesellschaft für Auswärtige Politik.

[26] Includes the production of cement, lime, glass, and ceramics

[27] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Anthropogene Luftemissionen," Statistisches Bundesamt, 2023, https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/energiefluesse-emissionen/_inhalt.html.

[28] Statistisches Bundesamt.

[29] Statistisches Bundesamt.

[30] The typical process for primary steel production involves a blast furnace and a basic oxygen furnace (BF-BOF), primarily using coke as an energy source, leading to high emission intensity.

[31] World Steel Association, "Steel Statistical Year Book 2020," 2020, https://worldsteel.org/wp-content/uploads/Steel-Statistical-Yearbook-2020-concise-version.pdf.

[32] Carina Harpprecht et al., "Decarbonization Scenarios for the Iron and Steel Industry in Context of a Sectoral Carbon Budget: Germany as a Case Study," *Journal of Cleaner Production* 380 (December 20, 2022): 134846, https://doi.org/10.1016/j.jclepro.2022.134846.

requiring major shifts in production techniques and energy sources, along with efforts in efficiency, material use, recycling improvements, and CO_2-management.[33] [34]

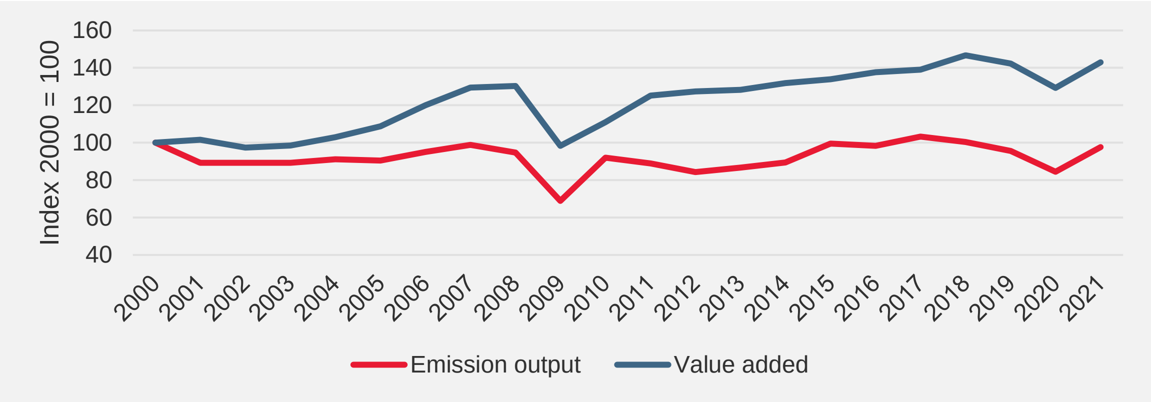

Figure 5: *Standardized Development of Emissions with Respect to the Value Added in the Metal Production and Processing Sector (Index level 2000 = 100).*[35] [36] [37]

Since 1990, the energy consumption required to produce a tonne of steel in Germany has been reduced significantly. Additionally, as can be seen in **Fehler! Verweisquelle konnte nicht gefunden werden.**, e missions output and value added in the sector have diverged over time, with the emissions output generally on a downward trend while the value added either remained stable or increased. This suggests advancements in the sector's efficiency. These successes were not only achieved on the integrated route, also known as the blast furnace route, but also through the electric arc furnace route. A major development that contributed to this reduction was the introduction of the ladle furnace, which allows the electric arc furnace to fully utilise its installed power for scrap melting, relieving it from metallurgical tasks. On average, this technological shift has resulted in a decrease in energy consumption by approximately 45% per tonne of steel over the last 40 years. As for the integrated route, by injecting hydrogen instead of pulverized coal, part of the carbon reduction agent can be replaced with hydrogen, potentially reducing emissions by up to a technical maximum of 20%[38] CO_2 emissions per tonne of steel produced today are about a fifth less than they were 20 years ago.[39] However, it is important to note that we have now reached the limits of emission reduction using established production methods. To further reduce the CO_2 emissions of steel production, companies in Germany are actively working on the implementation of alternative, low-CO_2 processes, including the use of green hydrogen.[40] Such a radical shift in the production method of steel manufacturing presents substantial economic challenges for the steel industry. These challenges are tied to the need for fundamental changes in the political framework conditions, which are highlighted in Chapter 4.

[33] Kompetenzzentrum Klimaschutz in energieintensiven Industrien (KEI), "Stahlindustrie | Auf dem Weg zur klimaneutralen Industrie," 2022, https://www.klimaschutz-industrie.de/themen/branchen/stahlindustrie/.

[34] Max-Planck-Gesellschaft, "Eiserner Klimaschutz," 2019, https://www.mpg.de/14112208/metallindustrie-nachhaltig-co2-neutral.

[35] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Anthropogene Luftemissionen."

[36] Statistisches Bundesamt, "Volkswirtschaftliche Gesamtrechnungen."

[37] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Energiegesamtrechnung - 2000 bis 2020," Statistisches Bundesamt, 2023, https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/energiefluesse-emissionen/Publikationen/Downloads/umweltnutzung-und-wirtschaft-energie-pdf-5850014.html.

[38] Wirtschaftsvereinigung Stahl, "Stahl und Stahlproduktion," *Wirtschaftsvereinigung Stahl | Informationen des Verbandes der stahlerzeugenden Unternehmen in Deutschland* (blog), August 18, 2020, https://www.stahl-online.de/startseite/stahl-in-deutschland/stahl-und-stahlproduktion/.

[39] Wirtschaftsvereinigung Stahl, "Fakten Zur Stahlindustrie in Deutschland 2021," 2021, https://www.stahl-online.de/wp-content/uploads/WV-Stahl_Fakten-2021_RZ_Web_neu.pdf.

[40] Bundesverband der Energie- und Wasserwirtschaft, "Wasserstoff statt Kohle: Wie wird Stahl grün?," 2020, https://www.bdew.de/verband/magazin-2050/wasserstoff-statt-kohle-der-stahl-der-zukunft-ist-klimafreundlich/.

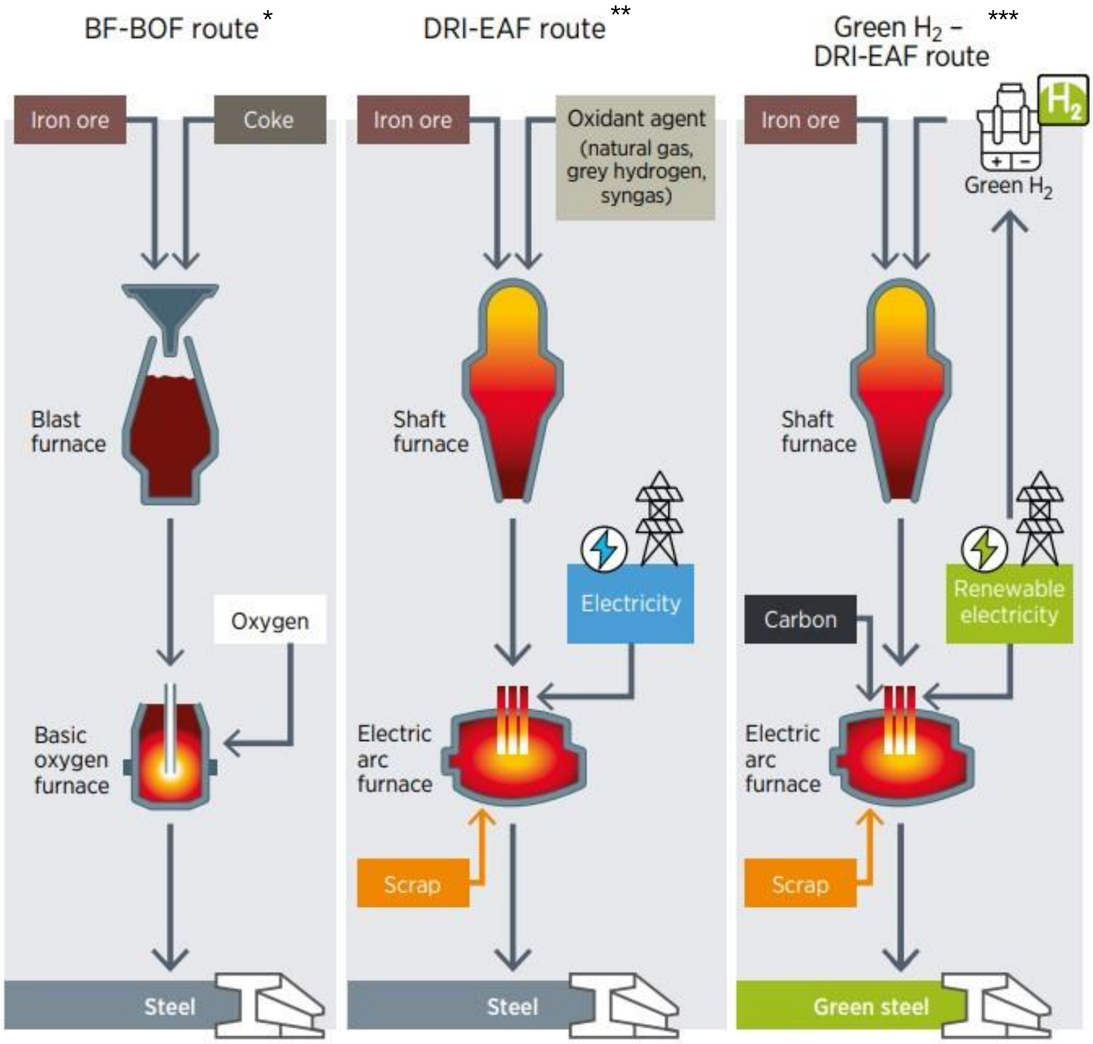

Figure 6: *Main Steel Production Routes*[41] *(IRENA 2022).*

* Blast furnace – basic oxygen furnace

** Direct reduction of iron – electric arc furnace

*** Green hydrogen – direct reduction of iron – electric arc furnace

2.2.2 Cement and Lime Manufacturing Sector

In 2021, the German cement industry was responsible for approximately 20.5 Mt CO_2e.[42] These emissions mainly result from the production of cement clinker. Roughly two-thirds of these emissions are caused by the release of CO_2 from the raw materials used, while one-third results from the combustion of fuels. The most significant portion of raw material-related emissions arises from the calcination of limestone at a temperature of about 850°C.[43] As these process emissions cannot be

[41] IRENA, "Green hydrogen for industry: A guide to policy making," 2022, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_Green_Hydrogen_Industry_2022.pdf.

[42] Deutsche Emissionshandelsstelle (DEHSt), "Treibhausgasemissionen 2021 Emissionshandelspflichtige Stationäre Anlagen Und Luftverkehr in Deutschland (VET-Bericht 2021)," 2022, https://www.dehst.de/DE/Europaeischer-Emissionshandel/EU-Emissionshandel-verstehen/Auswertungen-VET-Berichte/auswertungen-vet-berichte_node.html.

[43] Umweltbundesamt, "Dekarbonisierung Der Zementindustrie," 2020, https://www.umweltbundesamt.de/sites/default/files/medien/376/dokumente/factsheet_zementindustrie.pdf.

directly mitigated with currently available technologies, they represent the greatest challenge for the cement industry in its pursuit of climate neutrality.[44]

The cement industry predominantly relies on thermal energy, accounting for approximately 96% of the total energy consumption. The thermal energy is mainly required for the operation of rotary kilns for the production of clinker, an intermediate product, and for the drying of raw material in the raw mill (Integrated Cement Plants). About 66% of the thermal energy consumption is fulfilled using alternative fuels such as used tires, waste oil, animal meal, and plastic waste. The use of natural gas and oil, on the other hand, is rather minimal. Coal, including lignite, hard coal, and petroleum coke, serves as the second-largest energy carrier for the generation of thermal energy. In terms of electricity, integrated cement plants have a relatively low demand compared to thermal energy during cement production. Nevertheless, the manufacture of one tonne of cement requires an average of approximately 110 kWh.[45] [46]

Energy consumption in the lime industry is predominantly attributed to lime burning, with coal being the main fuel source. A significant 75% of the industry's total energy consumption is traced back to brown coal (lignite) at 59%, and hard coal (anthracite) and coke at 16%. Notably, a large proportion of these fuels are utilised not only for energy but also materially in the furnaces. The role of electrical energy in the lime industry is rather subordinate, accounting for a mere 8% of the total energy consumption. This highlights the industry's heavy reliance on thermal sources, particularly coal-based ones, for its major processes such as lime burning. Despite the relatively minimal use of electricity, it remains an integral part of the industry's overall energy mix. The low percentage is also indicative of the industry's efficiency measures or operational strategies that prioritise thermal energy.[47]

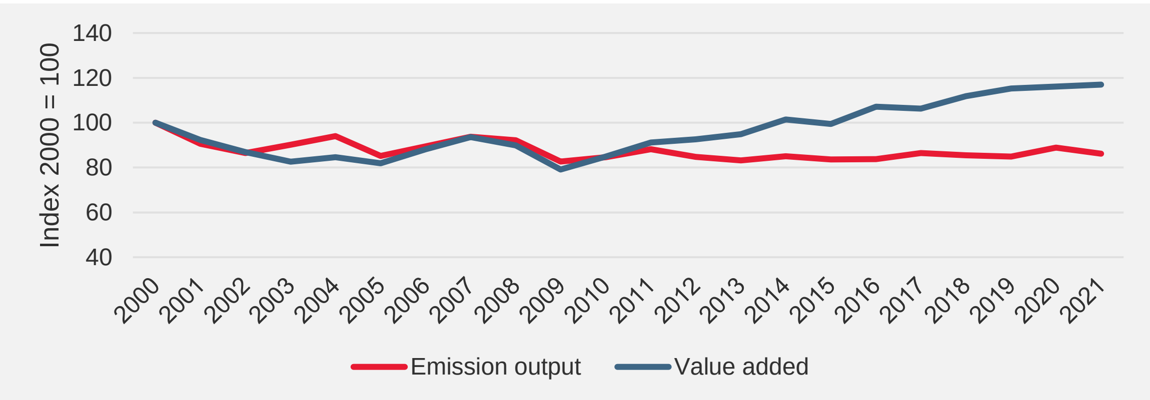

Figure 7: *Standardized Development of Emissions with Respect to the Value Added in the Cement and Lime Manufacturing Sector (Index level 2000 = 100).*[48] [49] [50]

Since 1990, the German cement industry has reduced its specific emissions per tonne of cement by about 22%. A significant diversion between emission output and value added can particularly be seen from 2011 onwards (see Figure 7). These advancements are primarily due to measures such as enhancing thermal and electrical energy efficiency through various technical improvements, substituting fossil fuels with alternative, biomass-containing fuels with a lower CO_2 footprint, deploying alternative, pre-calcined raw materials, and efficient usage of the emission-intensive intermediate product, cement

[44] Verein Deutscher Zementwerke, "Dekarbonisierung von Zement und Beton – Minderungspfade und Handlungsstrategien," 2020, https://www.vdz-online.de/zementindustrie/klimaschutz/uebersicht.

[45] Navigant Energy Germany, "Energiewende in Der Industrie - Potenziale Und Wechselwirkungen Mit Dem Energiesektor: Branchensteckbrief Der Zement- Und Kalkindustrie," 2020, https://www.bmwk.de/Redaktion/DE/Downloads/E/energiewende-in-der-industrie-ap2a-branchensteckbrief-zement.pdf?__blob=publicationFile&v=4.

[46] Verein Deutscher Zementwerke, "Dekarbonisierung von Zement und Beton – Minderungspfade und Handlungsstrategien."

[47] Navigant Energy Germany, "Energiewende in Der Industrie - Potenziale Und Wechselwirkungen Mit Dem Energiesektor: Branchensteckbrief Der Zement- Und Kalkindustrie."

[48] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Anthropogene Luftemissionen."

[49] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Energiegesamtrechnung," Statistisches Bundesamt, 2023, https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/energiefluesse-emissionen/Publikationen/Downloads/umweltnutzung-und-wirtschaft-energie-pdf-5850014.html.

[50] Statistisches Bundesamt, "Volkswirtschaftliche Gesamtrechnungen, Inlandsprodukt."

clinker. However, conventional CO_2 mitigation measures will increasingly face limits. The thermal efficiency of cement plants is already close to the maximum feasible from a technical process perspective, and gains in electrical energy efficiency are often offset by increasing electricity demand. This is caused by demand for finer ground cements, technically complex exhaust gas filtering, or CO_2 mitigation measures. To reduce the clinker content of cement further, suitable alternative raw materials including blast furnace slag, fly ash, or calcinated clay are required, the availability of which is uncertain.[51] [52]

In addition to the aforementioned conventional mitigation measures, cement manufacturers in Germany have been intensely researching and working on various approaches for many years to significantly reduce the CO_2 intensity of cement production. This involves considering all CO_2 reduction potentials along the entire value chain of clinker - cement - concrete - construction - demolition. Key aspects include the use of innovative, especially CO_2-efficient types of cement such as CEM II/C and CEM VI[53], and the necessary advancement of concrete technology. Further focus is on the intelligent and resource-saving use of concrete in construction, CO_2 uptake in concrete (re-carbonation), the development of novel mineral binders, and technologies for CO_2 capture, transport, utilisation, and storage in suitable and secure geological formations.[54] [55] [56] Regardless of the efforts by the cement industry, a fully decarbonised construction sector will have to use significantly less cement or guarantee the abatement of process emissions through carbon capture technologies.

2.2.3 Chemical and Petroleum Product Manufacturing Sector

In 2021, the German chemical and petroleum industry was responsible for 60 Mt Co_2e, accounting for roughly 28% of total emissions in the industry sector. This sector, situated at the outset of the industrial production chain, plays a pivotal role in transforming substances into essential precursors for nearly all other industries.[57] [58]

As an energy-intensive sector, particularly during the initial stages of the conversion process, the chemical industry sees a substantial part of its CO_2 emissions - approximately a quarter - generated by process emissions. The remaining emissions are largely due to fuel combustion. The highest emitting processes within this sector are ammonia production and the manufacture of high-value chemicals such as ethylene, propylene, benzene, toluene, and mixed xylenes, alongside methanol. The industry's heavy reliance on energy becomes clear when considering that almost half of the chemical subsector's energy input is utilised as feedstock, serving as a raw material input rather than exclusively as an energy source. This usage results in considerable emissions being released through the combustion of fossil fuels, primarily utilised for electricity generation and process heat. Additionally, fossil hydrocarbons act as raw materials for organic compounds, plastics, synthetic rubbers, and synthetic fibres.[59]

In 2021, the chemical industry[60] accounted for almost 40% of the total energy consumption in the industry sector.[61] A significant part of the energy resources in the chemical industry, around 36%, was not used for electricity production but as raw materials for chemical products.[62] Natural gas was the predominant energy source for the chemical industry, accounting for 37.8% of energetic consumption. Electricity made up 25.2% of the energy used, followed by heat[63] at 15.0%. In the chemical industry, energy sources often serve functions beyond energy production. In the case of petroleum products, consumption as energy is minor. Instead, more than 90% of petroleum products are used materially.

[51] Verein Deutscher Zementwerke, "Dekarbonisierung von Zement und Beton – Minderungspfade und Handlungsstrategien."

[52] Umweltbundesamt, "Dekarbonisierung Der Zementindustrie."

[53] For further details, please visit https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7287906/

[54] Verein Deutscher Zementwerke, "Dekarbonisierung von Zement und Beton – Minderungspfade und Handlungsstrategien."

[55] Umweltbundesamt, "Dekarbonisierung Der Zementindustrie."

[56] Umweltbundesamt.

[57] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Anthropogene Luftemissionen."

[58] Verband der Chemischen Industrie (VCI), "Umwelt, Gesundheit, Sicherheit Daten Der Chemischen Industrie 2020," 2020, https://www.vci-nord.de/fileadmin/vci-nord/Bilder/publikationen/umwelt-gesundheit-sicherheit-auf-einen-blick_2020.pdf.

[59] International Energy Agency, "Chemicals – Analysis," 2022, https://www.iea.org/reports/chemicals.

[60] Chemical industry including petroleum product manufacturing

[61] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Energiegesamtrechnung."

[62] Statistisches Bundesamt, "Energieverbrauch in der Industrie 2021 um 4,6 % gegenüber dem Vorjahr gestiegen," Statistisches Bundesamt, 2022, https://www.destatis.de/DE/Presse/Pressemitteilungen/2022/12/PD22_530_435.html.

[63] Drawing on district heating, heating water and steam

Similarly, natural gas serves as a raw material in 30% of the industry's production processes. Plans are in place to increase electricity generation from renewable energy sources.[64]

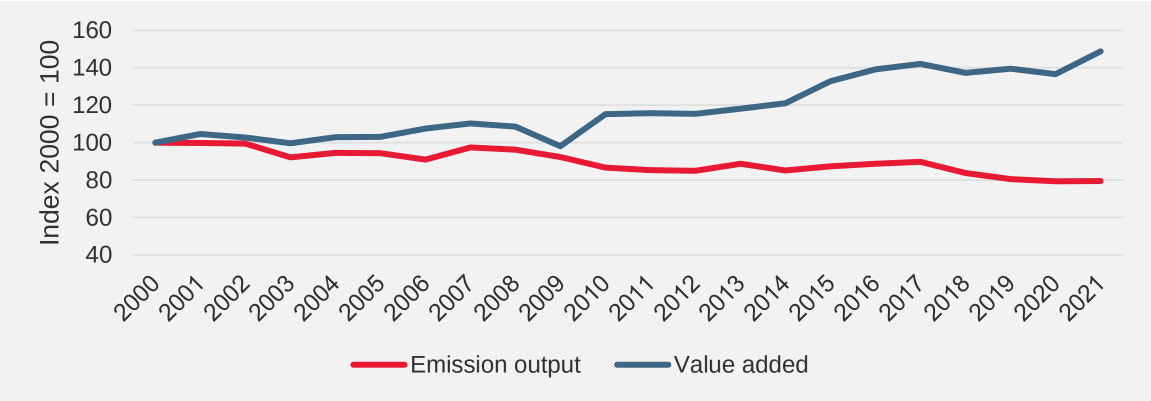

Figure 8: *Standardized Development of Emissions with Respect to the Value Added in the Chemical and Petroleum Product Manufacturing Sector[65] (Index Level 2000 = 100).[66] [67] [68]*

The German chemical industry has achieved a significant reduction in greenhouse gas emissions, with a 51% decrease from 1990 to 2018.[69] Compared to the sector's value added, it becomes apparent that the industry has become more efficient, as value added has grown without a corresponding increase in emissions, indicating a decoupling of economic growth from environmental impact (see Figure 8). This reduction has been facilitated by several key strategies. Firstly, the industry has optimised energy use through advanced heat integration techniques. This involves connecting heat sinks and sources directly or using heat pumps to recycle previously wasted heat, enhancing overall energy efficiency. Secondly, the industry has secured competitive renewable energy prices through collective agreements within chemical parks, further reducing reliance on fossil fuels and cutting emissions.[70]

Looking forward, Germany is committed to reaching greenhouse gas neutrality in the chemical industry by implementing innovative production processes and harnessing renewable sources of raw materials. The plans include transitioning away from fossil fuels used as feedstock and process gases, employing technologies such as chemical recycling and Carbon Capture and Usage (CCU) to manage carbon resources more efficiently. Electrification of processes that traditionally rely on fossil fuel combustion is another crucial strategy, with the development of electrically heated steam crackers, [71] [72] currently piloted by BASF in Germany as a prime example. If successful, about 90% of the currently generated emissions could be avoided.[73] Moreover, the chemical industry is moving towards using 'green hydrogen' produced via electrolysis powered by renewable energy. This shift not only aims to reduce CO_2 emissions but also enhances energy and material efficiency across the sector.[74] [75]

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[64] Verband der Chemischen Industrie (VCI), "Energiestatistik," 2024, https://www.vci.de/die-branche/zahlen-berichte/vci-statistik-grafiken-energie-klima-rohstoffe-chemie.jsp.

[65] To match New Zealand's industry classification,the chemical industry encompasses petroleum product manufacturing and the manufacture of rubber and plastic goods

[66] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Anthropogene Luftemissionen."

[67] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Energiegesamtrechnung."

[68] Statistisches Bundesamt, "Volkswirtschaftliche Gesamtrechnungen, Inlandsprodukt."

[69] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Anthropogene Luftemissionen."

[70] McKinsey & Company, "Decarbonizing the German Chemical Industry | McKinsey," 2023, https://www.mckinsey.com/industries/chemicals/our-insights/decarbonizing-the-chemical-industry#/.

[71] McKinsey & Company.

[72] Deloitte, "Gemeinsam Die Energiewende Meistern," 2020, https://www2.deloitte.com/content/dam/Deloitte/de/Documents/energy-resources/chemie_energiewirtschaft_whitepaper_.pdf.

[73] Handelsblatt, "BASF Will Seine Grüne Zukunft Mit Weltneuheit Sichern," 2024, https://www.handelsblatt.com/unternehmen/industrie/dax-konzern-basf-will-seine-gruene-zukunft-mit-weltneuheit-sichern-01/100031175.html.

[74] McKinsey & Company, "Decarbonizing the German Chemical Industry | McKinsey."

[75] Kompetenzzentrum Klimaschutz in energieintensiven Industrien (KEI), "Grundstoffchemische Industrie |," 2022, https://www.klimaschutz-industrie.de/themen/branchen/grundstoffchemische-industrie/.

2.2.4 Food, Beverage, and Tobacco Manufacturing Sector

The food, beverage, and tobacco manufacturing industry in Germany is a significant component of the nation's economy, counting as one of the five largest sectors with a turnover of 218 billion EUR in 2022.[76] The sector also accounts for a significant share of GHG emissions with 12 Mt CO_2e in 2021. The dairy industry is most important sub-sector of Germany's food sector, where dairy production accounted for 41.2% of animal products and 18.9% of agricultural products in 2020. With this, dairy production contributed around 10.8 billion EUR to the production value of German agriculture.[77] Overall, the food and beverage manufacturing sector, encompassing food processing, sales, distribution, and packaging contributes a share of between 4% to 14% to total emissions. A significant environmental factor within the food, beverage, and tobacco manufacturing sector is energy consumption, specifically during the stages of drying, cooking, and cooling food, which are highly energy-intensive. This heavy energy usage exerts considerable strain on resources and contributes to climate change, making energy efficiency a critical area for improvement in this sector.[78] [79] [80]

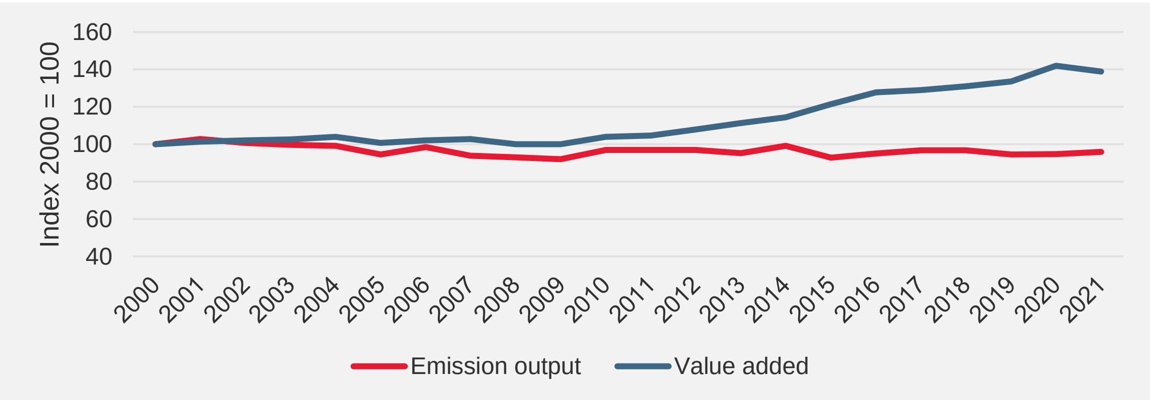

Figure 9: *Standardized Development of Emissions with Respect to the Value Added in the Food and Beverage Manufacturing Sector (Index Level 2000 = 100).*[81] [82] [83]

Energy consumption in the food industry exhibits significant variation, largely dependent on the specific operations and requirements of different sub-sectors. For instance, the meat processing sector and frozen food manufacturers typically demonstrate higher energy consumption, largely due to the energy-intensive cooling systems these sub-sectors employ.[84]

Analysis conducted by Fraunhofer ISI and IREES in 2013 indicated that the sugar industry, dairy industry, baked goods production, and meat processing were the most energy-intensive sectors within the food industry. Collectively, these sectors contribute significantly to the total energy consumption of the industry.[85]

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[76] Bundesvereinigung der Deutschen Ernährungsindustrie, "BVE-Jahresbericht 2023," 2023, https://www.bve-online.de/presse/infothek/publikationen-jahresbericht/bve-jahresbericht-ernaehrungsindustrie-2023.

[77] Bundesministerium für Ernährung und Landwirtschaft (BMEL), "Entwicklungen am deutschen Milchmarkt – ein Überblick," 2021, https://www.bmel.de/DE/themen/landwirtschaft/agrarmaerkte/entwicklungen-milchmarkt-de.html.

[78] Umweltbundesamt, "Nahrungsmittelindustrie," Umweltbundesamt (Umweltbundesamt, July 18, 2013), https://www.umweltbundesamt.de/themen/wirtschaft-konsum/industriebranchen/nahrungs-futtermittelindustrie-tierhaltungsanlagen/nahrungsmittelindustrie.

[79] WWF Deutschland, "Essen wir das Klima auf?," 2022, https://www.wwf.de/themen-projekte/landwirtschaft/ernaehrung-konsum/essen-wir-das-klima-auf.

[80] Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz (BMUV), "Mein Essen, die Umwelt und das Klima | Artikel | BMUV," bmuv.de, accessed July 24, 2023, https://www.bmuv.de/jugend/TW9.

[81] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Anthropogene Luftemissionen."

[82] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Energiegesamtrechnung."

[83] Statistisches Bundesamt, "Volkswirtschaftliche Gesamtrechnungen, Inlandsprodukt."

[84] Ines Thobe, "Die Ernährungsindustrie - Stabile Branche mit Potenzialen," 2011, https://papers.gws-os.com/tbericht_ernaehrungsgewerbe_2011-8.pdf.

[85] F. Idrissova and E. Jochem, "Ernährungsgewerbe," in *ErnährungsgewerbeEnergieverbrauch und CO2-Emissionen industrieller Prozesstechnologien: Einsparpotenziale, Hemmnisse und Instrumente*, ed. Tobias Fleiter, Barbara Schlomann, and Wolfgang Eichhammer, ISI-Schriftenreihe "Innovationspotenziale" (Stuttgart: Fraunhofer-Verl, 2013), 511–44.

The food industry's final energy consumption (FEC) stands at approximately 57.3 TWh per year, with thermal energy usage outstripping that of electricity. The four sub-sectors mentioned previously accounted for 55% of the total electricity consumption and 26% of the total heat consumption within the food industry as of 2013. These figures underline the significant role of process heat or cold, as well as the power consumption of electric motors, in driving the food industry's overall energy consumption. This is further evidenced by the fact that fuel usage is primarily directed towards generating process heat (steam, hot/warm water, warm air) and electricity for various power needs, such as cooling, compressed air, vacuuming, and transport, as well as lighting.[86]

Notably, the industry also utilises self-generation for about 20% of its total electricity consumption. The use of Combined Heat and Power (CHP) plants also plays a significant role in this context. As studies suggest, almost all of the food industry's self-generated electricity is produced via CHP, demonstrating the effectiveness of such systems in supporting the industry's energy needs.[87] [88]

In alignment with these sustainable practices, Figure 9 indicates that the food and beverage manufacturing sector has maintained a relatively stable level of greenhouse gas emissions over time, while value added has steadily increased. This suggests that the sector has managed to enhance its economic output without a proportional rise in emissions, reflecting improvements in energy efficiency and a commitment to more sustainable production methods.

2.3 State of Energy Efficiency and Management

In 2022, Germany's primary energy consumption (PEC) was recorded at 11,829 petajoules (PJ), marking a 4.7% decrease from the previous year. This was influenced by a notable shift: economic growth has increasingly become independent of energy consumption, demonstrating the decoupling of the country's energy use from its economic expansion. This trend is reinforced by the increased efficiency of renewable energy sources, which have become a larger part of the energy mix as the country moves away from nuclear and coal. The war in Ukraine has also led to a conscious reduction in energy use, anticipating shortages, especially in natural gas supplies, which saw a significant cutback despite being considered a transitional energy source.

The increased use of more efficient renewable energy sources has contributed significantly to the reduction in PEC in Germany. Efficiency improvements in fossil fuel power plants and combined heat and power systems have also played a crucial role. Additionally, energy-saving measures and structural changes in end-use sectors have helped offset increases from economic and population growth. As a result, final energy consumption (FEC) fell by 492 PJ, or 5.4%, between 2008 and 2021, with net electricity consumption also decreasing by 28 TWh or 5.4% during the same period.

In the industry sector, FEC has experienced a modest annual decline of 0.2% from 1991 to 2021, despite fluctuations. Concurrently, the sector's gross value added grew by 1% annually, leading to an average annual increase of 1.2% in final energy productivity. By 2021, industrial FEC reached 2,518 PJ. Over time, the industry has shifted from lignite, mineral oil, and coal to more renewable heat, district heating, electricity, and gases, with gases (899 PJ, 35.7%) and electricity (766 PJ, 30.4%) now being the leading energy carriers.

From 1991 to 2021, the average growth rate of electricity consumption in the industry sector was only 0.3% per year, while gross value added grew by 1.0% annually, resulting in a 0.6% annual increase in electricity productivity. By 2021, electricity maintained its role as a critical energy carrier, comprising 30.4% of industrial FEC, second only to gases. The primary use of electricity within industry was for mechanical energy to operate engines and machinery, which accounted for 135.4 TWh (66.8%), and 34.4 TWh (17%) was used for process heat.

[86] Navigant Energy Germany, “Energiewende in der Industrie - Potenziale und Wechselwirkungen mit dem Energiesektor: Branchensteckbrief der Nahrungsmittelindustrie,” 2020, https://www.bmwk.de/Redaktion/DE/Downloads/E/energiewende-in-der-industrie-ap2a-branchensteckbrief-nahrung.pdf?__blob=publicationFile&v=4.

[87] Öko-Institut, “Aktueller Stand Der KWK-Erzeugung (Dezember 2015),” 2015, https://www.oeko.de/oekodoc/2450/2015-607-de.pdf.

[88] Navigant Energy Germany, “Energiewende in der Industrie - Potenziale und Wechselwirkungen mit dem Energiesektor: Branchensteckbrief der Nahrungsmittelindustrie.”

3 Industry Composition in New Zealand

New Zealand plays an important role in the global economy as a leading exporter of dairy products, meat, and wine, with its agricultural sector driving a significant portion of its economic activity. Furthermore, it's a tourism hotspot, contributing to global travel and hospitality sectors.

3.1 Overview of New Zealand's Economy

Situated 52nd in the ranking of global economies by total GDP but just behind Germany, ranking 30th, in per capita terms, New Zealand is characterised by a wealthy, though comparatively small-scale economy with a GDP of 230 billion EUR.[89] [90] In the decade to 2022, New Zealand's economy experienced an average growth rate of 3.1%, showcasing steady expansion. Looking ahead, the International Monetary Fund (IMF) predicts that New Zealand's economic growth will continue, with expectations of reaching a GDP of more than 240 billion EUR by 2025.[91]

Despite its small scale, the country is recognised for its stability, high living standards, and business-friendly environment, making it a lucrative spot for investment and talent. New Zealand has a large services sector, where it is particularly strong in tourism, technology, and creative industries like film production.[92] New Zealand also has a comparatively large agricultural, especially dairy, sector.

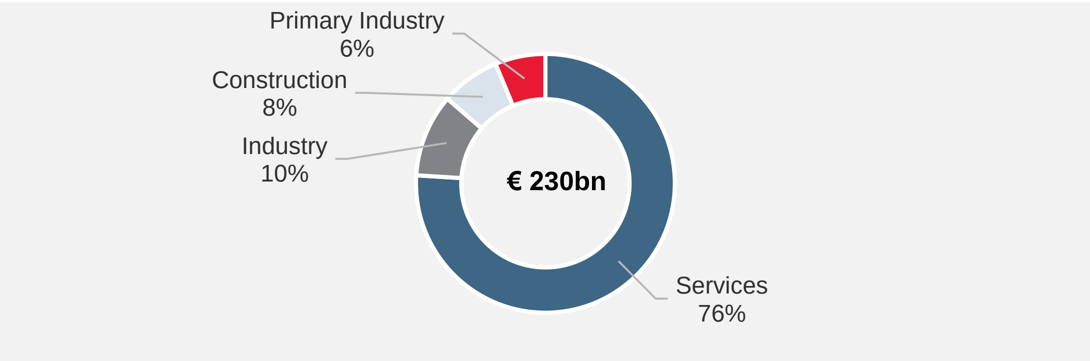

Figure 10: *Composition of New Zealand's Economy (2022).[93]*

The COVID-19 pandemic significantly impacted New Zealand's economy in 2020, causing a 12.2% contraction in GDP in the second quarter of 2020 and a peak unemployment rate of 5.3%. However, the economy proved resilient and adaptable, recovering swiftly in 2021 thanks to effective containment strategies and policy measures. By June 2021, the unemployment rate dropped to 4.0%, surpassing pre-pandemic levels and reflecting the country's robust economic framework and proficient crisis management. Still, global supply chain issues and extensive interest rate hikes to fight inflation have left their marks on New Zealand's export-oriented economy, as the country formally entered a recession in the last quarter of 2023, contracting by 0.1%.[94]

[89] International Monetary Fund, "World Economic Outlook Database," 2023, https://www.imf.org/en/Publications/WEO/weo-database/2023/April.

[90] World Bank Open Data, "GDP per Capita (Current US$) - New Zealand," World Bank Open Data, 2024, https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=NZ&most_recent_value_desc=true.

[91] International Monetary Fund, "World Economic Outlook Database."

[92] NZTE, "New Zealand Sectors of Strength," 2023, https://www.nzte.govt.nz/page/sectors-overview.

[93] Stats NZ, "Series, GDP(P), Nominal, Actual, ANZSIC06 Detailed Industry Groups (Annual-Mar)," 2023, https://infoshare.stats.govt.nz/ViewTable.aspx?pxID=140efa3a-0391-4898-beeb-7ca76c944374.

[94] Liam Dann, "GDP: It's Official - We're in Recession," NZ Herald, 2024, https://www.nzherald.co.nz/business/gdp-is-new-zealand-in-recession-we-find-out-today/Y32IL4XXMBH6BC66XYWGNPHGPE/.

3.1.1 Overview of New Zealand's Economic Sectors

New Zealand's economy presents a diverse blend of traditional and modern industries. Dominated by the service sector, which accounts for over 76% of its economic output, the country also maintains a strong agricultural foundation (see Figure 10). Notably, New Zealand is a top global exporter of animal and in particular dairy products (see Figure 11). Additionally, the nation excels in several other farming areas, such as sheep, beef, and horticulture, underscoring agriculture's continued importance to its economic landscape. This is complemented by the tourism sector, which capitalises on New Zealand's landscapes and adventurous outdoor activities, drawing millions of visitors each year and bringing in 12.6 billion NZD (7.2 billion EUR) in 2023.[95] Alongside these, the advanced industry sector has made significant strides, becoming the third-largest export revenue earner, with high-tech manufacturing and information and communication technology (ICT) as major contributors. This rapid growth has also attracted a surge in foreign direct investment. Advanced manufacturing has successfully diversified New Zealand's export base and demonstrated that innovation and quality can overcome geographical challenges.[96]

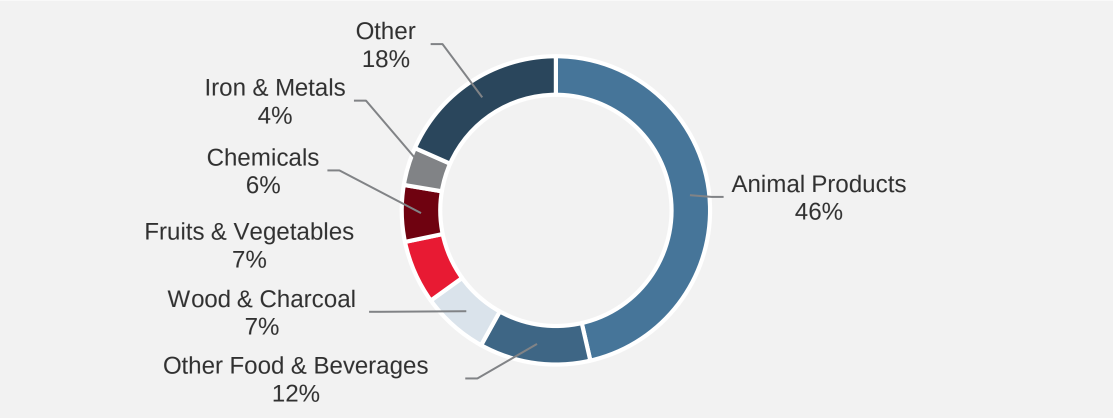

***Figure 11**: Share of Different Products in Total New Zealand Exports* (2022).[97]

3.1.2 Distribution and Development of Emissions in the New Zealand Economy

New Zealand's greenhouse gas emissions profile stands out when compared to most other countries, largely due to its significant agricultural sector. While agriculture accounts for about 13% of gross emissions globally on average, in New Zealand, it contributes more than 50% of the country's total emissions. This high level of agricultural activity leads to elevated levels of methane and nitrous oxide, gases that have a greater warming effect than carbon dioxide. [98]

As of the latest available data for 2022, New Zealand's gross emissions amounted to 78.4 Mt CO_2e, ranking it 60th in the world. However, when looked at on a per capita basis, New Zealand's emissions are the 19th highest globally, with 13.4 tonnes CO_2e per person.[99] While the country's gross emissions make up only about 0.16% of the world's total, they have been on the rise since 1990. This stands in contrast not only to many other countries like the United Kingdom and Germany, where emissions have decreased to levels below those of 1990, but also to New Zealand's own domestic climate policy targets.[100] [101]

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[95] Trading Economics, "New Zealand Tourism Revenues," 2024, https://tradingeconomics.com/new-zealand/tourism-revenues.

[96] Deloitte, "Shaping Our Slice of Heaven Industries of Opportunity," 2017, https://www2.deloitte.com/nz/slice-of-heaven.

[97] OEC, "New Zealand (NZL) Exports, Imports, and Trade Partners," 2024, https://oec.world/en/profile/country/nzl.

[98] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2022: Snapshot," 2024, https://environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-19902022-snapshot/.

[99] European Commission, "EDGAR - Emissions Database for Global Atmospheric Research," 2023.

[100] European Commission, "EDGAR - Emissions Database for Global Atmospheric Research," 2022.

[101] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2020," Ministry for the Environment, 2022, https://environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2020/.

As already mentioned, agriculture represents the main source of greenhouse gases (GHGs) in New Zealand, with methane and nitrous oxide being the most significant contributors from this sector. The sector accounts for half of the country's total gross GHG emissions (see Figure 12), a far more pronounced share than in other well-developed economies, for instance, the US or Germany.[102] [103]

In contrast, New Zealand's commitment to a predominantly green power mix has resulted in relatively low emissions from its energy sector, which accounted for about 9% of the total in 2022. Meanwhile, transportation contributed 17.5% and emissions from waste and other sources made up 8% of the overall emissions footprint. [104]

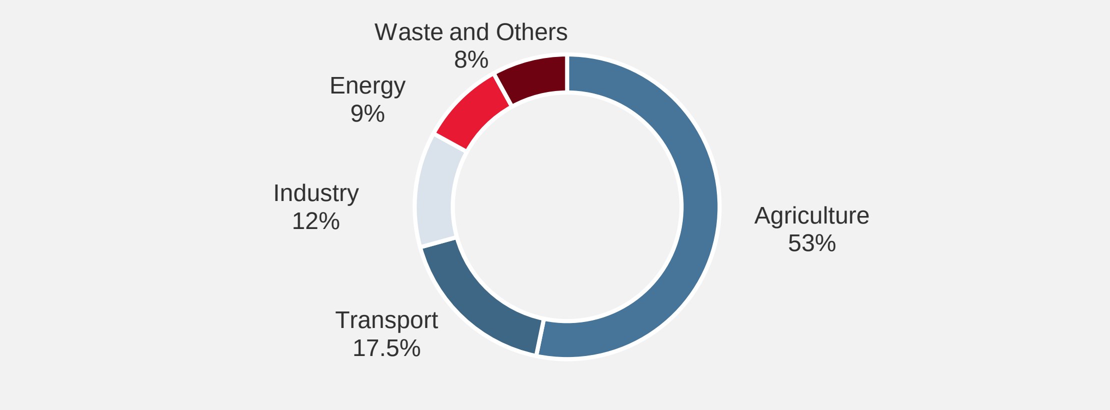

Figure 12: *Carbon Dioxide Equivalent Emissions by Sectors (2022).* [105]

The industry sector is another significant source of GHG emissions, which can be split into energy-related emissions and "Industrial Processes and Product Uses" (IPPUs). In contrast to emissions from fuels used to produce energy for manufacturing, the latter describe pollution stemming directly from industrial processes transforming materials or chemical reactions. Unlike in Germany, corporate reporting on scope 1 and 2 emissions is not mandatory in New Zealand and classifications in CO_2 accounting can differ, so that pollutants from industrial production can be found under manufacturing, other energy-related emissions or IPPUs. These, in turn, might sometimes not include all scope 2 or even scope 1 GHGs from industrial plants but rather just their direct process emissions.[106] [107]

Whereas New Zealand managed to cut emissions by 4% from 2021 to 2022, a more long-term increase of 14% in total greenhouse gas emissions from 1990 to 2022 reveals significant sectoral trends. Agriculture emissions rose by 12%, despite some declines in livestock (predominantly sheep, beef cattle, and deer), driven largely by an 82% expansion in dairy herding and a substantial increase in synthetic nitrogen fertilizer use. Albeit the energy industry managed to cut emissions by 48%, energy-related emissions saw a 20% increase in the same timeframe, attributed to road transport and fossil fuel consumption in manufacturing. In the IPPU sector, emissions increased 28% from 1990 to 2022, with a minor decrease being observed more recently due to reduced hydrofluorocarbon (HFC) use. The waste sector managed to cut emissions by a fifth, thanks to improved waste management practices. The land use sector acted as a carbon sink, removing more than 19.2 Mt CO_2e in 2022 but is declining in significance since 1990.[108] [109]

[102] EPA, "Importance of Methane," Overviews and Factsheets, 2016, https://www.epa.gov/gmi/importance-methane.

[103] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2022."

[104] Ministry for the Environment.

[105] Ministry for the Environment.

[106] Ministry of Business, Innovation & Employment (MBIE), "Primary Metal and Metal Product Manufacturing," 2018, https://www.mbie.govt.nz/dmsdocument/6563-primary-metal-and-metal-product-manufacturing-factsheet.

[107] Umweltbundesamt, "Chapter 4 - NFR 2 - Industrial Processes and Product Use," 2022, https://iir.umweltbundesamt.de/2022/sector/ippu/start.

[108] Ministry for the Environment, "Emission Trends by Sector," 2021, https://environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2019-snapshot/emissions-trends-by-sector/.

[109] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2022."

Overall, while the waste and land use sectors show positive emissions trends, sectors like agriculture, energy, and IPPU continue to increase their emissions, highlighting the need for more focused mitigation policies in New Zealand.

3.2 Distribution of Emissions in the Industry Sector

The industry sector is a significant contributor to greenhouse gas emissions amounting to 9.6 Mt CO_{2e} in 2022 (for combined fuel and IPPU emissions), [110] with over 50% of its energy stemming from non-renewable resources.[111] At the forefront is the food and beverage product manufacturing industry, which tops the list as the number one emitter (see Figure 13). This is due to New Zealand's large agricultural sector, where dairy processing, meat packaging, and beverage production are energy-intensive activities. Following the food and beverage sector are metal product manufacturing and the chemical industry, both of which are also major contributors to greenhouse gas emissions. Metal production involves a range of energy-intensive processes, including smelting and forging, that emit significant amounts of CO_2. The chemical industry is another heavy emitter, especially in the production of plastics, fertilizers, and other synthetic materials. These can release various greenhouse gases, such as CO_2 and gases like nitrous oxide or methane. The non-metallic mineral production sector is also notable for its high energy consumption and resulting emissions. The concentration of emissions in these four key industries calls for targeted environmental policies.[112]

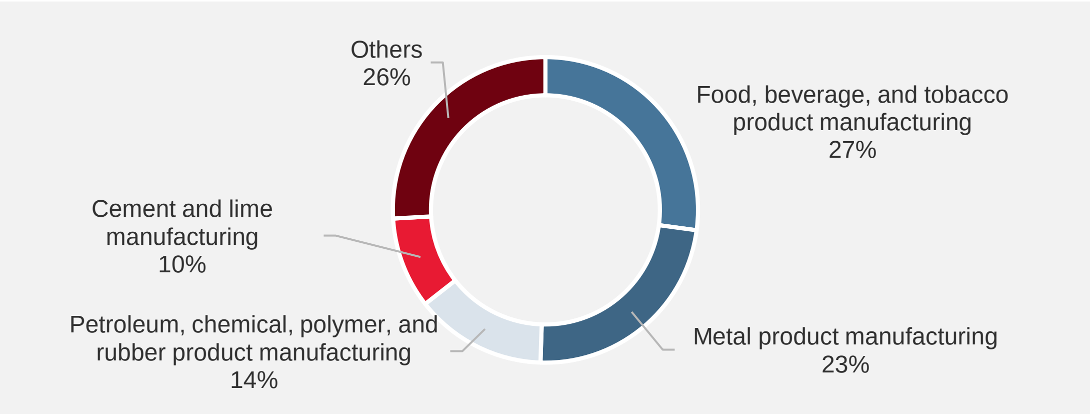

Figure 13: *Emission-Breakdown in the Industry Sector (2022).*[113]

3.2.1 Steel and Metal Production and Processing Sector

New Zealand's primary metal and metal product manufacturing sector is a significant player in the country's emissions profile. This sector primarily consists of two dominant operations: the New Zealand Aluminium Smelter (NZAS) at Tiwai Point, which produces over 340,000 tonnes of aluminium products annually by processing imported alumina, and the New Zealand Steel (NZS) plant at Glenbrook,

[110] Ministry for the Environment.

[111] EECA, "New Zealand Energy Scenarios," 2021, https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/New-Zealand-Energy-Scenarios-TIMES-NZ-2.pdf.

[112] Stats NZ, "Greenhouse Gas Emissions (Industry and Household)," 2021, https://www.stats.govt.nz/information-releases/greenhouse-gas-emissions-industry-and-household-year-ended-2019#:~:text=Together%20they%20made%20up%2088,most%20methane%20(31%2C330%20kilotonnes).

[113] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2022."

generating over 600,000 tonnes of steel products. The NZS plant employs a distinct iron-smelting technique, converting black iron sand from local beaches.[114] [115]

Fuel plays a pivotal role in the metal manufacturing processes, both as a heating agent, ensuring the necessary high temperatures, and as a reducing agent, aiding in the conversion of metal oxides to metals. The overall energy consumption for process heat in 2021 stood at 5.23 TWh, most of which was used for electric furnacing. In addition to electricity, which accounts for around 95% of energy for process requirements, less than 5% of the energy directly came from natural gas, which is used for furnaces and kilns.[116] Overall, in 2022, total emissions in primary metal and metal product manufacturing amounted to 2.31 Mt CO_2e[117], with the sector representing almost a fourth of all industry emissions in 2022 and 26% of New Zealand's total process heat emissions at their last evaluation in 2016.[118]

The NZAS plant, in particular, consumes an enormous amount of electricity, roughly 5 TWh annually, primarily for the smelting process. Moreover, carbon anodes used in this process result in IPPU emissions of around 540 Kt of CO_2. The plant's aluminium smelter was the main consumer, accounting for approximately 80% of the energy used. In 2016, the emissions from electricity constituted 21% of the sector's total, while those from non-energy IPPU sources made up a significant 74%. The NZS plant at Glenbrook utilises a considerable amount of electricity as well, nearly 1.1 TWh per year, mostly for iron melting and steelmaking, with natural gas being employed for heating molten iron and steel. [119] [120] [121]

While the future is currently uncertain for the NZAS, with its owner Rio Tinto announcing the plant's closure in 2020 before signing new short-term power supply and demand response contracts through 2024, efforts have been made to address the carbon intensity of the NZ Steel plant in Glenbrook through the installation of a new electric arc furnace which will be completed by 2026.[122] Additionally, the steel mill's current supplier of hydrogen, Linde subsidiary BOC, has announced efforts to switch its provision to green hydrogen soon.[123]

The development of emissions compared to value added in the metal production and processing sector, as presented in Figure 14, demonstrates a general trend of fluctuating yet slightly decreasing emissions since 2007. In contrast, the sector's value added has experienced growth, particularly after 2014. This pattern suggests a partial decoupling of economic growth from emissions, pointing to some progress in environmental efficiency, albeit not as significant as seen in other sectors.

[114] New Zealand's Aluminium Smelter, "New Zealand's Aluminum Smelter | 2017–18 Sustainable Development Report," 2018, https://www.nzas.co.nz/.

[115] Ministry of Business, Innovation & Employment (MBIE), "Primary Metal and Metal Product Manufacturing."

[116] Energy Efficiency & Conservation Authority, "EEUD Data 2017-2021," 2022, https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/EEUD-Data-2017-2021-Published-March-2023.xlsx.

[117] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2022."

[118] EECA, "EECA - Energy End Use Database," EECA, 2018, https://www.eeca.govt.nz/insights/eeca-insights/energy-end-use-database-eeud/.

[119] New Zealand's Aluminium Smelter, "New Zealand's Aluminum Smelter | 2017–18 Sustainable Development Report."

[120] Ministry of Business, Innovation & Employment (MBIE), "Primary Metal and Metal Product Manufacturing."

[121] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2020."

[122] Jamie Gray, "NZ Steel to Install $300m Electric Arc Furnace," NZ Herald, 2023, https://www.nzherald.co.nz/business/nz-steels-300m-electric-arc-furnace-gets-green/VBO2J777Q5HOBP7PJVR2E4ZKRE/.

[123] Jamie Gray, "BOC to Supply 'green' Hydrogen to NZ Steel at Glenbrook," NZ Herald, 2021, https://www.nzherald.co.nz/business/boc-to-supply-green-carbon-free-hydrogen-to-nz-steel-at-glenbrook/GHMPNXIBFBEIAORLACY56OL67U/.

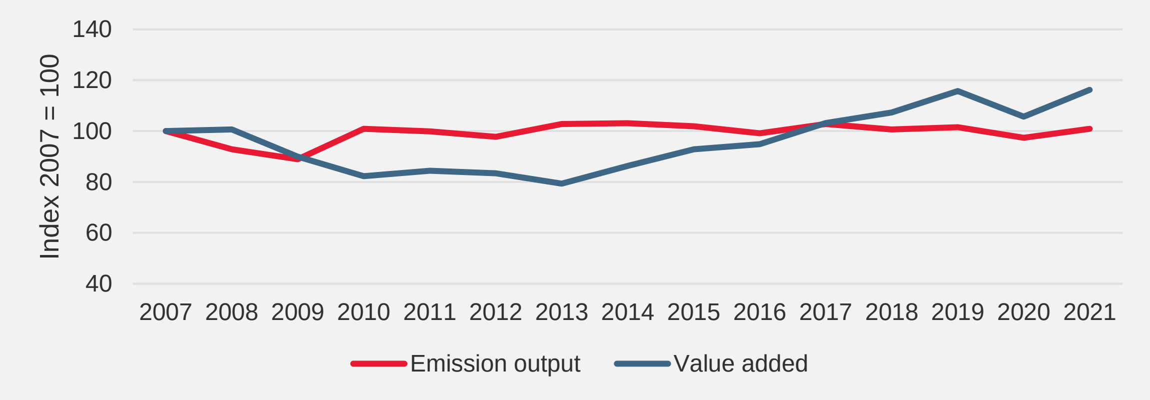

Figure 14: *Standardized Development of Emissions with Respect to the Value Added in the Metal Production and Processing Sector (Index Level 2007 = 100).*[124] [125]

3.2.2 Cement and Lime Manufacturing Sector

In New Zealand's non-metallic mineral sector, process heat serves as a transformative force, converting raw materials such as sand into glass and clay into ceramics. Predominantly produced from kilns or furnaces, most of this heat is high temperature, exceeding 300°C. For example, the creation of glass products requires furnaces that operate at around 1500°C.[126]

The products from this sector cater to domestic manufacturers and international markets. In terms of GHG emissions, the sector emitted 955 kt CO_2e in 2022. As in steel and metal processing, these emissions are not solely from energy consumption. A significant portion, 59%, of the sector's GHG emissions are Industrial Processes and Product Use (IPPU) emissions, which arise from manufacturing processes. For instance, cement production releases CO_2 as a by-product from its chemical reactions.[127]

Relative to sectors like wood processing or dairy production, the non-metallic mineral sector is not a major consumer of process heat. In 2021, it utilised 1.22 TWh of process heat, with the main sources being natural gas (48%) and, particularly in high-temperature heating, coal (47%) while only a few percentage points stem from electricity. This relative carbon intensity and reliance on non-renewable energy sources within the sector can also be observed when assessing the GHG emissions from process heat use, which stood at 440 kt CO_2e or 4.5% of New Zealand's total GHG emissions in 2016, while only accounting for a mere 2.6% of New Zealand's total process heat demand for that year.[128] [129]

On the flip side, renewable energy sources like biomass and electricity accounted for 9.6% of energy consumption but only contributed to 1.2% of the sector's energy-related GHG emissions. Thus, the overwhelming dependency on coal, responsible for almost half of the sector's energy consumption and 61.4% of energy-related GHG emissions, indicates a pressing need to reduce coal usage to effectively decrease the sector's emissions footprint.[130] [131] [132]

Emissions in the cement and lime manufacturing sector have been on a decline since 2007, displaying a significant divergence from the concurrently rising value added, as depicted in Figure 15. This trend indicates that the sector has successfully decoupled emissions from economic growth, signalling enhanced environmental efficiency.

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[124] Stats NZ, "New Zealand's Greenhouse Gas Emissions," 2022, https://www.stats.govt.nz/indicators/new-zealands-greenhouse-gas-emissions.

[125] Stats NZ, "National Accounts - Infoshare," 2024, https://infoshare.stats.govt.nz.

[126] Ministry of Business, Innovation & Employment (MBIE), "Non-Metallic Mineral Product Manufacturing – Process Heat and Greenhouse Gas Emissions," 2018, https://www.mbie.govt.nz/dmsdocument/6564-non-metallic-mineral-products-factsheet.

[127] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2020."

[128] EECA, "EECA - Energy End Use Database."

[129] Ministry of Business, Innovation & Employment (MBIE), "Non-Metallic Mineral Product Manufacturing – Process Heat and Greenhouse Gas Emissions."

[130] EECA, "EECA - Energy End Use Database."

[131] Ministry of Business, Innovation & Employment (MBIE), "Non-Metallic Mineral Product Manufacturing – Process Heat and Greenhouse Gas Emissions."

[132] Ministry of Business, Innovation & Employment (MBIE), "Energy in New Zealand," 2022, https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-publications-and-technical-papers/energy-in-new-zealand/.

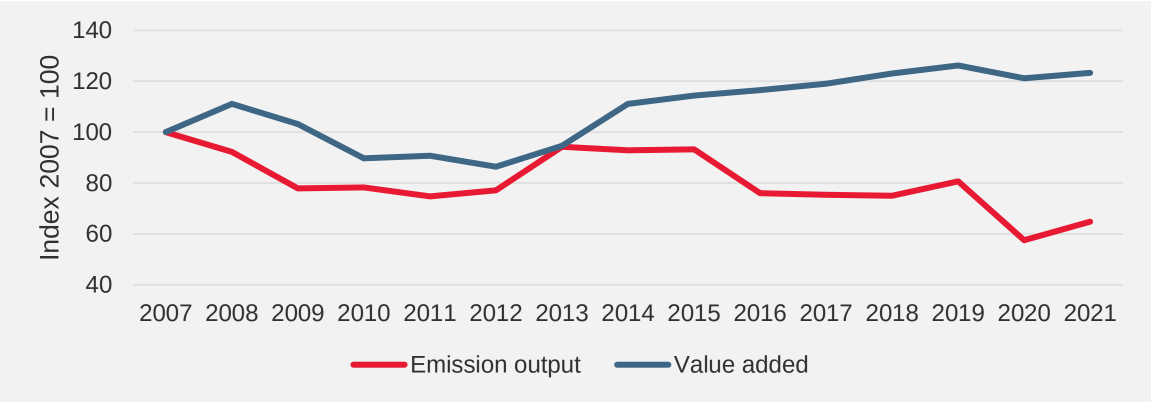

Figure 15: *Standardized Development of Emissions with Respect to the Value Added in the Cement and Lime Manufacturing Sector (Index level 2007 = 100).*[133] [134]

3.2.3 Chemical and Petroleum Product Manufacturing Sector

In New Zealand, this sector encompasses petroleum product manufacturing (like automotive diesel, petrol, and lubricating oil), basic chemical and chemical product manufacturing (like methanol and fertilisers), and polymer and rubber product manufacturing (including items like plastic bags, paint, and polymers).[135] Until recently, this list also included oil refining, however, New Zealand's sole refinery at Marsden Point has ceased its operations and became an import-only terminal in March 2022.[136]

Process heat within the sector is crucial for producing steam, hot water, or hot oil, typically generated onsite using boilers or furnaces. The application of this heat varies by product, including methanol, plastic products, and polymers, with temperature requirements ranging from low to high.[137]

However, most heat used in this sector is at high temperatures above 300°C, while temperatures of less than 100°C are only marginally represented.[138] Natural gas reformers provided about two-thirds of this heat in 2021, with the rest stemming from boiler systems, furnaces, and kilns. In total, chemical and petroleum manufacturing used 7.04 TWh of process heat that year, overwhelmingly stemming from non-renewable sources, predominantly natural gas at 98.7%.[139] Consequently, the sector's overall GHG emissions amounted to 1.38 Mt CO_2e, or 14% of total industry emissions, in 2022.[140]

The production of methanol, specifically from two plants in the Taranaki region, plays a pivotal role in this sector's natural gas consumption. Despite being heavily integrated with fossil-fuel-based process-heat technology, there might still be opportunities for the sector to achieve energy efficiency gains, for instance via advanced energy management practices. With Taranaki being the main prospect of New Zealand's offshore wind energy build-up, long-term investments in green hydrogen usage could also be feasible. Additionally, lower and parts of the intermediate temperature ranges could be served by industrial heat pumps in the future.[141]

Between 2007 and 2021, the chemical industry in New Zealand recorded a slight increase in emissions, with fluctuations, as shown in Figure 16. However, value added has increased significantly, reflecting

[133] Stats NZ, "New Zealand's Greenhouse Gas Emissions."

[134] Stats NZ, "National Accounts - Infoshare."

[135] Ministry of Business, Innovation & Employment (MBIE), "Petroleum, Chemical & Rubber Manufacturing – Process Heat and Greenhouse Gas Emissions," 2018, https://www.mbie.govt.nz/dmsdocument/4125-petroleum-chemical-rubber-manufacturing-process-heat-fact-sheet-pdf.

[136] Denise Piper, "Fuel Security Driving Government Study on Reopening Marsden Point Refinery," NZ Herald, 2024, https://www.nzherald.co.nz/northern-advocate/news/government-to-investigate-reopening-marsden-point-oil-refinery/

[137] Ministry of Business, Innovation & Employment (MBIE), "Petroleum, Chemical & Rubber Manufacturing – Process Heat and Greenhouse Gas Emissions."

[138] Ministry of Business, Innovation & Employment (MBIE).

[139] Energy Efficiency & Conservation Authority, "EEUD Data 2017-2021."

[140] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2022."

[141] Gas Industry Co, "THE NEW ZEALAND GAS STORY The State and Performance of the New Zealand Gas Industry," 2017, https://www.gasindustry.co.nz/assets/DMSDocumentsOld/gas-story/5806Gas-Story-Sixth-Edition-Updated-December-2017.pdf.

greater economic efficiency. Despite the sector's reliance on natural gas, a decoupling of economic output from emissions can be seen, indicating improved management of emissions intensity over time.

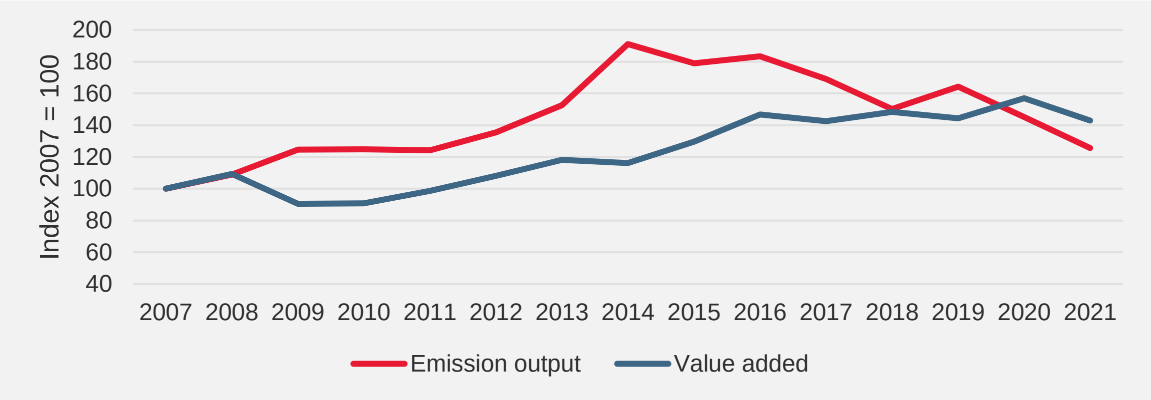

Figure 16: *Standardized Development of Emissions with Respect to the Value Added in the Chemical Manufacturing Sector (Index Level 2007 = 100).*[142] [143]

3.2.4 Food and Beverage Manufacturing Sector

As already mentioned, agricultural production and further processing represent important industries and export revenue sources for New Zealand's economy. This is especially true for the country's dairy industry but, on a smaller scale, also for meat, seafood, and other food manufacturing, which is why each sub-sector will be considered individually below.

In New Zealand, the dairy manufacturing sector heavily relies on process heat for various activities, primarily generated onsite using boilers or air heaters. Some facilities even possess cogeneration systems that produce both steam and electricity. Key dairy products include milk, milk powders, butter, cheese, and ice cream. Applications of process heat involve pasteurisation for safety and extended shelf-life, evaporation to concentrate milk solids, and spray drying, the latter being notably energy-intensive. In 2021, this sector consumed 5.35 TWh of fuel for generating process heat. A significant 56% of this fuel came from coal, 40% from natural gas, and the remaining 4% from other sources like LPG, biogas, diesel, and geothermal.[144]

Mainly due to the high coal usage rates, this relative carbon-intense energy mix led to overall sector emissions of 2.68 Mt CO_2e, or 28% of total industry emissions in 2022.[145] Lacking access to natural gas, dairy manufacturing sites in the South Island are particularly carbon-intensive, covering 97% of their fuel consumption with coal. This results in Southern regions representing a higher share in emissions albeit having fewer total plants.[146] [147] Notably, more than half of the sector's coal consumption (or 1.99 TWh) currently stems from low temperature (<100°C) usage forms, i.e. low-temp process heat or water heating, making the future adoption of industrial heat pumps (IHPs) particularly attractive in this sector.[148] [149]

[142] Stats NZ, "New Zealand's Greenhouse Gas Emissions."

[143] Stats NZ, "National Accounts - Infoshare."

[144] Energy Efficiency & Conservation Authority, "EEUD Data 2017-2021."

[145] Ministry for the Environment, "New Zealand's Greenhouse Gas Inventory 1990–2022."

[146] EECA, "Regional Heat Demand Database," 2023, https://www.eeca.govt.nz/insights/data-tools/regional-heat-demand-database/.

[147] Ministry of Business, Innovation & Employment (MBIE), "Dairy Manufacturing – Process Heat and Greenhouse Gas Emissions," 2018, https://www.mbie.govt.nz/dmsdocument/151-dairy-maufacturing-fact-sheet-pdf.

[148] EECA, "Industrial Heat Pumps for Process Heat," EECA, 2023, https://www.eeca.govt.nz/insights/eeca-insights/industrial-heat-pumps-for-process-heat/

[149] Energy Efficiency & Conservation Authority, "EEUD Data 2017-2021."

Besides dairy, meat and seafood production represents another important and export-intensive industry in New Zealand. The sector accounted for 491 kt CO_2e emissions in 2021, having a total energy fuel demand of 2.2 TWh, 0.42 TWh of which stemmed from process heat. Although recent data on the composition of process heat sources is incomplete, it appears that natural gas represents the major portion, with coal providing around a third and LPG, diesel, and wood only marginal shares to its energy mix. A significant portion of the sector's coal usage can be found on the South Island (490 GWh) and, again, in low to intermediate-temperature application areas, for instance, water heating.[150] [151]

In comparison, the other food and beverages sector employs process heat primarily for brewing, cooking, and commercial baking, generated mainly using onsite boilers and ovens. The sector had a total energy consumption of 1.64 TWh in 2021, 53% or 0.88 TWh of which were used to fuel process heat. Here, natural gas covers most of the demand with 64%, followed by lower shares of diesel (12.3%), coal (11.5%), LPG (10%), and electricity (2.4%). Again, this energy mix appears to be differing significantly between regions, with most of the South Island's fuel demand being met by coal. Thus, the South accounts for around three-quarters of the sector's total coal demand, resulting in an overall higher carbon intensity in production.[152] [153]

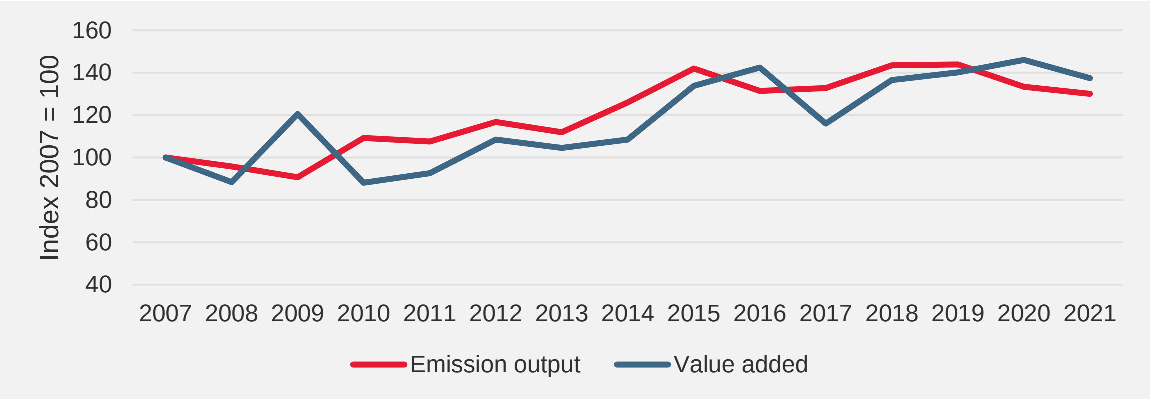

Figure 17: *Standardized Development of Emissions with Respect to the Value Added in the Food and Beverage Manufacturing Sector (Index Level 2007 = 100).*[154] [155]

A moderate decoupling of emissions from value added in New Zealand's food and beverage sector is evident from 2007 to 2021, as shown in Figure 17. While value added consistently increased, emissions did not rise as steeply, indicating some efficiency gains. However, the continued dependence on carbon-heavy fuels highlights the need for strategies that more effectively separate economic gains from environmental costs.

3.3 State of Energy Efficiency and Management

In New Zealand, efforts to improve energy efficiency span various sectors and are guided by multiple factors, including government policies, industry pledges, and global events and price developments.

The country's Emission Trading Scheme (ETS) has a relatively broad coverage, encompassing 52% of the nation's gross emissions and power, industrial, buildings, transport, domestic aviation, waste, and forestry sectors.[156] Notably, however, agriculture, New Zealand's biggest sectoral source of emissions,

[150] Energy Efficiency & Conservation Authority.

[151] EECA, "Regional Heat Demand Database."

[152] EECA.

[153] Energy Efficiency & Conservation Authority, "EEUD Data 2017-2021."

[154] Stats NZ, "New Zealand's Greenhouse Gas Emissions."

[155] Stats NZ, "National Accounts - Infoshare."

[156] Ministry for the Environment, "About the New Zealand Emissions Trading Scheme," 2023, https://environment.govt.nz/what-government-is-doing/areas-of-work/climate-change/ets/about-nz-ets/.

is currently not part of its ETS, and further expansions originally planned for the mid-2020s are pending.[157] In addition, New Zealand's Climate Change Commission criticised the widespread availability of carbon credits in March 2024, urging the government to drastically limit the supply of certificates to reach its climate goals.[158]

Besides agriculture, the industry sector in New Zealand has been identified as a significant consumer of energy, especially for process heat, and electricity. Projections suggest that energy efficiency in this sector could increase by 35% by 2060 through the adoption of electric boilers and biomass conversion. Decarbonisation efforts in industry are further influenced by carbon pricing and government policies, underlining the complexity of achieving energy efficiency on a larger scale.[159]

Not least due to rising global energy prices, private sector initiatives promoting energy efficiency and sustainability in New Zealand have experienced recent growth. This is most notably seen in BusinessNZ and its Sustainable Business Council (SBC) and Energy Council divisions. In 2023, the SBC alone connected companies that made up more than 40% of the country's GDP and 15% of its labor force, facilitating impactful initiatives like AgriZeroNZ for agricultural emissions reduction, promoting the decarbonisation of heavy transport and advancing sustainability practices among its members.[160] Other business initiatives towards increased sustainability include the Climate Leaders Coalition, whose members pledge to keep their scope 1, 2, and 3 emissions in line with the 1.5°C goal and to publicly disclose them together with their climate change risks by September 2025.[161]

In summary, New Zealand's industry sector stands as a critical area for advancement in sustainability practices, where the implementation of the ETS and the integration of new technologies promise significant improvements in energy efficiency. However, the nation's overall emission trends over past decades highlight the necessity for intensified efforts to drive sustainable development and energy optimisation within this industry sector.

[157] Lucy Craymer, "New Zealand Pushes Back Start Date for Price on Farm Emissions," *Reuters*, August 18, 2023, https://www.reuters.com/business/environment/new-zealand-pushes-back-start-date-price-farm-emissions-2023-08-18/.

[158] Eloise Gibson, "Climate Change Commission Urges Govt to Cut Carbon Credit Surplus," RNZ, 2024, https://www.rnz.co.nz/news/national/511479/climate-change-commission-urges-govt-to-cut-carbon-credit-surplus.

[159] EECA, "New Zealand Energy Scenarios."

[160] Sustainability Business Council, "Annual Snapshot 2023," 2024, https://sbc.org.nz/resources/annual-snapshot-2023/.

[161] Climate Leaders Coalition, "Statement of Ambition," 2022, https://climateleaderscoalition.org.nz/about/statement-of-ambition/.

Excursus: Data Centres

Both Germany and New Zealand have seen a surge in data consumption in the past decade, but their approach to energy use and emissions from data centres diverges notably. In Germany, data volume increased from 3.4 billion gigabytes (GB) in 2010 to an estimated 72 billion GB in the pandemic year of 2020.[162] Alongside, the energy consumption for servers and data centres went up by 7% in 2020, totalling 16 GWh.[163] Due to advancements in digital technologies like Artificial Intelligence (AI) and blockchain, Germany expects the energy needs of its data centres to increase by more than 60% from 2015 to 2025. Despite a 21% improvement in infrastructure efficiency between 2010 and 2020, as evidenced by the gains in data center IT and infrastructure components, data centres are expected to face an ongoing increase in energy demand in the future. The construction boom of data centres in Germany, which has persisted for several years, is likely to continue going forward.[164] From 2010 to 2020, Emissions from data centres have increased from 5.7 Mt CO_2e to 7.7 Mt CO_2e.[165] While renewable capacities in the grid rise, this substantial increase has led to a recent expansion of Germany's regulatory framework of the industry. For example, data centres with volumes above 1 MW are required to have an Energy Reuse Factor (ERF) of at least 10 % and to cover their energy consumption (by half beginning in 2024 and fully by 2027) through electricity from renewables.[166] Further regulations under Germany's Energy Efficiency Act include an obligation for data centres with a certain energy consumption to register in a public "efficiency registry" and to make the waste heat from their operations available to operators of heating networks.[167]

Similarly, in 2022 New Zealand saw the average monthly data usage per broadband connection reach 416 GB, which is 16 times more than a decade ago and translates to a total data volume of roughly 9.3 billion GB per year.[168] The power requirements of New Zealand's data centres are forecasted to grow from 81 MW in the past year to 303 MW by 2030.[169] Despite this, the country is harnessing its rich renewable energy sources to offset the environmental impact. Companies like CDC, Datacom, and Microsoft have already signed PPAs for fully renewable energy supply and operate all or part of their data centres in New Zealand carbon neutral. Besides being provided with renewable energy, CDC, for instance, also uses innovative waste and water efficiency measures to ensure carbon neutrality.[170]

In summary, both nations face a rise in data volumes and associated energy requirements. Thanks to its overall less carbon-intensive power mix, New Zealand has made more progress towards sustainability so far. Besides an increasing share of renewables in the grid, individual PPAs with fully renewable energy providers, closed-loop cooling systems and zero-waste strategies can help to make data centres carbon-neutral as previous experience from New Zealand demonstrates. With increasing pressure on the power system, also through electrification of other industry sectors, reuse of energy as targeted by recent German legislation should become interesting for New Zealand as well.

[162] Deutscher Bundestag, "Sachstand-Energieverbrauch von Rechenzentren," 2021, https://www.bundestag.de/resource/blob/863850/423c11968fcb5c9995e9ef9090edf9e6/WD-8-070-21-pdf-data.pdf.

[163] Borderstep Institut, "Energiebedarf Der Rechenzentren Steigt Trotz Corona Weiter An," 2020, https://www.borderstep.de/wp-content/uploads/2021/03/Borderstep_Rechenzentren2020_20210301_final.pdf.

[164] Borderstep Institut.

[165] Frankfurter Rundschau, "Die digitalen Stromfresser," September 8, 2023, https://www.fr.de/politik/die-digitalen-stromfresser-92508813.html.

[166] Dentons, "Energieeffizienzgesetz – Relevanz für Rechenzentren," 2023, https://www.dentons.com/de/insights/articles/2023/september/25/energy-efficiency-act-relevance-for-data-centers.

[167] Bundesministerium für Wirtschaft und Klimaschutz, "Energieeffizienzregister für Rechenzentren (RZReg)," 2024, https://www.bmwk.de/RZReg/rechenzentrums-register.html.

[168] Statista, "New Zealand: Monthly Data Use per Broadband Connection 2022," 2023, https://www.statista.com/statistics/995805/monthly-data-use-per-broadband-connection-new-zealand/; Statista, "New Zealand: Fixed Broadband Connections 2022," 2023, https://www.statista.com/statistics/995773/fixed-broadband-connections-new-zealand/.

[169] Stuff, "NZ Could Become Land of the Long 'green' Cloud, NZTE Report Finds," 2022, https://www.stuff.co.nz/business/128638239/nz-could-become-land-of-the-long-green-cloud-nzte-report-finds.

[170] Shannon Williams, "NZ's First Hyperscale Data Centres Now First Net Carbon Zero," IT Brief NZ, 2023, https://itbrief.co.nz/story/nz-s-first-hyperscale-data-centres-now-first-net-carbon-zero.

4 Policy Framework in Germany and New Zealand

4.1 Policy Framework in Germany

4.1.1 Targets for Sectors

As with other policy fields, Germany is bound to regulation developed within the institutions of the European Union (EU). A key instrument for achieving the target of climate neutrality by 2050 is the EU Emission Trading System (EU ETS), which covers the energy, energy-intensive industry, maritime transport, and aviation sectors and demands emission reductions of 62%. As part of the European Green Deal, the European Climate Law, adopted in 2021, established new emission reduction goals for 2030. This new piece of legislation mandates that the member states collectively must reduce their emissions by 55% by 2030 compared to the baseline year of 1990.[171] [172] Moreover, the Climate Law addresses all sectors not covered by the EU ETS and subjects them to an “effort-sharing” system among the member states. These sectors account for almost 60% of overall emissions in the EU. In a deviation from the framing of the overall goal, 2005 is set as the baseline year for the effort-sharing regulation. With a 50% reduction goal by 2030 for the emissions covered by the Climate Law, Germany is among the member states with the highest mitigation targets. This is consistent with the bloc’s intention that member states with higher GDP per capita should carry the bulk of the collective emission reduction.[173] While emission reduction quotas increase progressively every year, member states are granted some flexibility in their achievement, leaving room for subpar years and even the trade of parts of their allocations among each other.[174]

The German regulatory framework for greenhouse gas emission reductions is set in line with EU regulation by the Federal Climate Action Act, first passed in 2019. After a ruling by Germany’s constitutional court, the Act was reformed in 2021 with stricter reduction goals. In the new version, the country has committed itself to a 65% emission reduction compared to 1990 by 2030, an 88% reduction by 2040, and climate-neutrality by 2045.[175] The Act defines goals for each sector of the economy and obliges ministries responsible for a given sector to introduce urgent measures if targets are missed. For the industry sector, a maximum of 119 Mt Co_2e are to be emitted in 2030 under the Climate Action Act, resulting in a 57% decrease compared to 1990 (see also Figure 18). In early May 2024, a reform was passed that removes the individual accountability mechanism for the sector goals focusing instead on overall emission reductions and imposing resulting obligations on the government as a whole rather than on individual ministries. The reform has drawn criticism from civil society and parts of the scientific community due to fears that it might lead to a diffusion of responsibility and impede the overall effectiveness of the law.[176]

Germany’s environmental protection agency, the Umweltbundesamt (UBA), has released its newest emission data in March 2024. It states that the largest annual reduction in greenhouse gas emissions since 1990 was achieved in 2023 with a decrease of 10.1 %. According to UBA’s projections, for the first time since the adoption of the Climate Action Act, emission budgets for 2030 appear to be in reach. Main drivers for the record emission reduction where the energy (- 20.1%) and industry sectors (- 7.7%), while the building and transport sectors remain off track regarding their sectoral targets (see Figure 18).[177] However, emission reductions in the energy and industry sector were not only due to the

[171] In February 2024, the Commission set the next interim target for 2040 to be at 90% below 1990 levels.

[172] European Commission, “European Climate Law“, 2024, https://climate.ec.europa.eu/eu-action/european-climate-law_en

[173] European Commission, "Effort sharing 2021-2030: targets and flexibilities," 2024, https://climate.ec.europa.eu/eu-action/effort-sharing-member-states-emission-targets/effort-sharing-2021-2030-targets-and-flexibilities_en.

[174] European Commission, "Effort sharing 2021-2030: targets and flexibilities," 2024, https://climate.ec.europa.eu/eu-action/effort-sharing-member-states-emission-targets/effort-sharing-2021-2030-targets-and-flexibilities_en.

[175] Bundesregierung, "Intergenerational contract for the climate," 2021, https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/climate-change-act-2021-1913970.

[176] Jan Zimmermann, "Warum es Kritik am Klimaschutzgesetz gibt," 2023, https://www.tagesschau.de/inland/innenpolitik/klimaschutzgesetz-110.html.

[177] Umweltbundesamt, "Klimaemissionen sinken 2023 um 10,1 Prozent – größter Rückgang seit 1990," 2024, https://www.umweltbundesamt.de/presse/pressemitteilungen/klimaemissionen-sinken-2023-um-101-prozent.

increased usage of renewable energy sources and greater efficiency, but also due to a relatively mild winter and reduced economic activity.

Development and target achievement of greenhouse gas emissions in Germany

in the differentiation of the sectors of the Climate Protection Act

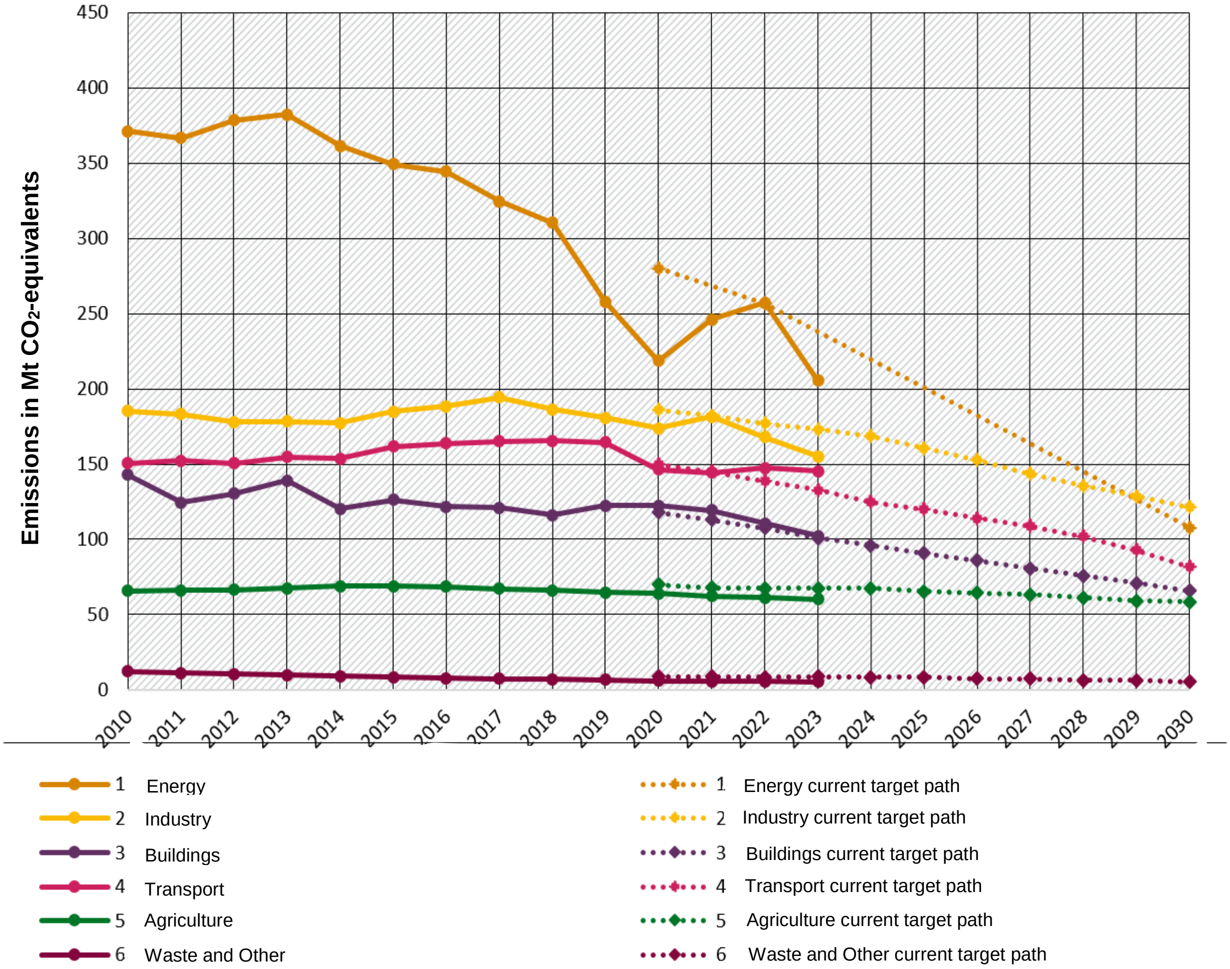

***Figure 18:** Sectoral Emission Reduction Goals According to the Federal Climate Change Act.*[178]

In order to achieve the emission reduction goals shown in Figure 18, the government has translated the targets into tangible pathways for renewable energy and green hydrogen expansion. The Climate Action Act requires Germany's electricity mix to be 80% renewable in 2030. Accordingly, overall capacities for solar PV and wind energy are set to reach 215 GW and 145 GW, respectively. 30 GW of the latter figure for wind energy are to come from offshore wind energy.[179] To ensure the decarbonisation of hard-to-electrify industrial appliances and backup power plants, the government has updated its National Hydrogen Strategy (NHS) in late 2023. This strategy sets the goal of establishing domestic electrolysis capacities of 10 GW by 2030. The current hydrogen demand of 55 TWh per year is projected to rise to 95 – 130 TWh in 2030, highlighting the need for increased import capacities.[180] As industrial applications like the provision of process heat are seen as a major use case for green hydrogen in the German discourse, this envisioned market ramp-up is especially crucial for the decarbonisation of the German industry sector.

[178] Umweltbundesamt, "Treibhausgasminderungsziele Deutschlands," 2023. https://www.umweltbundesamt.de/daten/klima/treibhausgasminderungsziele-deutschlands#undefined.

[179] Bundesministerium für Wirtschaft und Klimaschutz, "Erneuerbare Energien," 2024, https://www.bmwk.de/Redaktion/DE/Dossier/erneuerbare-energien.html.

[180] Bundesministerium für Wirtschaft und Klimaschutz, "National Hydrogen Strategy Update," 2023, https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/national-hydrogen-strategy-update.pdf?__blob=publicationFile&v=2.

4.1.2 CO2- Price and Regulations

When looking at EU policy, the EU ETS has long been the most consequential instrument for cutting greenhouse gas emissions. Since its introduction in 2005, sectors covered by the EU ETS have achieved emission reductions of 43%. This is a huge success, as these sectors account for 41% of the EU's overall emissions.[181] In May 2023, agreement on a reform of the existing ETS was reached in the trilogue format. The reformed regulation mandates a strengthened emissions reduction target for ETS sectors of 62% by 2030 compared to 2005 and regulates the gradual phase-out of free allowance allocations in some sectors. Additionally, the regulation broadens the existing ETS' scope to include maritime transport and has introduced a separate ETS (EU ETS II) for direct emissions from the buildings, road transport sector, and some other smaller industries not previously covered. These provisions will come into effect in 2027[182] and will essentially cover all emissions. The regulation also initiates the phase-in of a Carbon Border Adjustment Mechanism (CBAM), which seeks to prevent carbon leakage of emission-intensive products and improve competitiveness of European producers. The CBAM has started operating in October 2023 and initially covers products from the steel and iron, cement, fertilizers, aluminium, electricity, and hydrogen sectors.[183]

In addition to the EU ETS, Germany has set up its own ETS system in 2021, covering the transport, buildings and small industry sectors, which were previously not regulated by the existing EU ETS. The German ETS has started with a fixed price of 25 EUR/t CO_2e and will be increased to 55 EUR/t CO_2 in 2025. From 2026 onwards, allowances will be auctioned. In 2027, the national ETS will be replaced by the EU ETS II. [184]

Aside from the ETS, a range of other European regulations affect the decarbonisation of Germany's industry sector. One very important example of this is the Energy Efficiency Directive, revised throughout 2023 and adopted in September of the same year. The Directive aims to increase the contribution of energy efficiency measures towards the EU's climate goals by establishing the 'energy efficiency first'-principle and setting a legally-binding energy consumption reduction goal of 11.7% by 2030 compared to 2020. The Directive obliges member states to set their own national contributions, raises the annual savings obligation, and includes a "gap-filling mechanism" should individual member states fall short of their goals.[185] As with any EU Directive, the goals set by this Directive need to be translated into national legislation. Accordingly, the German Bundestag has passed its Energy Efficiency Act (Energieeffizienzgesetz) in September of 2023. The Act includes the target of a 26.5% reduction of energy consumption by 2030 compared to the baseline year of 2008. It also mandates enterprises with an energy consumption exceeding a certain threshold to implement environmental or energy management systems and identify cost-efficient measures increasing efficiency. However, the Act includes no obligation to actually implement these measures.[186] For this, and its lack of ambition, the Act was criticised by different special interest groups.

The European Union tries to address both energy savings as well as increased circularity in the lifecycle of energy intensive products through its Ecodesign Directive passed in 2009. It is estimated that the Directive has led to a 10% decrease in energy consumption by products belonging to the 31 product groups covered by the Directive. A revised edition of the Directive proposed by the EU Commission in 2022 ("Ecodesign for Sustainable Products Regulation") establishes a new framework for requirements regarding energy performance, circularity, and other sustainability parameters. It also envisions the establishment of "digital product passports", providing customers with valuable information, such as the

[181] Clean Energy Wire, "Germany's carbon pricing system for transport and buildings," 2024, https://www.cleanenergywire.org/factsheets/germanys-planned-carbon-pricing-system-transport-and-buildings.

[182] International Carbon Action Partnership, "EU adopts landmark ETS reforms and new policies to meet 2030 target," 2023, https://icapcarbonaction.com/en/news/eu-adopts-landmark-ets-reforms-and-new-policies-meet-2030-target.

[183] European Council, "EU climate action: provisional agreement reached on Carbon Border Adjustment Mechanism (CBAM)," 2022, https://www.consilium.europa.eu/en/press/press-releases/2022/12/13/eu-climate-action-provisional-agreement-reached-on-carbon-border-adjustment-mechanism-cbam/.

[184] Clean Energy Wire, "Germany's carbon pricing system for transport and buildings," 2024, https://www.cleanenergywire.org/factsheets/germanys-planned-carbon-pricing-system-transport-and-buildings.

[185] European Commission, "Energy Efficiency Directive," 2024, https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en.

[186] EMAS, "Energieeffizienzgesetz verpflichtet zu Energie- oder Umweltmanagement," 2024, https://www.emas.de/aktuelles/news/18-10-23-enefg.

product's origin, components, and recycling options.[187] The Commission estimates that by 2030, the new framework could lead to energy savings equivalent to the amount of gas the EU imported from Russia before Russia's invasion of Ukraine (150 billion m^3).[188] The Parliament and Council agreed on the revised Directive in December 2023 so that the rules are likely to come into effect in 2024.[189]

Further, in 2023, the EU's Corporate Sustainability Reporting Directive (CSRD) entered into force. The Directive requires all listed companies to disclose information on environmental and social risks associated with their business. The new rules are designed to increase transparency for investors, costumers, and other stakeholders Companies will have to report according to European Sustainability Reporting Standards (ESRS).[190]

4.1.3 Incentive Systems and Funding Programmes

The German government supports the decarbonisation of the country's industry sector with several funding mechanisms and, in some cases, special funding opportunities for specific sectors.

In May of 2023, the revised funding programme on "Energy and Resource Efficiency in the Economy" (EEE) came into force. The programme is one of the main funding options in Germany for enterprises looking to decarbonise their production and improve energy and resource efficiency. The revised directive now offers funding in six categories ("modules"), compared to five in the previous version. Further, geothermal plants for process heat generation were added to the funded technologies and funding for small enterprises was increased.[191] The modules feature different possibilities for more efficient industrial processes, like the exchange of appliances, the establishment of renewable heat generation, energy management systems, and electrification measures for small enterprises. Under each module a different maximum funding volume is indicated, with the overall maximum project funding standing at 20 million EUR (see Figure 19).[192] The EEE programme is an important incentive lever for the decarbonisation of Germany's industry sector and attracts a lot of attention by businesses with over 17,000 funding requests submitted each year. In 2023, projects with an overall volume of 1.2 billion EUR received funding.[193] The programme's evaluation by Fraunhofer ISI et al. calculates that all implemented measures supported by the programme will lead to emission reductions of 22.5 Mt CO_2e over their lifecycle.[194]

[187] University of Cambridge Institute for Sustainability Leadership (CISL) and the Wuppertal Institute, "Digital Product Passport: The ticket to achieving a climate neutral and circular European economy?," 2022, https://circulareconomy.europa.eu/platform/sites/default/files/cisl_digital_products_passport_report_v6.pdf.

[188] European Commission, "Ecodesign for Sustainable Products Regulation," 2024, https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_en?prefLang=de.

[189] Simon, Frédéric, "Deal on new 'ecodesign' rules to make EU products greener, easier to repair," 2023, https://www.euractiv.com/section/circular-economy/news/deal-on-new-ecodesign-rules-to-make-eu-products-greener-easier-to-repair/.

[190] European Commission, "Corporate sustainability reporting," 2024, https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en.

[191] Bundesamt für Wirtschaft und Ausfuhrkontrolle, "Bundeswirtschafts – und Klimaschutzministerium baut Förderung zur Dekarbonisierung von Unternehmen aus," 2023, https://www.bafa.de/SharedDocs/Pressemitteilungen/DE/Energie/2023_08_eew.html.

[192] Bundesamt für Wirtschaft und Ausfuhrkontrolle, "Übersicht zur Bundesförderung für Energie- und Ressourceneffizienz," 2024, https://www.bafa.de/DE/Energie/Energieeffizienz/Energieeffizienz_und_Prozesswaerme/Uebersicht/uebersicht_node.html.

[193] Klimaschutz- und Energieagentur Niedersachsen, "Novelle der Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft (EEW) in Kraft getreten," 2024, https://www.klimaschutz-niedersachsen.de/Novelle-der-Bundesfoerderung-fuer-Energie-und-Ressourceneffizienz-in-der-Wirtschaft-EEW-in-Kraft-3685.

[194] Neusel, Lisa; Schlomann, Barbara; Heinrich, Stephan; Weinert, Karsten; Grodeke, Anna-Maria; Radgen, Peter; Anzaldo Grundler, Alina T: Schumacher, Katja; Nissen, Christian; Ludig, Sylvie, "Evaluation der „Bundesförderung für Energieeffizienz in der Wirtschaft"," 2023, https://publica-rest.fraunhofer.de/server/api/core/bitstreams/768b21ed-2ada-4893-8ec9-0e684a48bed3/content.

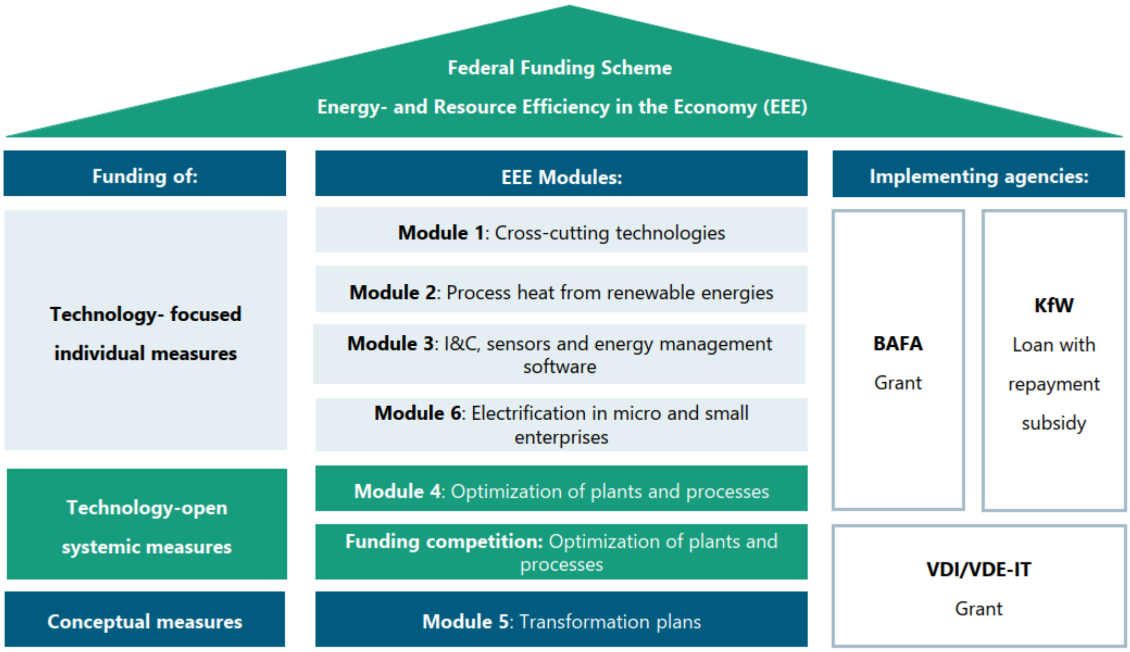

Figure 19: *Overview of the German EEE-Funding Scheme (Neusel 2024).*[195]

In April 2024, a new funding programme called "Federal Funding for Industry and Climate Protection" was approved by the European Commission's competition authority. The new funding mechanism is intended to support the decarbonisation of middle-sized companies with grants of up to 200 million EUR, if the respective Federal State provides a third of the funding volume. Projects can be funded starting from investment costs of 500.000 EUR, investments of over 15 million EUR need to be complemented by Federal State funding. Investments in projects under this scheme have to save a significant portion of a company's emissions (at least 40%) in order to receive funding.[196] The new funding succeeds the previous "Decarbonisation in Industry" funding, which was specifically aiming at innovative projects lowering process emissions in energy-intensive industrial sectors. By the time of publication of this study, specifications on the funding scheme's conditions were still being developed.[197]

In a more recent development, Germany has become the first country globally to implement "Carbon Contracts for Difference" (CCfD) with the aim of speeding up the decarbonisation of its energy-intensive industries while preserving international competitiveness. The instrument is derived from the private sector, where similar contracts are used to hedge against investment risks. The government's CCfD programme guarantees a certain carbon price for companies regulated under the EU ETS with savings over the fixated amount flowing back to the government (see Figure 20).[198] The mechanism is designed as a learning system, as there is no guarantee that funded companies or technologies will ultimately prevail in the market. 4 billion EUR are earmarked for the first round which is currently underway, with an additional 19 billion EUR following in the summer of 2024.[199]

[195] Lisa Neusel, Lisa; Schlomann, Barbara; Heinrich, Stephan; Weinert, Karsten; Grodeke, Anna-Maria; Radgen, Peter; Anzaldo Grundler, Alina T: Schumacher, Katja; Nissen, Christian; Ludig, Sylvie, "Evaluation der „Bundesförderung für Energieeffizienz in der Wirtschaft"," 2023, https://publica-rest.fraunhofer.de/server/api/core/bitstreams/768b21ed-2ada-4893-8ec9-0e684a48bed3/content.

[196] Bundesministerium für Wirtschaft und Klimaschutz, "Dekarbonisierung für den industriellen Mittelstand," 2024, https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2024/04/20240410-dekarbonisierung-fuer-den-industriellen-mittelstand.html.

[197] Zukunft Umwelt Gesellschaft, "Förderprogramm Dekarbonisierung in der Industrie," 2024, https://www.z-u-g.org/foerderung/dekarbonisierung-in-der-industrie/.

[198] Bundesministerium für Wirtschaft und Klimaschutz, "Carbon Contracts for Difference," 2024, https://www.klimaschutzvertraege.info/en/home.

[199] Sorge, Petra; Rathi, Akshat, "Germany's €23 Billion Green Experiment to Save Its Industrial Economy," 2024, https://www.bloomberg.com/news/articles/2024-03-27/germany-s-23-billion-green-experiment-to-save-its-industrial-economy?cmpid=BBD032724_GREENDAILY&utm_medium=email&utm_source=newsletter&utm_term=240327&utm_campaign=greendaily.

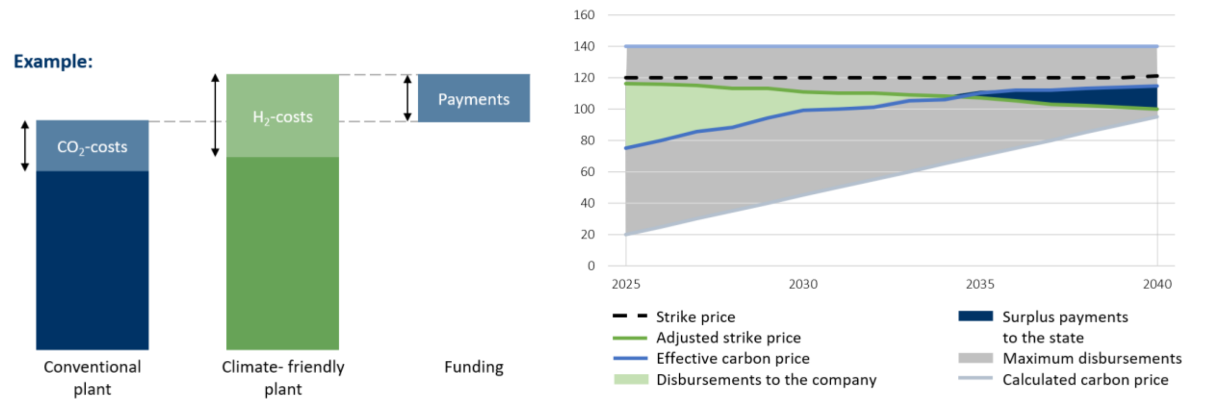

***Figure 20:** Overview of the Functioning and Height of the Funding in the German Carbon Contracts for Difference (BMWK 2024).*[200]

While the European Union's single market typically does not allow unilateral subsidies for specific enterprises in order to preserve competition and the market's integrity, exceptions can be made for so called 'Important Projects of Common European Interest (IPCEI)'. IPCEIs have to be co-financed by the relevant enterprises, contribute to strategic goals of the EU, be implemented in multiple member states, lead to positive spill-over effects into other member states, and have especially ambitious and forward-thinking goals in terms of technology development. If these requirements are fulfilled, subsidies for individual enterprises can be approved by the European Commission[201]. Additionally, since 2022 the Commission's 'Guidelines on State aid for climate, environmental protection and energy (CEEAG)' specify how member states are allowed to assist projects conducive to the objectives of the EU's Green Deal "in a targeted and cost-effective manner".[202]

The German government has sought to use these legal exemptions to European competition law to assist key industries in their decarbonisation efforts and thereby ensure continued global competitiveness in various sectors. As has become evident above, the steel manufacturing and processing industries are a key component in the decarbonisation of the German industry sector. Therefore, the German government has announced extensive special funding for various steel producers in 2023. In order to help with the transformation of their production towards the use of green hydrogen, Thyssenkrupp, Salzgitter AG and Stahlholding Saar are receiving grants of almost one and close to two billion EUR, respectively.[203] Funding for the first two companies has already been approved by the European Commission's competition Directorate.[204]

The Federal Ministry for Economic Affairs and Climate Action offers an interactive manual on its website giving companies and citizens an orientation on which funding programmes for energy efficiency are suitable for their needs.[205]

One central initiative in the industry sector is the Initiative for Energy Efficiency and Climate Action Networks (IEEKN). Introduced in 2014 as one pillar in Germany's National Action Plan on Energy Efficiency (NAPE), the Initiative for Energy Efficiency Networks (IEEN) created a voluntary agreement between the German government and 20 business associations with the aim of increasing energy efficiency and reduce emissions in the German industry. The IEEN aimed to generate 500 new energy efficiency networks of usually 5 to 15 companies each of which cooperate on a voluntarily basis for 24

[200] Bundesministerium für Wirtschaft und Klimaschutz, "Klimaschutzverträge," 2024, https://www.klimaschutzvertraege.info/lw_resource/datapool/systemfiles/agent/ewbpublications/ff178284-eabb-11ee-8b39-a0369fe1b6c9/live/document/240322_Vorstellung_der_Klimaschutzvertr%C3%A4ge.pdf.

[201] Bundesministerium für Wirtschaft und Klimaschutz, "Häufig gestellte Fragen zum "Important Project of Common European Interest (IPCEI)"," 2024, https://www.bmwk.de/Redaktion/DE/FAQ/IPCEI/faq-ipcei.html.

[202] State aid: Commission approves German €550 million direct grant and conditional payment mechanism of up to €1.45 billion to support ThyssenKrupp Steel Europe in decarbonising its steel production and accelerating renewable hydrogen uptake," 2023, https://ec.europa.eu/commission/presscorner/detail/en/IP_23_3928.

[203] Mayer, Florian, "Habeck verspricht Milliardenhilfen für Stahlkocher im Saarland," 2023, https://www.tagesschau.de/wirtschaft/unternehmen/stahl-saarland-habeck-100.html.

[204] Mayr, Jakob, "Grüner Stahl: EU genehmigt Milliarden-Beihilfe für Thyssenkrupp," 2023, https://www.tagesschau.de/wirtschaft/unternehmen/gruener-stahl-thyssenkrupp-100.html.

[205] Bundesministerium für Wirtschaft und Klimaschutz, "Förderwegweiser Energieeffizienz," 2024, https://www.energiewechsel.de/KAENEF/Navigation/DE/Foerderprogramme/Foerderfinder/foerderfinder.html.

to 48 months. Each company first carries out an energy audit and sets itself a savings target. After that, the companies meet regularly and support each other with the implementation of the energy savings measures as well as subject themselves to monitoring at the end of the network runtime. Deemed successful, the initiative has been expanded under NAPE 2.0 with a broader scope – besides energy saving measures, measures which directly result in GHG reductions can now also contribute towards the official savings goal of 9 to 11 TWh of final energy and 5 to 6 Mt of CO_2-equivalents. 300 to 350 new networks are to be established by 2025. While the concept was originally developed in Switzerland in 1987, today, Germany is the country with the most energy efficiency networks.

4.2 Policy Framework in New Zealand

4.2.1 Targets for Sectors

New Zealand's current overall decarbonisation and climate change-related policy framework was established with the Climate Change Response (Zero Carbon) Amendment Act in 2019. It amended the Climate Change Response Act from 2002 and summoned all climate legislation within one Act. The legislation sets a net zero greenhouse gas emission target for 2050 and mandates the establishment of intermediate emissions budgets as stepping stones towards the 2050 goal. Biogenic methane has a separate target of a reduction by 24 – 47% compared to 2017 levels by 2050.[206] Since methane is responsible for nearly half of New Zealand's greenhouse gas emissions (43% in 2020), the exemption of biogenic methane emissions from the overall 2050 target suggest that GHG neutrality is not the 2050 target.[207] In order to specify its pathway to climate neutrality in 2050, the government released three emission budgets for the near to mid-term future, spanning from 2022 to 2035. In the years up to the end of 2025, the country aims not to exceed an emissions budget of 290 Mt CO_2e in total (average of 72.4 Mt/year). For the second budget, leading up to and including 2030, it aims for a maximum total of 305 Mt CO_2e (61 Mt/year) emissions. For the third budget, running until the end of 2035, an emission limit of 240 Mt CO_2e (48 Mt/year) is set, equalling a 35% decrease in emissions compared to the five years leading up to 2022.[208] To reach the 2050 target and achieve arithmetic climate neutrality, it is planned to purchase carbon credits from overseas, amounting to estimated costs ranging from 3.3 billion NZD (1.8 billion EUR) to 23 billion NZD (13 billion EUR) until 2030.[209]

In May 2022, New Zealand's Ministry for the Environment published the country's first Emission Reduction Plan (ERP) setting out New Zealand's path "towards a productive, sustainable and inclusive economy". The plan defines the goal of an additional greenhouse gas emission reduction of 11.5 Mt CO_2e between 2022 and 2025 to be able meet the emission budget for the same period that was published in 2022. It builds on previous steps like the passing of the Climate Change Response (Zero Carbon) Amendment Act in 2019, reforms to the national Emission Trading Scheme and measures like the end of offshore fossil fuel exploration. The plan frames the transition away from fossil fuels as one with manifold benefits for New Zealand's society, like lowering the cost of living and improving the overall quality of life. Key export industries, like the food and fibre industry, are supposed to become known as global leaders in sustainable production. Agricultural emissions are planned to be subject to a carbon price from 2025 onwards.[210] The plan has been lauded for a holistic approach by including nature-based solutions but was criticised for its low level of ambition, seemingly avoiding contentious topics and focusing on the acceptability of the proposed measures.[211]

After the change in government from Labour to the conservative coalition government in late 2023, it remains to be seen whether all provisions of the ERP will be enacted. While the current government has pledged commitment to the existing climate targets, the reversal of key climate initiatives like the ban on gas and oil field exploration suggest that progress towards those targets might be slower than expected.[212] In addition, a 2023 assessment by the International Monetary Fund has shown, that New Zealand is not yet on track to achieving its 2030 emission reduction targets. The assessment called for

[206] Ministry for the Environment, "Climate Change Response (Zero Carbon) Amendment Act 2019," 2021, https://environment.govt.nz/acts-and-regulations/acts/climate-change-response-amendment-act-2019/.

[207] The Guardian, "What New Zealand is really doing on climate – and the issues with carving out farming from net zero emissions," 2021, https://www.theguardian.com/environment/2021/feb/09/what-is-new-zealand-doing-to-reach-net-zero-what-would-happen-if-australia-did-the-same.

[208] New Zealand Government, "Aotearoa sets course to net-zero with first three emissions budgets," 2022, https://www.beehive.govt.nz/release/aotearoa-sets-course-net-zero-first-three-emissions-budgets.

[209] Gibson, Eloise, "The woman fighting climate change with accounting," 2024, https://www.rnz.co.nz/news/national/515875/the-woman-fighting-climate-change-with-accounting.

[210] New Zealand Government, "Towards a productive, sustainable and inclusive economy," 2022, https://environment.govt.nz/assets/publications/Aotearoa-New-Zealands-first-emissions-reduction-plan.pdf.

[211] Hall, David; Meng, Melody; Ives, Nina, "Air of compromise: NZ's Emissions Reduction Plan reveals a climate budget that's long on planning, short on strategy," 2022, https://theconversation.com/air-of-compromise-nzs-emissions-reduction-plan-reveals-a-climate-budget-thats-long-on-planning-short-on-strategy-181478.

[212] Olivia Wannan, Olivia, "Govt 'strongly committed' to cutting NZ's carbon footprint, Climate Minister Simon Watts says," 2024, https://www.stuff.co.nz/climate-change/350155468/government-strongly-committed-cutting-nzs-footprint-climate-minister-simon.

much stronger policies, like a doubling of the CO_2 price under the second Emission Reduction Plan (ERP), which is due to be released in December 2024.[213]

New Zealand's Ministry of Business, Innovation and Employment (MBIE) is currently developing an Energy Strategy, addressing the energy sector's emissions. The government envisions the establishment of "a highly renewable, sustainable, and efficient energy system" by 2050. The MBIE is now in the process of conducting various rounds of public consultations and is expected to publish the Energy Strategy by the end of 2024.[214] Since the current lack of a long-term energy strategy creates a somewhat uncertain policy environment and may thus hamper investment decisions, the publication of the strategy is highly anticipated. Contributing to the expansion of renewables, a new piece of legislation introduced in March aims at speeding up the approval process of big infrastructure projects. The proposed Bill would enable ministers to refer projects for fast tracking of consenting and could therefore significantly speed up renewable energy projects.[215] The bill was criticised by the opposition, who fears that it might enable an institutional abuse of power and threaten ecosystems.[216]

Until 2022, the New Zealand Energy Efficiency and Conservation Strategy (NZEECS) outlines government policies, targets and measures. It included the targets to reduce industrial emissions intensity by 1% per annum from 2017-2022. According to the government, a new NZEECS will be developed.[217] Energy efficiency regulation includes the minimum product energy efficiency standards through the Equipment Energy Efficiency (E3) program in cooperation with the Australian government. It sets minimum energy performance standards (MEPS) for products to be sold in New Zealand and mandates energy performance labelling (MEPL) to help customers make more informed choices when purchasing energy-intensive appliances.[218] [219]

Another potentially very impactful piece of regulation concerns the ban on coal boilers announced in June 2023. The ban on new fossil fuel boilers emitting over a certain threshold of greenhouse gases in a year for heat generation in manufacturing processes came into effect immediately, while a phase out of existing boilers is targeted for 2037.[220] As the new government coalition member ACT has rejected the policy as a case of "virtue signaling", the future of the emission reduction measure is unclear.[221]

4.2.2 CO2- Price and Regulations

Serving as New Zealand's primary policy response to climate change, the country's Emissions Trading Scheme (ETS) has been the most consequential policy regarding industry decarbonisation, similar to Germany.[222] While New Zealand was an early adopter of an ETS globally, it has so far failed to deliver emission reductions compared to the baseline year of 1990. On the contrary, overall emissions have increased by 21% compared to 1990,[223] with emissions per capita remaining almost exactly on the same level of 14 t CO_2e.[224] Next to a significant population increase from 3.4 million in 1990 to 5.2 million[225] today, the increase in overall emissions can also be explained by certain impediments to the ETS'

213 Pullar-Strecker, Tom, "NZ won't meet 2030 emissions promise without further action, IMF warns," 2023, https://www.stuff.co.nz/business/132817501/nz-wont-meet-2030-emissions-promise-without-further-action-imf-warns?lid=4q17mnviwbgg.

214 Ministry of Business, Innovation & Employment (MBIE), "Energy strategies for New Zealand," 2022, https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-strategies-for-new-zealand.

215 Chris Bishop, Chris; Jones, Shane, "One-stop shop major projects on the fast track," 2024, https://www.beehive.govt.nz/release/one-stop-shop-major-projects-on-the-fast-track.

216 Margaret Stanley, Margaret, "5 reasons why the Fast-track Approvals Bill threatens NZ's already fragile ecosystems," 2024, https://theconversation.com/5-reasons-why-the-fast-track-approvals-bill-threatens-nzs-already-fragile-ecosystems-227888.

217 Ministry of Business, Innovation & Employment (MBIE), "Energy strategies for New Zealand," 2022, https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-strategies-for-new-zealand.

218 Eeca, "Equipment Energy Efficiency (E3) Programme," 2024, https://www.eeca.govt.nz/regulations/equipment-energy-efficiency/about-the-e3-programme/.

219 Eeca, "Regulatory requirements under review," 2024, https://www.eeca.govt.nz/regulations/regulatory-requirements-under-review/.

220 New Zealand Government, "Government ban on new coal boilers in place," 2023, https://www.beehive.govt.nz/release/government-ban-new-coal-boilers-place.

221 ACT New Zealand, "Coal boiler ban is virtue signalling," 2024, https://www.act.org.nz/coal_boiler_ban_is_virtue_signalling.

222 IEA, "New Zealand 2023 – Energy Policy Review," 2023, https://www.iea.org/reports/new-zealand-2023.

223 Stats NZ, "New Zealand's greenhouse gas emissions," 2022, https://www.stats.govt.nz/indicators/new-zealands-greenhouse-gas-emissions.

224 World Resources Institute, "Climate Watch Historical Country Greenhouse Gas Emissions Data," 2022, https://www.climatewatchdata.org/ghg-emissions.

225 Worldometer, "New Zealand Population (2024)," 2023, https://www.worldometers.info/world-population/new-zealand-population/#google_vignette.

effectiveness. Reasons are the high numbers of free allowances and the inclusion of forestry as an offsetting mechanism, a practice that has been criticised by New Zealand's Climate Change Commission (CCC) as harmful to the decarbonisation of the country's most important emission sources. Compared to the EU ETS, allowance prices under the NZ ETS have been significantly lower during the last three years (see Figure 21). The CCC has called on the government to reduce the number of allowances in line with the emission reduction goals as the only effective way to increase the ETS' impact.[226]

Figure 21: *Comparison of Allowance Prices between the NZ ETS and EU ETS* [227]

In 2020, 49% of the country's emissions were covered by the ETS in the sectors forestry, waste, domestic aviation, transport, buildings, industry, and power. A notable exception is the emissions-intensive agricultural sector. Biological emissions from the sector must be reported but currently face no additional obligations. As mentioned above, the first ERP planned the implementation of a carbon price for agricultural emissions by 2025, either through the ETS or a separate pricing scheme. In a partnership between the government and the sector, preparations for the introduction of emissions pricing, including accounting and reporting systems for emissions, had been initiated.[228] In August 2023, the partnership published a concrete plan for the pricing of agricultural emissions. According to this plan, a comparatively low price would be put on agricultural emissions under the existing ETS.[229]

4.2.3 Incentive Systems and Funding Programmes

Generally, governments of New Zealand lean more on funding and other incentive mechanisms than on regulatory interventions. Policies for the decarbonisation of the industry sector are no exception.

A central actor in the decarbonisation of the industry sector in New Zealand is the national Energy Efficiency and Conservation Authority (EECA). The entity is overseen by the MBIE and was established under the Energy Efficiency and Conservation Act in 2000. EECA is intended to aid companies'

[226] Farmers Weekly, "CCC warns of critical ETS oversupply," 2024, https://www.farmersweekly.co.nz/news/ccc-warns-of-critical-ets-oversupply/.

[227] International Carbon Action Partnership, "ICAP Allowance Price Explorer," 2024, https://icapcarbonaction.com/en/ets-prices.

[228] International Carbon Action Partnership, "New Zealand Emissions Trading Scheme," 2023, https://icapcarbonaction.com/system/files/ets_pdfs/icap-etsmap-factsheet-48.pdf.

[229] New Zealand Government, "New emissions reduction plan will future-proof NZ's largest export sector," 2023, https://www.beehive.govt.nz/release/new-emissions-reduction-plan-will-future-proof-nz%E2%80%99s-largest-export-sector.

decarbonisation efforts by providing financial and technical support upon request. It further conducts research in the field and advises the government.[230]

The Government Investment in Decarbonising Industry (GIDI) Fund has so far been an important pillar of decarbonisation activities as a public funding program supporting businesses transitioning away from fossil to renewable energy sources and investing in energy efficiency measures. It was part of the Climate Emergency Response Fund (CERF) and funded by proceeds from the Emissions Trading Scheme. In 2022, 650 million NZD (370 million EUR) were allocated to enterprises via the fund.[231] The GIDI: Industrial section of the program was geared towards helping medium to large businesses using process heat to transition to cleaner energy forms and technologies. Businesses could apply for projects worth over 300,000 NZD implementing proven technologies, like high temperature heat pumps or biomass boilers, and achieving measurable emission reductions.[232] Under the partnership pillar of GIDI, businesses from the emission-intensive sectors of the economy were supported in their transition. GIDI partnered with steelmaker NZ Steel to co-fund an electric arc furnace replacing fossil fuel-based furnaces and kilns in the largest emission reduction project in New Zealand to date. The project implemented at the Glenbrook steel factory alone was said to eliminate one percent of the country's annual emissions. The base funding by the government was 110 million NZD (63 million EUR) and additional incentives were built into the agreement preconditioned on NZ Steel building the furnace until 2027.[233] In another special partnership, leading dairy producer Fonterra receives up to 90 million NZD (51 million EUR) of funding for the implementation of certain decarbonisation measures. The government calculates that the measures by Fonterra will cut 2.1 Mt CO_2e by 2030. These two examples show how the former government focused on achieving significant emission reductions through select partnerships with the main economic actors rather than implementing regulatory interventions.

In a move criticised by the independent Climate Change Commission, the new government has ended the GIDI fund citing its ostensible ineffectiveness in light of an existing ETS and unwanted levels of government interference with the free market. Existing grants under the GIDI are not impacted by the decision. While the CCC has stated that the ETS in its current form alone is not enough to achieve the required emission reduction goals,[234] the fossil fuel business association Energy Resources Aotearoa has called the decision a "win for climate" as it would help restore confidence in the ETS.[235]

[230] Eeca, "Statement of Intent 2018-2022," 2022, https://www.eeca.govt.nz/assets/EECA-Resources/Corporate-documents/EECA-Statement-of-Intent-2018-2022.pdf.

[231] Eeca, "Approved GIDI projects," 2024, https://www.eeca.govt.nz/co-funding-and-support/approved-gidi-projects/.

[232] Eeca, "Approved GIDI projects," 2024, https://www.eeca.govt.nz/co-funding-and-support/approved-gidi-projects/.

[233] New Zealand Government, "NZ's biggest ever emissions reduction project unveiled," 2023, https://www.beehive.govt.nz/release/nz%E2%80%99s-biggest-ever-emissions-reduction-project-unveiled.

[234] Gibson, Eloise, "Save $2b a year by cutting carbon, Climate Change Commission tells government," 2023, https://www.rnz.co.nz/news/national/504568/save-2b-a-year-by-cutting-carbon-climate-change-commission-tells-government.

[235] Energy Resources Aotearoa, "Ending GIDI a win for climate action," 2023, https://www.energyresources.org.nz/news/ending-gidi-a-win-for-climate-action/.

5 Collaboration Opportunities and Recommendations

5.1 Comparison Between New Zealand and Germany

Having a similar GDP per capita, Germany and New Zealand both represent well-developed market economies with large service sectors. However, besides the countries' differences in size, further differences exist in their industry sector compositions, energy mixes, and relative emission distributions. Figure 22 summarises key facts including industry composition, emission sources, energy mixes, and the role of the food manufacturing sector in both Germany and New Zealand.

The most notable difference is the high relevance of the agricultural sector for New Zealand, particularly for its export sector. This dominance is also reflected in the country's emissions, where the agricultural sector is responsible for more than half of the country's emissions, compared to only 8% in Germany. Overall, New Zealand has a much more concentrated industry base, with ten companies being responsible for over 50% of the country's emissions.[236] In contrast, Germany's industrial base is much more diversified with over 200.000 companies of which 97% are SMEs and sources of emissions therefore much more distributed. While the energy mix in the industry sectors at first sight appears to be a commonality, a more detailed look reveals further key differences. Germany still uses more coal, especially its metal and steel plants. However, in the cement and lime sector, New Zealand is still much more dependent on coal than Germany.

Chapter 2 has shown that not only the relative relevance and composition of industrial sub-sectors differs between Germany and New Zealand, but also that approaches to reducing emissions within each sub-sector need to take country-specific circumstances into account and be adapted accordingly. This is necessary to ensure that the measures taken are effective and efficient.

Since the industry sector is the second largest sector in Germany in terms of emissions, responsible for 22% of Germany's total emissions, it offers huge potentials for emission reductions. Within the industry sector, metal production and processing as well as chemical and petroleum product manufacturing emerge as the main emitters, responsible for 28% of industry emissions each. Within the metal production and processing sector, the production of iron and steel is decisive, as it accounts for 90% of its emissions. To tackle these emissions, new and innovative low-carbon production methods are required. As many processes are not suitable for electrification, the usage of green hydrogen will be crucial here. In the chemical industry, ammonia production and the manufacturing of high-value chemicals such as ethylene and benzene are key emitters. Here, fossil hydrocarbons are used as feedstock, energy source, and raw material, thus necessitating a variety of replacement solutions. These include the electrification of processes, the usage of green hydrogen where electrification is not possible, and the usage of recycled carbon, for instance by implementing CCU technologies. Overall, decarbonisation of the energy-intensive industry sector in Germany will hence require a strong focus on electrification, green hydrogen, coupled with a build-out of renewable energy sources, and recycled carbon (CCU technologies). These measures will also benefit other industry sub-sectors, with additional measures being the expansion of CHP plants and innovative approaches in the production of cement.

[236] Gibson, Eloise, "New Zealand's biggest emitters for 2023 revealed," 2023, https://www.rnz.co.nz/news/national/500074/new-zealand-s-biggest-emitters-for-2023-revealed.

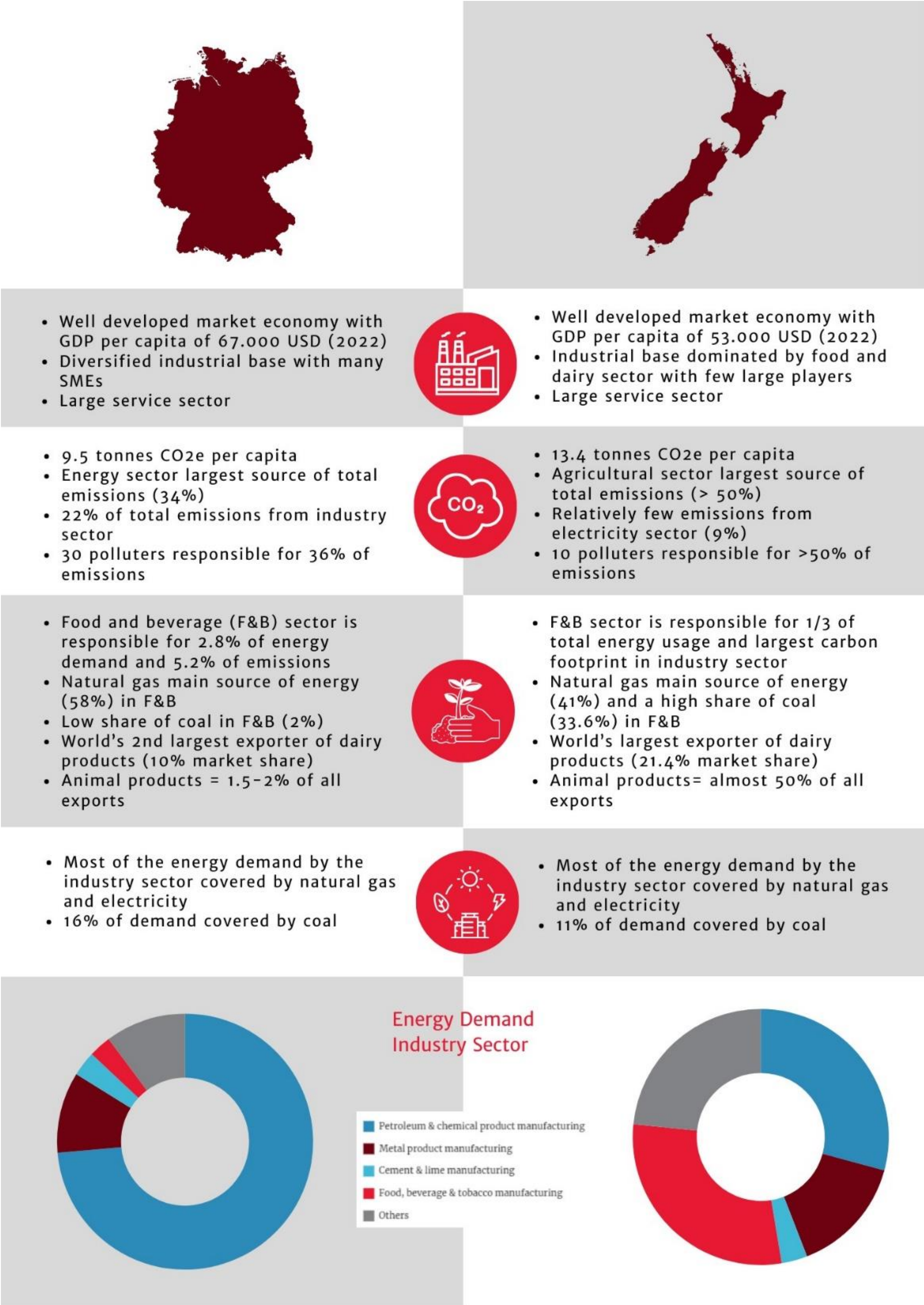

Figure 22: *Comparison of Industry Composition, Emissions, Food and Beverage Sector and Energy Demand in Germany and New Zealand.* [237] [238] [239] [240] [241] [242]

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[237] World Bank Open Data, "GDP per capita, PPP (current international $)," 2024, https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD.

[238] OEC, "The Observatory of Economic Complexity," 2024, https://oec.world/en.

[239] Gibson, Eloise, "New Zealand's biggest emitters for 2023 revealed," 2023, https://www.rnz.co.nz/news/national/500074/new-zealand-s-biggest-emitters-for-2023-revealed.

[240] Simmons, Lennard; AFP, "Emissionen: 30 Unternehmen sorgen für ein Drittel deutscher Treibhausgase," 2022, https://www.zeit.de/green/2022-03/treibhausgas-sz-analyse-unternehmen.

[241] Energy Efficiency & Conservation Authority, "EEUD-Data-2017-2021," 2022, https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.eeca.govt.nz%2Fassets%2FEECA-Resources%2FResearch-papers-guides%2FEEUD-Data-2017-2021-Published-March-2023.xlsx&wdOrigin=BROWSELINK.

[242] Statistisches Bundesamt, "Umweltökonomische Gesamtrechnungen - Energiegesamtrechnung," 2022, https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/energiefluesse-emissionen/Publikationen/Downloads/umweltnutzung-und-wirtschaft-energie-pdf-5850014.html.

In New Zealand, the industry sector is responsible for a substantially smaller but still relevant share of the country's overall emissions (12%). Within the industry sector, food, beverage, and tobacco manufacturing is the greatest emitter responsible for 28% of the sector's emissions. It is followed by metal product manufacturing (24% of emissions) and chemical and petroleum manufacturing (14.3% of emissions). Hence, the food, beverage, and tobacco sector appear as an additional priority area for the decarbonisation of the industry sector in New Zealand. Here, process heat demand drives up emissions, as it is largely met by coal (particularly in the South) and natural gas. Since New Zealand already possesses a relatively low-carbon power mix, the extensive roll-out of heat pumps would be a crucial step forward. This is also true for the chemical and petroleum manufacturing sector, which is heavily reliant on natural gas. Additionally, advanced energy management practices would help decarbonise this sub-sector. Lastly, the metal production sub-sector requires the switch to green hydrogen and the installation of the planned electric arc furnace at the NZS plant.

This, however also shows, that despite several differences, a number of overlapping challenges can be identified, including the overhaul or exchange of production processes where high amounts of process emissions appear, the electrification of the energy supply wherever possible, and the use of green hydrogen where electrification is impossible due to high temperature requirements or other physical factors. In addition, increasing energy efficiency remains an important approach across industries in both countries. While industries in both countries have already implemented a number of energy efficiency measures and thus achieved (at times) significant emission reductions, a continued effort in this regard is required next to the measures mentioned above. This is especially true in the light of both countries having signed the commitment on doubling energy efficiency by 2030 at COP29 in Dubai.

As political framework conditions are key to enabling the implementation of any such measures, Figure 23 summarises and contrasts industrial policy measures taken by Germany and New Zealand thus far.

From this comparison it becomes clear that Germany has established more stringent targets and regulation and that manufacturing companies are subject to higher CO_2 prices but can also access a wider variety of funding mechanisms. However, given that decarbonisation in the industry sector is as necessary in New Zealand as it is in Germany, and that both countries share some common technical reform requirements (albeit in different sub-sectors), fostering closer collaboration between the two countries, both in the fields of technology transfer and best practice sharing, promises to be a valuable endeavour. Therefore, this study would like to conclude with suggestions for several collaborative activities between Germany and New Zealand to help accelerate the decarbonisation of the industry sector in both countries.

• EU ETS: -62% GHG emissions in energy, energy-intensive industry, maritime transport & aviation sectors (compared to 1990) • EU Climate Law: -50% GHG emissions in all other sectors (compared to 2005) • National targets: -65% GHG emissions by 2030, -88% GHG emissions by 2040, net zero by 2045 (compared to 1990) • Industry sector target: -57% GHG emissions by 2030 (compared to 1990)	• Net zero by 2050, excl. biogenic methane emissions • Methane: -24-47% by 2050 compared to 2017
• EU ETS I: energy, energy-intensive industry, maritime transport & aviation sectors • Average allowance price between 2020 and 2023: 59.80 EUR • EU ETS II: building, road transport & smaller industries sectors • National ETS: building, road transport & smaller industries sectors -> 45 EUR/tCO2e in 2024, 55 EUR/tCO2e in 2025 (from 2027 onwards integrated into EU ETS II)	• National ETS: forestry, maritime transport, waste, domestic aviation, transport, buildings, industry & power sectors • Average allowance price between 2020 and 2023: 55 NZD (31 EUR)
• EU Energy Efficiency Directive • German Energy Efficiency Act • EU Ecodesign Directive • EU Corporate Sustainability Reporting Directive	• Emission Reduction Plan (ERP) • Equipment Energy Efficiency (E3) programme
• Energy & Resource Efficiency in the Economy Funding Programme • Carbon Contracts for Difference • State aid to steel companies • EU IPCEIs	• Government Investment in Decarbonising Industry (GIDI) Fund (not active anymore)

Figure 23: *Comparison of Policy Measures for Industrial Decarbonisation in Germany and New Zealand.*

5.2 Recommendations

Exchange knowledge on the roll-out of heat pumps and share best practices with regards to Energy Service Companies (ESCOs) in the **Dairy Industry**.

With New Zealand's **dairy industry** being a cornerstone of the country's economy, decarbonisation in this specific sector is a possible focal topic for cooperative activities. While Germany is the second largest exporter of dairy products globally, its dairy sector is responsible for a comparably small share of energy use. However, given that further emission reductions will be required, a number of scientific projects look into the potential application of large-scale heat pumps. The knowledge gained and technologies developed could be of high value to New Zealand, where emissions from the dairy sector remain high. The partnership between MAN Energy Solutions and dairy producer Fonterra shows that there is an interest by industry players in cooperation in this area.[243] In a bilateral workshop with industry representatives from both countries as well as political representatives and researchers, the current state of heat pump roll-out in industry, the political framework, scientific advances and potentials for either side could be showcased and discussed. Another valuable area of cooperation could be the sharing of best practices regarding the establishment and operation of Energy Service Companies (ESCOs).[244] ESCOs provide services to final energy users, such as the installation and management of energy efficient equipment. Crucially, ESCOs can guarantee energy savings and are being paid based on the energy savings achieved. Several ESCOs have been active in Germany and across Europe for some years now with promising results including in the dairy sector. One example here is the German ESCO Bilfinger SE, which is offering a diverse set of efficiency improvement measures. Already in 2015 it partnered with FrieslandCampina, one of the largest dairy producers globally. The aim was to reduce the dairy companies' CO_2 emissions by 40k tonnes and achieve energy savings of 6% per site.[245] Policy makers and ESCO representatives could present the ESCO concept to New Zealand counterparts and explore whether partnerships could be established to bring ESCOs to New Zealand. While the dairy sector could act as an entry point, ESCOs are also valuable to other industries so that the concept could gradually be expanded over time.

Establish sectoral dialogues on the usage of green hydrogen, particularly in the **Steel and Chemical Industries**.

The NZ Steel plant is a good example of a possible way forward for the **steel industry**, both in New Zealand and Germany. Not only will the plant install an electric arc furnace, jointly funded by the operators of the plant in Glenbrook and the government and run on electricity from New Zealand's largely renewable electricity grid (wind, hydro, and geothermal), the plant has also entered a partnership with BOC, a subsidiary of originally German company Linde, for the supply of **green hydrogen**. This

[243] MAN Energy Solutions, "MAN Energy Solutions to examine the use of an industrial-scale heat pump for Fonterra," 2023, https://www.man-es.com/company/press-releases/press-details/2023/02/08/man-energy-solutions-to-examine-the-use-of-an-industrial-scale-heat-pump-for-fonterra.

[244] European Commission, "Energy Service Companies (ESCOs)," 2016, https://e3p.jrc.ec.europa.eu/communities/energy-service-companies.

[245] Bilfinger SE, "DOING WHAT'S BEST- Sustainability Report 2015," 2015, https://www.bilfinger.com/fileadmin/One_Global_Website/Investors/overview/non-financial-reporting/Bilfinger_Sustainability_Report_2015.pdf.

will be used in the plant's metal coating and treatment processes.[246] [247] [248] [249]Since Germany is a major international steel producer and eager to transition to the production of green steel, the development of alternative production methods, crucially including the use of green hydrogen, is a topic of keen interest and research. Salzgitter AG has, for instance, recently launched its green steel brand SALCOS, where direct reduction plants use green hydrogen to produce near-CO_2-free steel.[250] Meanwhile, the **chemical industry** today largely relies on grey hydrogen to produce, for instance, ammonia and methanol. In many instances, little modification of processes is needed to switch to green hydrogen, as the product used, i.e. hydrogen, remains the same.[251] Yet, new supply networks and infrastructures must be created. Germany and New Zealand are both in the midst of the process of creating a market for green hydrogen, which remains more expensive than its grey counterpart, securing supply and demand, and putting adequate infrastructures into place. An exchange between policy makers and companies within the steel and chemical sectors respectively (G2G, G2B, and B2B) can enable the sharing of lessons learned and establish industry partnerships. This would accelerate progress and help actual projects to be devised and get off the ground.

Host a workshop to share the concept of **Energy Efficiency and Climate Protection Networks** as successful and business-driven initiative to lower emissions.

In times of rising fuel prices, energy efficiency measures not only play a role in meeting national or company-level climate goals but can also lead to significant financial benefits through lower energy expenses. In order to connect companies willing to implement energy-saving measures, the German government and a number of major business associations have founded the concept of Energy Efficiency Networks in 2014. The networks are intended to connect companies from the same region or industry and facilitate the sharing of knowledge and good practices on efficiency measures. In 2021, the second phase of the initiative, now called **Initiative on Energy Efficiency and Climate Protection Networks** (IEEKN) was initiated, with the goal of saving 9 to 11 TWh of final energy and 5 to 6 Mt of greenhouse gases nationally. Such a pragmatic, bottom up, and business-driven approach to preventing energy losses and carbon emissions might be interesting for New Zealand businesses as well. This study therefore suggests a workshop format, in which the idea of the IEEKN is presented to interested stakeholders from industry and public administration. Over the past 35 years, the concept of the Networks has been successfully tried and implemented in more than 20 countries worldwide.

Establish a regular **Policy Dialogue** on new and existing regulations and funding mechanisms for industrial decarbonisation.

Further, establishing a regular **policy dialogue** on regulatory and funding measures may be beneficial to both countries. Sharing experiences on novel instruments such as the Carbon Contracts for Difference, digital product passports as well as on existing measures such as the countries' respective Emission Trading Systems can help in fostering new ideas and approaches and implement lessons learned. While it has become clear that Germany and New Zealand are quite distinct in terms of their industry composition and hence require tailor-made approaches that address their respective economies' make-up, a mutual understanding of each other's policies in this field can ease trade

[246] New Zealand Hydrogen Council, "NZ Hydrogen Projects — New Zealand Hydrogen Council," 2024, https://www.nzhydrogen.org/nz-hydrogen-projects.

[247] The Guardian, "New Zealand announces its biggest emissions reduction project in history," 2023, https://www.theguardian.com/world/2023/may/22/new-zealand-announces-its-biggest-emissions-reduction-project-in-history.

[248] Oram, Rod, "Govt offers NZ Steel $30m more in bonuses for bigger, faster emissions cuts," 2023, https://newsroom.co.nz/2023/05/21/govt-offers-nz-steel-30m-more-in-performance-bonuses-for-bigger-faster-emissions-cuts/.

[249] Gray, Jamie, "BOC to supply 'green' carbon-free hydrogen to NZ Steel at Glenbrook," 2021, https://www.nzherald.co.nz/business/boc-to-supply-green-carbon-free-hydrogen-to-nz-steel-at-glenbrook/GHMPNXIBFBEIAORLACY56OL67U/.

[250] SALCOS®, "THE CONCEPT FOR A SUSTAINABLE FUTURE Our program SALCOS," 2024, https://salcos.salzgitter-ag.com/en/salcos.html.

[251] IRENA, "Green hydrogen for industry: A guide to policy making," 2022, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_Green_Hydrogen_Industry_2022.pdf.

relations and accelerate internal processes as new ideas are created. Since Germany is embedded in the EU, cooperation could potentially facilitate New Zealand's interaction with other EU countries as well, as German experiences are often applicable to other EU countries as well.

Exchange on cutting emissions, saving money and ressources and increase resilience through the implementation of **Circular Economic Measures**.

Lastly, another topic for discussion could be the implementation of measures from the field of **economic circularity**. Research by Agora Energiewende from Germany has shown that through a combination of decarbonised means of production and increased circularity, climate goals could be achieved quicker, cheaper and with a higher degree of energy efficiency. The study by Agora Energiewende has found that in the energy-intensive steel, cement and plastics industries decarbonised production and circularity measures could reduce emission by 25%, transformation costs by 45%, and energy consumption by 20%.[252] A circular economy approach can further increase resilience to supply shocks to critical materials primarily imported from abroad and reduce waste. With New Zealand being active in all of the above industrial sectors and especially with packaging for its agricultural export products playing an important role, the implementation of circular forms of production could save the country's economy money, energy, increase its resilience to supply shocks and reduce the strain on its exceptional landscapes. We therefore suggest the organisation of a bilateral workshop highlighting the current regulatory and political environment in both countries, the current state of research, and innovative industry approaches to implementing measures of circularity in practice.

[252] Agora Industry, Systemibilfq, "Circular Economy and Net-Zero Industry: Potentials for energy-intensive value chains in Germany," 2024, https://www.agora-industry.org/fileadmin/Projekte/2022/2022-11_IND_Kreislaufwirtschaft/A-EW_320_Circular_Economy_Summary_EN_WEB.pdf.

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