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EXPLORING OPTIONS TO MEASURE THE CLIMATE CONSISTENCY OF REAL ECONOMY INVESTMENTS: THE MANUFACTURING INDUSTRIES IN NORWAY – ENVIRONMENT WORKING PAPER N°999

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Abstract

This paper is the first of a series of pilot studies to explore data availability and methodologies for measuring the consistency of real economy investments with climate change mitigation objectives. The analysis focuses on investments in tangible fixed assets in the manufacturing industries in Norway between 2010 and 2017, estimated at USD 2.5 billion per year on average. It then measures the consistency or inconsistency of these investments at subsector level based on two reference points: the draft European Union Taxonomy for sustainable activities, and a 2°C scenario for the Nordic region from the International Energy Agency. The analysis further identifies sources of financing in these subsectors and discusses potential future investment and financing challenges. Finally, the study draws methodological conclusions and identifies the need for further country- and sector-level pilot studies to improve and scale up such analysis at an international level.

Résumé

Ce document est le premier d'une série d'études pilotes visant à explorer la disponibilité des données et les méthodologies afin de mesurer la comptabilité des investissements dans l'économies réelles avec les objectifs d'atténuation du changement climatique. L'analyse se concentre sur les investissements dans les actifs corporels immobilisés au sein des industries manufacturières norvégiennes entre 2010 et 2017, estimés à 2,5 milliards USD par an en moyenne. La compatibilité ou l'incompatibilité de ces investissements est ensuite mesurée au niveau de sous-secteurs vis-à-vis de deux points de références : la version actuelle de la Taxonomie des activités durables de l'Union Européenne, et un scénario 2°C de l'Agence Internationale de l'Énergie pour la région nordique. L'analyse identifie également les sources de financement dans ces sous-secteurs et envisage de possibles futurs défis en termes d'investissement et de financement. Pour finir, l'étude tire des conclusions méthodologiques et met en avant le besoin d'études pilotes complémentaires au niveau de pays et de secteurs afin d'améliorer et de généraliser ce type d'analyse à un niveau international.

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The working paper is the first of an intended series of pilot studies exploring options for measuring the climate consistency of investments in tangible assets. It is a contribution to the body of work of the OECD-led Research Collaborative on Tracking Finance for Climate Action. The Research Collaborative is a technical research network and platform to advance and share knowledge for improving the tracking of climate-relevant finance, including towards addressing and informing finance-related discussions under the United Nations Framework Convention on Climate Change (UNFCCC). This is done based on dedicated work by Research Collaborative staff as well as through joint initiatives and co-operation with other parts of the OECD, external analytical partners, financial institutions, and countries.

The paper benefited from inputs from and interaction with a number of Norwegian stakeholders. Gard Lindseth, from the Ministry of Climate and Environment, was instrumental for making this study possible, at each step from inception to completion. Elin Økstad, also from the Ministry of Climate and Environment, helped with data and guidance relating to Norwegian greenhouse gas emissions. Kirsten Hovi and Hanne Fedje, from Norsk Hydro, provided both the necessary material and text for a Norsk Hydro case study as well as more general insights into the aluminium industry. Other members of the Federation of Norwegian Industries also provided comments on the analysis. Anita Fossdal (ENOVA), Gaute Moldestad and Håvard Solem (SIVA), Marianne Tonning Kinnari (INNOVASJON NORGE), Marthe Norberg-Schulz (Samfunnsøkonomisk Analyse, an economics independent analytical consultancy) provided qualitative and quantitative information on public subsidies.

The authors are grateful to the following OECD colleagues who provided valuable advice, input, and comments at various stages of advancement of the analysis and drafting: Philip Hemmings (Economics department), Brilé Anderson, Simon Buckle, Mireille Martini, Daniel Nachtigall, Isabella Neuweg, Dirk Röttgers and Cecilia Tam (Environment Directorate). Peter Levi and Tiffany Vass (International Energy Agency) provided data and insights relating to the scenarios that underpin the IEA's Nordic Energy Technology Perspectives.

The work also benefited from country delegates' feedback on an earlier scoping note presented at the 10-11 April 2019 WPCID meeting, as well as oral comments from country delegates, researchers and financial institutions that participated in the 28 October 2019 workshop of the Research Collaborative. Further written comments were received from Canada, France, and Sweden as well as from Hadrien Hainaut from the Institute for Climate Economics (I4CE).

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Executive Summary

Reaching the Paris Agreement long-term temperature goal requires rapid and far-reaching transformations in all sectors of the economy as well as in underlying investments and financing activities. The present analysis is the first of an intended series of pilot studies exploring options for measuring the climate consistency of investments in physical assets. This focus is motivated by the significant lock-in of greenhouse gas (GHG) emissions by such assets, and complements other tracking initiatives that concentrate on financial markets and investors' portfolios.

The present study focuses on investments in tangible fixed assets in the manufacturing industries in Norway between 2010 and 2017. This scope encompasses an annual average volume of investments of around NOK 22.5 billion (approximately USD 2.5 billion). The choice of an eight-year period balances data availability limitations with the need to smooth out annual fluctuations. The mapping of investments was completed using structural business and gross fixed capital formation statistics from Eurostat combined with firm-level financial statements from the Norwegian Register of Enterprises. GHG emission data was sourced from the Norwegian Pollutant Release and Transfer Register.

The analysis separates out eight subsectors covering 70% of investments in tangible fixed assets by manufacturing industries in Norway, and over 99% of these industries' GHG emissions: non-metallic mineral products (including cement), chemicals (with a separate focus on fertilisers), food processing, metals (with a separate focus on aluminium), oil refining, and pulp and paper. Upstream oil and gas activities are not in scope, since they can be considered as part of the energy sector.

There is, for the time being, no agreed approach or set of criteria to classify investments with respect to climate objectives. Here, two complementary reference points are tested and evaluated:

- the current draft European Union (EU) taxonomy for sustainable activities, aimed at establishing criteria for economic activities with a substantial contribution to a set of environmental objectives;
- the 2°C scenario from the 2013 Nordic Energy Technology Perspectives (NETP) by the International Energy Agency, which consists of a GHG emission trajectory for 2010-2050 that is consistent with limiting the average global temperature increase to 2°C with at least a 50% chance;

These reference points are neither representative of official objectives for Norway, nor originally designed for estimating the climate consistency of sector- or subsector-wide investments and financing. They are used here to explore options for measuring the consistency of investments in terms of climate change mitigation according to different types of criteria, without making a statement on which investment and emission trajectory should be followed. A comprehensive evaluation of the climate consistency of investments at national level would benefit from a country-specific complementary reference point. However, Norway's national emission reduction targets and objectives are not broken down per sector, let alone sub-sectors, which prevents matching them with the level of granularity of the present analysis.

The current draft EU taxonomy defines technical criteria to determine economic activities with significant climate change mitigation benefits. Based on available data, approximately 3% of total investments in scope, mainly in the chemicals industry, satisfy these criteria. The remaining 97% could not be classified due to a combination of three main reasons. First, the taxonomy does not further characterise activities that do not satisfy its stringent criteria. In particular, it does not distinguish activities without significant climate benefits from activities that undermine climate objectives. Second, the taxonomy's current coverage of economic activities is limited. Third, applying the technical criteria requires access to granular investment and GHG emissions data. Hence, to allow independent application and verification of its screening criteria, the EU taxonomy would need to be complemented with disclosure requirements.

Scenario-based analyses is tested as a complementary approach to identify both climate-consistent and -inconsistent investments. Actual subsector-level GHG emissions for 2010-18 are compared to the IEA Nordic 2° scenario as a possible transition pathway towards long-term climate objectives. As a result, 15% of analysed investments were in subsectors whose actual emissions were consistent with the 2° scenario (parts of the chemicals, food processing, pulp and paper, cement, and other sectors), while 37% were in subsectors whose emissions evolved inconsistently. The remaining 48% of investments could not be classified as consistent or inconsistent as they occurred in non-GHG-emitting subsectors and subsectors not fully addressed by the chosen scenario.

Such scenario-based analysis has further limitations. Any individual scenario relies on modelling assumptions resulting in one possible pathway among potential trajectories for reaching a given level of GHG emissions. Further, supranational scenarios do not match the granularity of country-level investment and GHG data analysed here. Even country-level scenarios, although more accurately reflecting national circumstances, would typically only yield an aggregate assessment per (sub)sector rather than for individual installations or investment projects. As a result, this approach does not allow for an identification of individual climate-consistent investments within a subsector assessed as overall climate-inconsistent.

It is challenging to determine reasons for the relatively low share of investments identified as consistent in the scenario-based analysis. Subsector-level GHG emission volumes result from combined emission intensity changes and output changes. For instance, GHG productivity gains resulting from investments in process efficiency and new technologies can be outweighed by growth in production volumes. In addition, improving GHG productivity in industrial processes is challenging and often relies on break-through technologies. Such technologies may require long lead times for research, development, and demonstration before resulting in industrial scale investments.

The main financing mechanism for the investments in scope of the study are companies' retained earnings (34% of total investments). As Norwegian companies also have ample access to credit, this suggests that investment and financing capacity is available in most subsectors. However, establishing the role of financing conditions in climate-relevant investment decisions would require detailed data on loan terms and interest rates, as well as the expected revenues and operating expenditures associated with investments. Such data is commercially sensitive and frequently confidential.

The choice of reference point affects all aspects of the climate-consistency measurement: the proportion of total investments addressed, the categories to classify investments as consistent or inconsistent, and the subsector-level assessment results. Such variation indicates a need to carefully select relevant reference points depending on the aim and policy context of the analysis. It also calls for further discussions on what kind of reference points, or combinations thereof, to use for measuring progress towards making finance climate-consistent at domestic and international levels.

Drawing more general and robust conclusions of relevance for systematic measurement (e.g. in the context of OECD work on indicators or of the UNFCCC Global Stocktake in 2023) requires further research work. First, the approach tested in the present study can be further trialled in other sectors and countries to shed light on data availability in different contexts. Second, the geographical scope can be extended to analyse the climate-consistency of a sector across countries or globally. Whether at country or supranational level, the analytical scope could be expanded to cover investments in intangible assets, as well as the value, depreciation and decommissioning of stocks of existing assets. Third, incorporating resilience to climate change in the analysis would enable links to the analysis of climate-related physical climate risks.

1. Scope and rationale for the pilot project

1.1. Why such a study?

Reaching the goal of the 2015 Paris Agreement of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C" requires rapid and far-reaching transformations in all sectors of the economy(UNFCCC, 2015[1]). This, in turn, is only possible if investments and financing are aligned with this goal. Making finance flows consistent with such temperature goals, as called for in Article 2.1c of the Paris Agreement (UNFCCC, 2015[1]), requires mobilising investments and finance for activities that contributes to climate objectives. It also implies shifting investments and finance away from activities that undermine these objectives. A range of frameworks are being developed to initiate, implement and monitor such actions (e.g. (OECD/The World Bank/UN Environment, 2018[2]); (ODI et al., 2018[3]); (Climate Transparency, 2018[4])).

A prerequisite for designing and monitoring the efficiency of these actions is, however, to measure the climate alignment of current investments and financing across the entire financial value chain. A number of initiatives are already analysing the stock of financial instruments held in investors' portfolios. This includes OECD work on institutional investors ((Röttgers, Tandon and Kaminker, 2018[5]), (OECD, 2017[6]), (OECD, 2016[7]), (OECD, 2015[8])) and ongoing initiatives by other institutions aimed at estimating climate-related risk exposures (e.g. (TCFD, 2017[9]); (2° Investing Initiative, 2018[10]); (Battiston et al., 2017[11])). Such investor-focused initiatives and analyses are necessary components for measuring the overall consistency of the financial system with both climate-related risks and objectives.

In this context, the analytical work pursued by the OECD-led Research Collaborative on Tracking Finance for Climate Action – including the present study – complements other finance tracking initiatives by looking at investments in physical assets and linking these investments to underlying sources of financing. The aim in doing so is also to produce results that are primarily of relevance to policy makers. Following the methodology outlined in (Jachnik, Mirabile and Dobrinevski, 2019[12]), this work analyses primary investments in the creation and refurbishment of infrastructure and equipment, a scope close to what the System of National Accounts defines as "tangible fixed assets" (UN, 2010[13]). Considering such long-lived assets (as illustrated in Figure 3.2) is especially relevant, since they are responsible for a majority of current greenhouse gas (GHG) emissions and lock in emissions for the following decades (NCE, 2016[14]). This lock-in effect makes it important to include the analysis of infrastructure that may have little direct climate impact but will influence the technological platform for other investments (e.g. roads and railways in the case of the transport sector) (OECD, 2017[15]).

GHG reduction objectives, possible trajectories or abatement potentials can be set on the level of individual institutions, countries, and internationally. These different reference points may not always be coherent. Hence, and as outlined in (Jachnik, Mirabile and Dobrinevski, 2019[12]), the present work estimates the consistency of investments in relation to climate change mitigation from multiple viewpoints, rather than suggesting one specific characterisation. As detailed in Section 3.1.2 and 5. Annex C, inputs used to this end include available working definitions of “green” and “sustainable” activities, sector-specific emission and transition pathways at global or regional level, as well as national-level GHG reduction scenarios, potentials or objectives.

While the focus of the analysis is on climate change mitigation, climate adaptation is an essential component for achieving climate goals. However, obtaining data and devising methodologies for measuring the consistency of investments and financing with climate-resilient development is more difficult than for mitigation (Jachnik, Mirabile and Dobrinevski, 2019[12]). Measuring the consistency of investment and financing flows with adaptation objectives, therefore, deserves a complementary mapping and analytical effort to the present one.

Measuring the climate consistency of investments and financing yields policy-relevant benefits both for individual countries and in an international context. At country level, Norway in the case of the present study, such finance tracking efforts complement physical indicators of progress on climate change mitigation. These efforts can also provide input both for national policies aimed at shifting investment, as well as for long-term national climate strategies. Sub-section 1.2 and Section 2. highlight the rationale for, and relevance of the present study in the specific Norwegian context, including the choice of focusing on the industry sector.

In an international context, such measurement efforts can help identify potential indicators and data sources that might be relevant for measuring progress towards climate change mitigation at a global level. This could be useful input to UNFCCC processes, notably the Standing Committee on Finance’s Biennial Assessments (UNFCCC, 2018[16]), which have been mandated to inform finance-related elements of the future Global Stocktakes of collective progress (first one in 2023). Knowledge of remaining data gaps and limitations is necessary for potential future finance-related disclosure initiatives by the public and private sectors. Finally, in the context of broader OECD work, such tracking initiatives may be a first step towards filling an existing gap on investment- and finance-related indicators within the framework of OECD green growth indicators (OECD, 2017[17]).

1.2. What and how?

The present study is the first of an intended series of pilots to explore options for estimating the climate consistency of investments and financing for different sectors, in different country contexts and at different geographical scales. It focuses on the industry sector in Norway for the period 2010-2017. The choice of an eight-year period balances data availability limitations with the need to smooth out annual fluctuations. Considering the industry sector is relevant, since this sector is responsible for a high share of current GHG emissions (over the considered period, 23% in Norway and 20% across OECD countries). Furthermore, the climate consistency of industrial investments is important due to the lock-in of future GHG emissions by the long lifetime of industrial installations.

In principle, the entire range of manufacturing industries is covered, with a deep dive on sub-sectors that represent high shares of GHG emissions and/or of all investments, e.g. aluminium production, manufacturing of chemicals, and food processing (see section 3.1.1). Extractive industries, in particular upstream oil and gas, are out of scope since they can be considered together with the energy sector. The tracking encompasses investments in industrial infrastructure and equipment located in Norway, which consist primarily of industrial installations such as plants and factories. Other investments into tangible fixed assets in Norway (such as corporate headquarters buildings) are also included for companies belonging to the manufacturing sector, although GHG emissions from such assets are typically not included in GHG accounts for the industry sector. Annex A provides further details on this sectoral scope.

The analysis covers in principle all actors investing in the aforementioned assets, whether public (in particular, governments and state-owned enterprises) or private (large corporations as well as small and medium size enterprises), or households.[1] As introduced above and further explained in (Jachnik, Mirabile and Dobrinevski, 2019[12]), the point of measurement is set at the primary investment in infrastructure and equipment (covering both new assets and refurbishment of existing ones). The sources of financing for these investments are then identified.[2] These include financing from public actors (e.g. via subsidies or loans from development banks), private actors (e.g. via loans from commercial banks), and own funds of the investors (e.g. from retained earnings). While a large share of the financing mix underlying the tracked investments could be analysed in this way, some gaps remain (see Section 3.2).

Data collection is largely based on publicly available sources as published by a number of public and private sector actors. This includes both financial data (e.g. statistics on government subsidies, annual financial statements of private companies) and non-financial data (e.g. production capacities). Annex B provides a detailed description of the data sources and estimation methods on investment and financing.

The analysis then explores methodological options for estimating the climate consistency of investment and financing flows, by testing the use of two complementary reference points. The first one is the eligibility of specific activities with respect to the current draft European Union (EU) taxonomy for sustainable activities (EU Technical Expert Group on Sustainable Finance, 2019[18]). The second one consists in comparing the actual trajectory of 2010-2018 GHG emissions (on the level of industry subsectors) to a possible transition pathway as foreseen by the IEA 2° scenario over the same period. At the level of a country pilot study like the present one, including country-specific reference points would have been beneficial. However, a suitable quantifiable reference for climate consistency in the national Norwegian context could not be identified. In particular, Norway's national emission reduction targets are not broken down per sector, let alone sub-sectors, which prevents matching them with the level of granularity needed in the present analysis. Section 3.1.2 and Annex C provide a detailed description of the reference points used for the measuring the climate-consistency of investments.

The analysis also relies on qualitative information and expert judgements from relevant stakeholders (e.g. associations, government actors) to fill data and methodological gaps as well as verify the plausibility of and complement quantitative results. In Norway, these notably included the Norwegian Ministry of Climate and Environment, and representatives from the manufacturing industries. Further consultations took place with relevant experts at the OECD (e.g. Economics Department, IEA), as further detailed in the Acknowledgements.

[1] For the industry sector, households do not play a direct role.

[2] Only the first-level sources of finance are considered. Analysing multiple levels of the financing and ownership hierarchy, in particular tracking refinancing and securitisation within the financial sector, requires separate dedicated work.

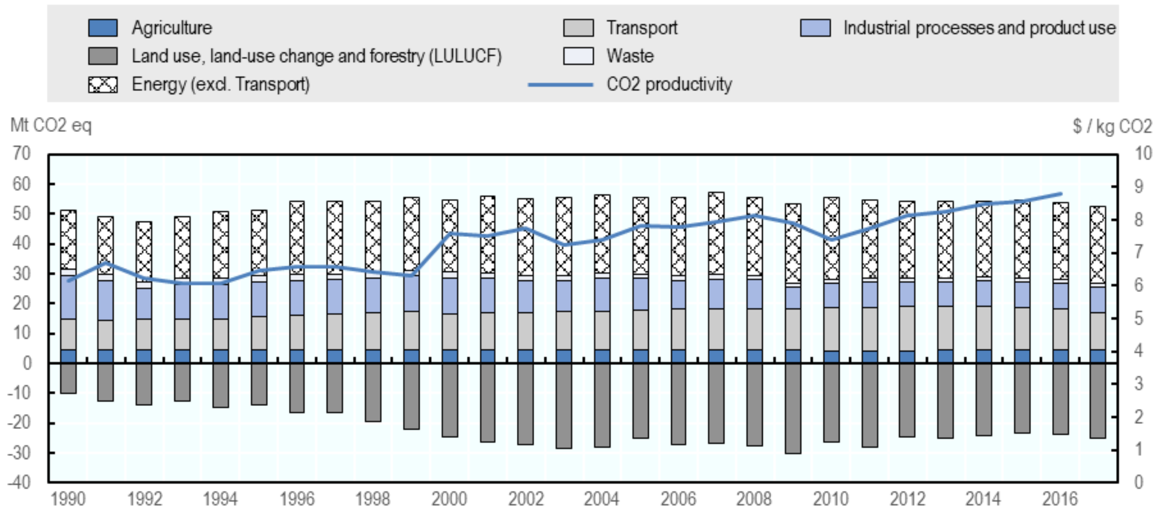
2. The industry sector in Norway

2.1. Economic and environmental characteristics of Norway

Norway is a high-income country and holds the first place in the UNDP Human Development Index ranking as of 2017 (UNDP, 2018[19]). It is a member of the OECD and participates in the EU single market through the Agreement on the European Economic Area. Indicators of the strong performance of Norway's economy in recent years include solid gross domestic product (GDP) growth despite volatile petroleum markets, strong inclusiveness (low levels of income inequality, small gender gap), and high overall well-being (OECD, 2017[20]). In 2018, Norway's GDP per capita in current Purchasing Power Parity (PPP) was almost 40% higher than the OECD average, and more than three times the world average (World Bank, 2019[21]). Nevertheless, challenges remain, such as strengthening diversification away from oil-related activities, and maintaining competitiveness despite high labour costs.

Thanks to its broad usage of hydropower, Norway is among the countries with the highest share of renewable energy supply. Its share of renewables in total primary energy supply is 53%, compared to an OECD average of 10% and a world average of 14% (IEA, 2019[22]). This means that manufacturing industries in Norway largely avoid indirect emissions from electricity generation, and hence typically compare favourably to other countries from a total GHG emissions perspective (see section 3.1.1).

Figure 2.1. Norway's greenhouse gas emission profile and trends



Note: Production-based CO_2 productivity is measured as GDP (in 2010 $) per kg of energy-related CO_2 emissions.
Source: UNFCCC National Inventory Reports, OECD Green Growth indicators

Between 2010 and 2017, total GHG emissions in Norway decreased slightly despite sustained economic growth (see Figure 2.1). In 2016, Norway's production-based CO_2 productivity was 8.8 international dollars (2010 PPPs) per kg CO_2, compared to an OECD average of 4.2 and a world average of 3.4 (OECD, 2018[23]).

On national and international levels, Norway has put forward the following climate change mitigation objectives and commitments:

- Under the Kyoto Protocol, Norway committed to reduce GHG emissions by 30% in the second commitment period (i.e. between 2013 and 2020), compared to the base year 1990 (UNFCCC, 2012[24]). This target is aimed to be achieved through a combination of domestic measures and international cooperation, e.g. purchase of credits through the clean development mechanism (Norwegian Ministry of Climate and Environment, 2019[25]).
- Following the 2015 Paris Agreement under the UNFCCC, Norway committed in its nationally-determined contribution to reducing its total GHG emissions by at least 40% by 2030, compared to the base year 1990 (Government of Norway, 2016[26]). This target is also embedded in national legislation through the Climate Change Act (Klima- og miljødepartementet, 2017[27]).
- On a long-term horizon, Norway aims to become a low-emission society by 2050 (similarly to the long-term climate strategy of the EU). The corresponding target of 80% to 95% reduction of GHG emissions (compared to the base year 1990) is also included in the Climate Change Act (Klima- og miljødepartementet, 2017[27]). Both the 2030 and 2050 targets are to be achieved taking into account participation in the EU Emission Trading Scheme (ETS), which covers most of the manufacturing industries, and/or joint fulfilment with the EU in non-ETS sectors, if agreed.

Norway's relative emission reduction commitments, if applied worldwide, would be in line with global climate change mitigation targets estimated in the 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5° (IPCC, 2018[28]). The possible greenhouse gas emission pathways discussed in this report typically foresee annual CO_2 emissions in 2030 to be between 74% and 143% of their 1990 levels, and require reaching net zero emissions between 2040 and 2060.

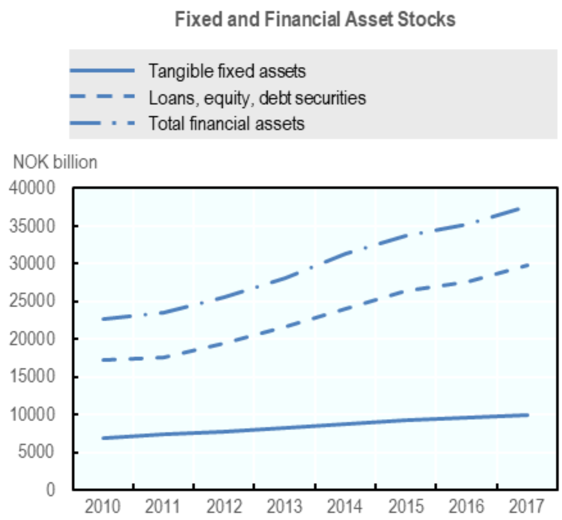
The policy roadmap towards achieving Norway's objectives, in particular its 2030 target, is defined in Norway's climate strategy (Norwegian Ministry of Climate and Environment, 2017[29]). This white paper outlines possible cross-sectoral policy measures (e.g. carbon taxation, direct regulation, support for technology development) following the basic principles of polluter-pays, and effectiveness in terms of environmental impact and cost. It also suggests a range of sector-specific policies for the main GHG emitting sectors, including transport, agriculture, manufacturing, and the petroleum industry. However, to date, none of the above domestic GHG reduction objectives has been broken down and specified per sector. As further explained in Section 3.1, such sector-specific breakdown would be needed for measuring the consistency of investments in the industry against domestic GHG targets and scenarios.

While the focus of the present study is on climate change mitigation, climate change adaptation is an essential component of the Paris Agreement. In this context, the main challenges and approaches in Norway are summarised in the white paper "Climate change adaptation in Norway" (Norwegian Ministry of Climate and Environment, 2013[30]).

2.2. General investment and financing characteristics in Norway

This study focuses on industrial infrastructure and equipment in Norway, which is part of the stock of tangible fixed assets as measured in the national accounts. Investments in excess of the depreciation of these physical assets led to a growth of the stock of tangible fixed assets between 2010-2016. As highlighted in Figure 2.2, the total stock of financial assets in Norway is close to three times higher and, since 2011, growing at a faster rate than real economy investments. This may be related to valuation gains of Norwegian investors on domestic and foreign financial markets, increases in household indebtedness (outstanding mortgages and consumer debt), increasing levels of financial intermediation activity, all of which are out of the scope of this analysis.

Figure 2.2. Stocks of tangible fixed assets and financial assets in Norway



Note: Shows stocks of physical vs. financial assets, as well as gross fixed capital formation as share of GDP, both within the scope of the given country. Total financial asset stocks include loans, equity and debt securities outstanding and, in addition: financial derivatives, insurance pension and standardised guarantees, currency and deposits, monetary gold and SDRs and other accounts receivable. In particular, financial assets include e.g. the investments of pension funds. The value of the Government Pension Fund Global alone was 8488 billion NOK at the end of 2017 (NBIM, 2017[31]), corresponding to 23% of total financial assets. Some financial assets held in Norway may correspond to underlying physical assets in other countries.
Source: SNA tables 1 and 720R.

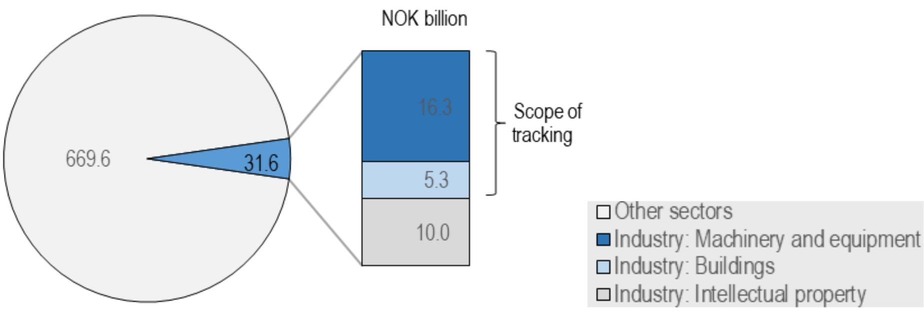
Investment in tangible fixed assets in Norway consists broadly of mainland business and housing investment on the one hand, and investment in petroleum extraction offshore, on the Norwegian continental shelf, on the other hand. In part related to oil price fluctuations, petroleum investment has been volatile since 2015 and is expected to gradually decrease in the long run (Norges Bank, 2019[32]). On the other hand, mainland business investment (which includes the investment in the manufacturing industries as tracked in the present study) has grown continuously since 2016 and is not expected to recede in the near future (Norges Bank, 2019[33]).

In addition to mapping investment volumes, the scope of the analysis presented in this report covers the sources of finance behind these. In general terms, Norwegian companies have ample access to credit, and debt to non-financial corporates follows broadly operating revenue growth ((Norges Bank, 2018[34]), (Norges Bank, 2019[32])). The overall domestic credit to the private sector (145% of GDP) is above the average in EU countries (95%) (World Bank, 2019[35]), linked in part to Norway having one of the highest ratios of household indebtedness among OECD countries. While this is recognised as a potential economic vulnerability ((OECD, 2017[20]), (Norges Bank, 2019[32])), it is not of direct relevance to the scope of the present study as households do not invest directly in industrial facilities and equipment.

2.3. Characteristics of the Norwegian industrial sector

Manufacturing industries are important for climate change mitigation in Norway: they were responsible for approximately 23% of the total Norwegian GHG emissions in 2010-2017.[3] In economic terms, these industries contributed approximately 7% to the Norwegian GDP in 2016 (OECD, 2019[36]) and employed approximately 8% of the total workforce (OECD, 2019[37]). In terms of investment, as highlighted in Figure 2.3, gross fixed capital formation (GFCF) in the manufacturing industries averaged 4.5% of the total GFCF over the period 2010-2017 (OECD, 2019[38]). As mentioned in section 1.2, extractive industries (in particular upstream oil and gas) are not within the scope of manufacturing industries considered here.

Figure 2.3. Average yearly gross fixed capital formation in Norway (2010-2017)



Source: SNA tables 9A and 8A.

The GFCF in the Norwegian industry sector consists of investments in machinery and equipment (52%), buildings (17%) and intellectual property products (32%) (Figure 2.3). Since the focus of the present study is on tangible fixed assets (as those are directly responsible for GHG emissions), intellectual property products are excluded from the scope of tracking where data granularity allows doing so. In the case of industrial research and development investment, successful innovations are expected to give rise to investment in tangible fixed assets at a later stage. Such investments are then captured within the perimeter of the study.

Owners of (and investors in) industrial property, plants and equipment in Norway are typically companies, most of them with majority private-shareholding. While the Norwegian state owns shares in several large industrial companies (e.g. a current 34% share in the aluminium company Norsk Hydro ASA, see Box 3.1), in most cases these are minority interests. Furthermore, guidelines of the Norwegian government encourage the management of its company holdings consistently with private sector practices (Norwegian Ministry of Trade, Industry and Fisheries, 2017[39]).

Norway implemented a range of policy measures applicable to or specifically targeting the industry sector, which support the country's overall climate change mitigation objectives (summarised in Section 2.1 above). Notably, there is, since 1991, a general tax on CO_2 emissions. It covers mineral oil, gasoline, natural gas, LPG, and offshore petroleum activities on the Norwegian continental shelf. A few industries (wood processing, pigments and dyes, fish oil and fishmeal) benefit from reduced tax rates, while those covered by the ETS are full exempt from the tax.

[3] This includes direct energy-related emissions from manufacturing industries, and direct emissions from industrial processes and product use, compared to the total emissions excluding LULUCF.

In 2005, Norway put an ETS in place, which has since 2008 been linked with the EU ETS. While the ETS initially only covered 11% of total Norwegian emissions, its scope expansion in 2013 increased this share to about 50% (Norwegian Ministry of Climate and Environment, 2014[40]), including a large proportion of the processes in the manufacturing industries (Norwegian Ministry of Climate and Environment, 2018[41]). The total number of emission allowances is subject to a cap, which decreases year by year, in line with the EU climate targets for 2020 and 2030. In the Norwegian industry sector in 2015, 79% of emissions were priced at above 5 EUR per ton of CO_2, and 46% at above 60 EUR per ton of CO_2 (OECD, 2018[42]). Hence, from the perspective of the Norwegian government, the ETS has been the main public policy instrument for incentivising the industry sector to improve its environmental performance.

Furthermore, a range of public organisations provide subsidies for energy efficiency investments and environmentally friendly technologies. This covers both early-stage research (e.g. via the Norwegian Research Council) and industrial-scale investment (e.g. via ENOVA).These subsidies are partially financed via earmarked tax revenue (e.g. the Energy Fund, which is financed by a levy on the electricity grid). Public subsidies and financing in support of investments by the industry sector in tangible assets are included in the mapping of sources of finance (Section 3.2).

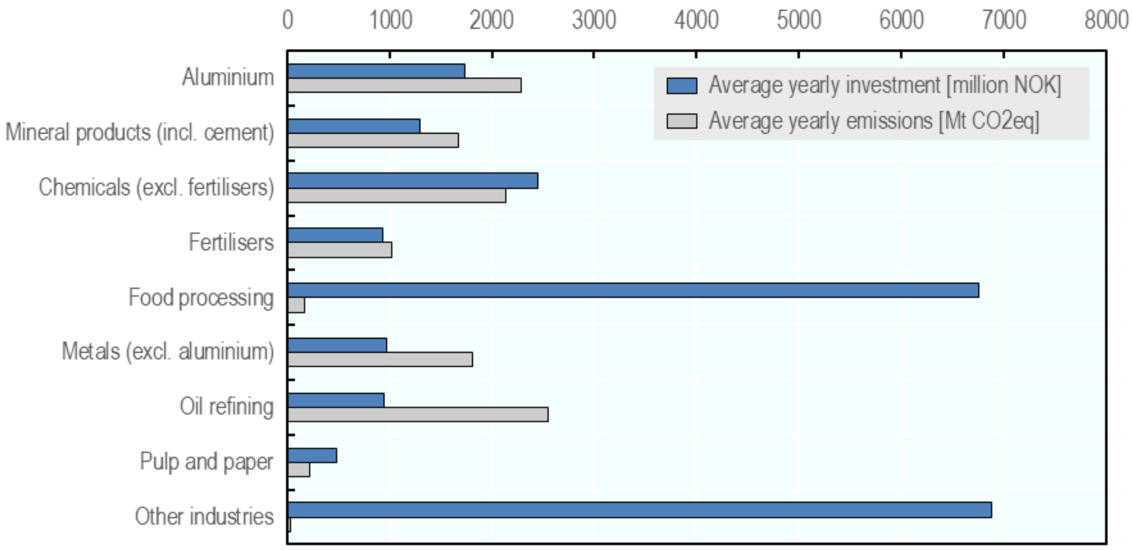
3. Results

3.1. Overview of past and current investments flows, financing and of their climate consistency

3.1.1. Relevant subsectors in terms of GHG emissions and investments

Within the manufacturing industries, this study considers eight subsectors in depth and aggregates the remaining subsectors (see Figure 3.1 and Annex A for details). The subsectors that are separated out cover the main sources of direct GHG emissions (e.g. petroleum refining, manufacturing of aluminium). These deep dives also include industries that account for a significant share of total investments in tangible assets, without being GHG intensive (e.g. food processing). Overall, over the period 2010-2017, the eight subsectors in focus cover over 99% of GHG emissions and approximately 70% of the investment in the Norwegian industry. The total annual investment volume tracked averages around 22.5 billion NOK.[4] Annex A provides year-by-year estimates of investment volumes and GHG emissions.

Figure 3.1. Overview of subsectors in focus (2010-17 annual average)



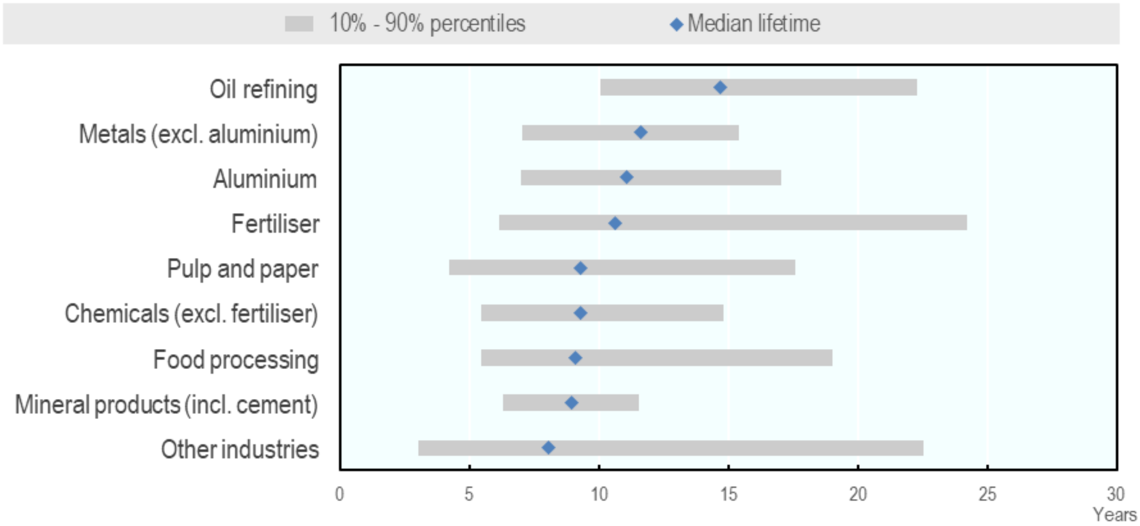
Note: Investment volumes are restricted to tangible fixed assets (infrastructure and equipment). The coverage of industries is limited to the NACE section C "Manufacturing", and hence does not include for example oil and gas extraction.

[4] This is comparable to the total GFCF in tangible fixed assets, which is approximately 21.6 billion NOK annually (Figure 2.3). The discrepancy is due to different data sources: section 3. is based on structural business statistics, which are more granular than GFCF reported in national accounts. Annex B describes the data sources and their differences in more detail.

As shown in Figure 3.1, the subsectors with a large investment volume in industrial infrastructure and equipment and the subsectors with a large emissions volume do not always coincide. This is due to different factors, including the relative capital and energy intensities of subsectors, their degree of maturity, as well as the lifespan of corresponding physical assets. Food processing (mostly fish processing and dairy) is among the top in terms of investment (30% of total), but not a major contributor to GHG emissions (1% of total GHG emissions). Other sectors, like aluminium production and chemicals manufacturing, are both significant areas of investment and significant emission sources.

Infrastructure and equipment are long lasting. Investment decisions, therefore, lock in GHG emissions. Figure 3.2 shows the estimated average lifetimes of fixed assets in each of the subsectors covered above. In oil refining, manufacturing of metals and in the production of fertilisers, this is estimated to be over a decade.

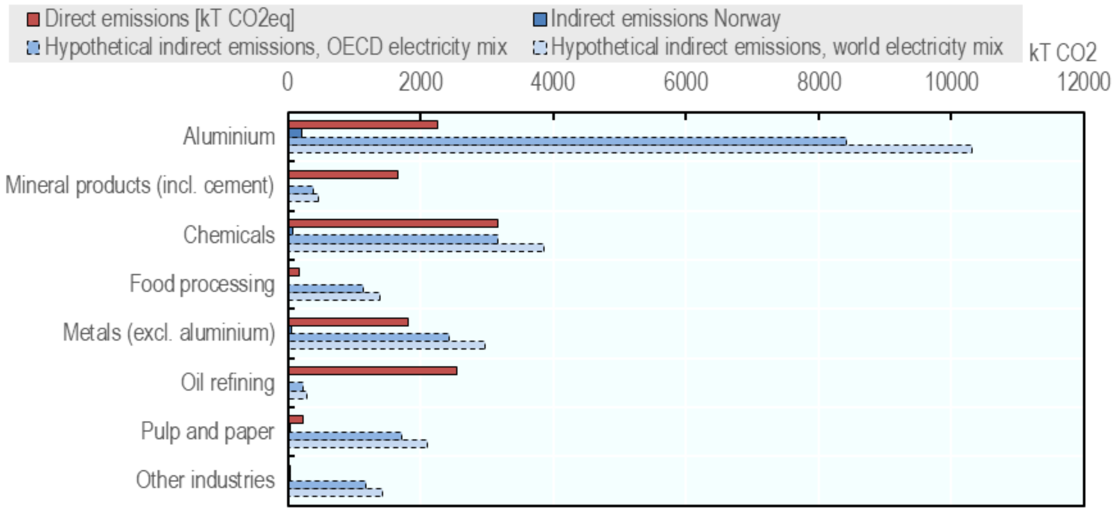
Figure 3.2. Lifetime of fixed assets in Norwegian manufacturing industries (2010-2017)



Note: The typical lifetimes are estimated by dividing the total volume of fixed assets by the annual depreciation volumes. This estimation covers both tangible and intangible fixed assets; data on depreciation for tangible fixed assets only was not available. It covers all fixed assets owned by the companies, i.e. not just the industrial installations themselves but also buildings and vehicles, which typically have a shorter lifespan. Furthermore, in general financial accounts may overestimate depreciation (e.g. for tax reasons). Hence, the lifetimes of the main GHG emission sources (i.e. industrial installations) are likely larger than the values indicated above.
Source: Companies' financial statements provided by the Brønnøysund Register Centre.

Whenever GHG emissions are analysed in the following, only direct emissions (from industrial processes as well as fuel combustion in industrial installations) are considered. Figure 3.3 illustrates that in the Norwegian manufacturing industries, indirect emissions from electricity generation are less than 4% of direct emissions, thanks to the high share of renewables in Norway's electricity production. This contrasts with the much higher absolute and relative level of indirect emissions that Norway's industrial sub-sectors would reach if the country's electricity mix were similar to the OECD or world averages (hypothetical scenarios in Figure 3.3). Such differences highlight that indirect emissions would need to be considered when conducting work on a larger geographical scale or aimed at cross-country comparison.

Figure 3.3. Comparison of direct and indirect emissions in Norway's manufacturing industries (2010-17 annual average)



Note: Direct emissions shows the 2010-2017 average direct GHG emissions from Norwegian industries based on data from N-PRTR. Indirect emissions are estimates of indirect emissions from Norwegian industries, based on their average electricity consumption in 2010-2017, and three different assumptions for the GHG intensity of electricity: the average GHG intensities of electricity for Norway (which yields an estimate for the actual indirect emissions), OECD average, and world average (which provide hypothetical estimates of what the indirect emissions would have been, if Norway had a different structure of electricity production). GHG intensities of electricity are based on 2010-2015 average data from the IEA (no later data was available).
Source: Electricity consumption: Statistics Norway table 08205. GHG intensity of electricity: (IEA, 2019[43]).

3.1.2. Measuring the climate consistency of investments

There is for the time being no privileged approach or agreed set of indicators to classify investments with respect to climate objectives. To test possible options, the present study categorises the investments mapped above according to two different inputs described below and further detailed in 5. Annex C. These reference points are neither representative of official objectives, nor originally designed for estimating the climate consistency of sector- or subsector-wide investments and financing. They are used here to explore options for ”colouring” investments according to different types of criteria, without making a statement on which investment and emission trajectory should be followed.

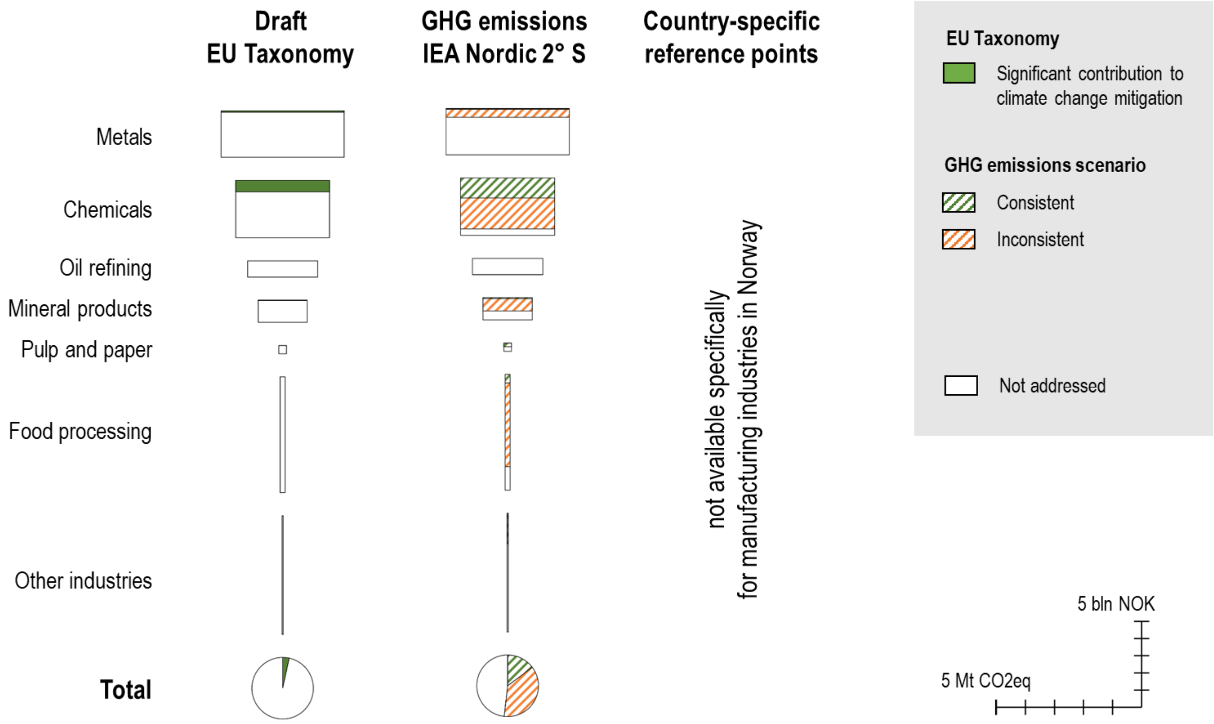
- **The current draft of the EU taxonomy for sustainable activities** (EU Technical Expert Group on Sustainable Finance, 2019[18]). This initiative aims at establishing legal criteria for investments that make a substantial contribution to different environmental objectives. Such criteria can, for instance be based on best-available technology or GHG emission intensity thresholds of best performers within a given subsector. The draft EU taxonomy only provides criteria for defining activities that are clearly climate beneficial but not for defining those that are detrimental to climate objectives or that may play a transition role over a limited period. At this stage, the EU taxonomy is primarily aimed at investors in financial assets (institutional investors, asset managers) in order to provide transparent standards for environmentally sustainable investment products. The present measurement explores how the draft taxonomy technical screening criteria for climate change mitigation can be applied on the scale of an economic sector.

- **The 2° scenario from the 2013 Nordic Energy Technology Perspectives (NETP) by the International Energy Agency** (IEA, 2013[44]). In general, this scenario for 2010-2050 outlines an emissions trajectory limiting the average global temperature increase to 2°C with at least a 50% chance. A newer scenario for 2013-2050 was published in the 2016 NETP (IEA/Nordic Council of Ministers, 2016[45]) with broadly similar emission reduction projections (differences between 5% and 10% for 2020, 2030 and 2050 relative emission reductions). Here the older scenario is used intentionally, in order to compare forecast emission reduction potentials in the studied period to actual emission reductions in that same period. In general, the IEA scenario models macroeconomic developments (e.g. GDP growth) as well as supply and demand evolution in a number of sectors (energy, transport, industry) consistent with such an emissions trajectory. This scenario is based on the current state of technological development and does not assume breakthrough innovations. However, it does assume incremental technological progress and improvements in cost-effectiveness. As a broad guideline, this scenario allows estimating possible contributions from different industries in the Nordic region[5] to global GHG reductions. In particular, due to the required modelling assumptions and uncertainties, this is not a prediction or a prescriptive trajectory, but an example of possible developments compatible with a below-2° future.

Figure 3.4 provides an overview of the consistency measurement of 2010-2017 investments based on these inputs. The perspectives taken in the two viewpoints are different as explained above, and hence the results are not directly comparable, but rather complementary. As previously highlighted, the analysis lacks a domestic reference point as Norwegian emission reduction targets for the period covered were not broken down per sector or sub-sector. The variation in results illustrates that the choice of reference points has a significant impact on the share of total investments and on which individual subsectors are coloured as “consistent” and “inconsistent”. In order to provide a forward-looking view, these results would need to be matched with relative GHG reductions required from the manufacturing industries in order for the sector to contribute to Norway meeting its future mitigation objectives. Here again, such break down is not available from Norway’s NDC or other relevant official documents.

[5] Covering Norway, Sweden, Finland, Denmark, Iceland

Figure 3.4. Overview of consistency of investment flows in 2010-2017 with climate change mitigation benchmarks



Note: The width of the boxes indicates emission volumes (annual average for 2010-2018), the height investment volumes (annual average for 2010-2017). The measurement of consistency with the draft EU taxonomy relies on 2018 data for emission and production volumes. The measurement of consistency with GHG emission scenarios relies on total emissions in the period 2010-2018. Emissions data has intentionally been used up until the last available year (2018) since a time lag between investments and potential emission reductions is expected.
Source: See Annex B and Annex C for details on data sources and methodology.

The draft EU Taxonomy provides well-defined and stringent technical screening criteria to determine economic activities contributing significantly to climate change mitigation. Based on the available data, on average approximately NOK 715 million per year (corresponding to USD 78 million, or 3.2% of the total investments in scope of this study) satisfy these criteria and can be classified as "sustainable". These investments consist of two types of eligible activities included in the draft EU guidelines (EU Technical Expert Group on Sustainable Finance, 2019[18]):

- "Greening by" activities (around 2.7% of total investments, NOK 604 million or USD 66 million): Investments in manufacturing of components for low-emission technologies, such as renewable energy production or zero-emission vehicles. In the scope of the present study, this includes mostly the manufacturing of solar PV components such as silicon ingots and wafers (part of the chemicals subsector).
- "Greening of" activities (around 0.5% of total investments. NOK 110 million or USD 12 million): Investments in low-emission manufacturing in certain subsectors, which are typically emissions-heavy. In most cases, the draft taxonomy proposes pre-defined thresholds for emissions intensities (usually derived from the most efficient 10% of installations in Europe, based on the benchmarking exercise prior to start of the ETS phase III in 2013). Within the scope of the present study, these criteria apply to part of the installations in the chemicals, cement, and aluminium sectors. For this analysis, the installation-level emission intensities were calculated based on data from the Norwegian Pollutant Release and Transfer Register (see Annex C). A detailed example for the aluminium sector

is shown in section 3.1.3. The draft taxonomy guidelines consider all investments in installations below the emission intensity thresholds as eligible, and do not restrict to investments specifically towards energy efficiency or emission reduction. The same approach was followed here.

The current draft EU taxonomy only provides guidance for a small subset of the total investment volume for multiple reasons.

- The focus is on activities that provide a substantial contribution to environmental objectives (in this case, climate change mitigation). Hence, the relatively low share of eligible investments as estimated here can be taken as an indication that the draft taxonomy screening criteria are indeed stringent and help avoiding “greenwashing”. Further, the draft does not distinguish activities without a significant climate impact from activities potentially inconsistent with climate objectives.
- In addition, the criteria developed to date only cover certain economic sectors, and within these sectors only certain production processes. Activities and products, which are not covered by the EU taxonomy will not be eligible as taxonomy compliant, regardless of level of emission intensity. For example, while manufacturing primary aluminium below a pre-determined emission and energy intensity is eligible, the subsequent parts of the aluminium value chain (such as manufacturing rolled aluminium products) are not covered for now and hence not eligible - even if based on the same primary aluminium and themselves emission-free.
- A small subset of the investment volumes could not be addressed due to data limitations in the present study. The taxonomy’s intended usage is initially as a tool for investors and companies. Investors routinely request granular data for assessing their investment projects from the non-financial companies receiving the financing, and can use such data e.g. for applying the detailed technical screening criteria as formulated in the taxonomy. On the other hand, the present analysis relies on limited data that companies are required to publish or report to public authorities. Such data is not always sufficient to compute e.g. emission intensities for the manufacturing of individual products, or to isolate individual production processes. Such investments are conservatively counted as “not addressed” in Figure 3.4.

Scenario-based analyses constitute a complementary approach and permit the identification of both climate-consistent and climate-inconsistent investments. Here, actual subsector-level GHG emission trajectories for the period 2010-18 are compared to the IEA Nordic 2° scenario as a possible transition pathway compatible with the 2° objective of the Paris Agreement. Approximately 15% of investments within the scope of this study were in subsectors whose emissions evolved consistently with the 2° scenario. Approximately 37% of investments were in subsectors whose emissions’ trajectories were inconsistent with the 2° scenario, i.e. grew faster. The remaining 48% of investments could not be classified as consistent or inconsistent based on this approach as they occurred in non-GHG-emitting subsectors and other subsectors not fully addressed by the chosen scenario. These gaps include the oil refining sector (for which the 2013 NETP does not provide a separate emission projection) and the aluminium sector (for which the 2013 NETP only considers emissions from combustion processes, and not process emissions from electrolysis which are the key emissions driver in the Norwegian aluminium industry (Section 3.1.3).[6]

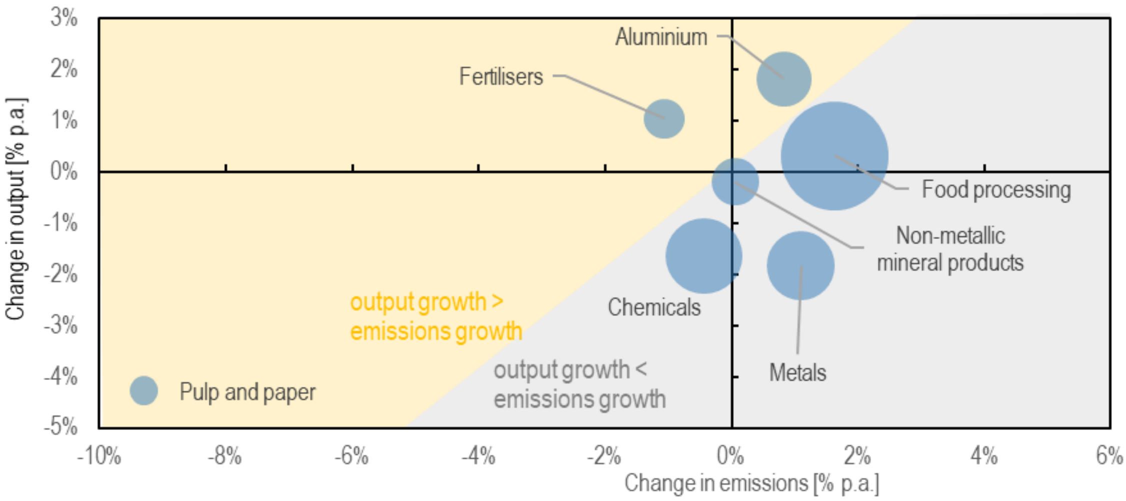
The actual emissions in the cement, fertilisers and pulp and paper sectors were below the corresponding IEA 2° scenario trajectories, and hence investments in these subsectors are labelled as consistent with the trajectories in Figure 3.4. Likewise, several smaller subsectors (in particular, parts of the aggregate sectors food processing and other industries) were in line with the sector-level possible emission

[6] The most recent edition of the NETP (IEA/Nordic Council of Ministers, 2016[45]), however, does cover such process emissions. This implies that an IEA scenario-based estimate of consistency for aluminium would be possible for a more recent period that the one considered in the present study.

reductions estimated in the IEA scenario. However, such a comparison does not necessarily indicate sufficient investment in emission intensity reduction measures: production volumes in each subsector also influence total emissions. In order to illustrate subsectors for which this plays a significant role, Figure 3.5 relates the subsector-level emissions and output volume trends. In the time period considered:

- In the fertilisers subsector, output increased and hence the consistency of emissions in this subsector with the IEA trajectory indicates that some investments in emission reductions have likely taken place. The chemical industry more broadly reduced emissions as well as output volumes.
- The emission reductions in the pulp and paper sector are likely to be at least partly linked to significant reductions in production volumes. While capital investments in emission reductions may have taken place, this structural change may also be caused by a shift of production to other locations (which would result in leakage of Norwegian GHG emissions to another country), or reduced demand.
- The results for the cement sector could be linked to the expected output increases forecast in the IEA scenario, which, in practice, did not take place at Norwegian cement plants.
- Other subsectors were above the IEA 2° trajectory in terms of emissions, which could be due to production increases, a lack of investments in emission reductions, current unavailability of alternative production technologies, or a combination of the three.

Figure 3.5. Trends in emissions and in output volumes (2010-2017 annual average)



Note: Disk sizes are proportional to investment volumes. Trends in output volumes are estimated based on the subsector-level industrial production index provided by Statistics Norway, except for the Aluminium and Fertilisers subsectors where actual production volumes as reported in the UNFCCC NIR reports are used. Trends in emission volumes are estimated based on N-PRTR emissions data. Above (below) the diagonal line, output growth is larger (smaller) than emissions growth.

While the analysis based on the IEA Nordic 2° scenario makes it possible to classify a much larger share of total investments than the current draft EU taxonomy, as well as to identify inconsistent investments, it has limitations of its own.

- Any chosen scenario is only one possible trajectory out of a wide range of different transition scenarios compatible with the same long-term climate targets. Especially in the short term, different scenarios can imply different GHG emission trajectories.

- Like any scenario model, the IEA Nordic 2° scenario relies on assumptions on overall economic development, including the demand for different products and resulting production volumes. The scenario estimates for the shares of emission reductions implemented in different geographical regions and sectors depend on additional assumptions, such as optimising for least-cost trajectories. Actual economic developments can be very different in all of these aspects. When a scenario is updated periodically, these assumptions as well as the modelling scope and methodology are also subject to change. This may limit the comparability of scenario analysis results over time.
- As the above examples show, inconsistency with an emission reduction scenario could have different reasons. There could be insufficient investment in technology improvement, but also increased demand and increased production. Likewise, consistency of total emissions with emission reduction trajectories could be linked not only to investments in abatement measures, but also to decreases in output volumes or shifts to other locations, i.e. carbon leakage. Decomposing these aspects would require more granular data on emission intensities of individual production processes, as well as global product-level demand and production data.
- A regional scenario, such as the IEA Nordic 2° scenario used here, does not provide a breakdown on country level. Comparison to this scenario can be seen as a benchmark within the Nordic region. However, this scenario does not break down structural differences and trends between different Nordic countries, which could contribute to some of the observed consistencies or inconsistencies. Even country-level scenarios, although more accurately reflecting national circumstances, would typically only yield an aggregate assessment of per (sub)sector rather than for individual installations or investment projects. As a result, portions of climate-consistent investments within an overall climate-inconsistent subsector cannot easily be identified with this approach.
- Comparing actual GHG emissions to emission reduction scenarios only addresses economic activities, which have a significant GHG footprint. This may miss related upstream or downstream activities in the economic value chain, which can be crucial for enabling emission reductions or can influence the main GHG sources via demand for products or supply of materials.

Additional details on data sources, methodology and resulting limitations for the measurement of consistency are provided in section 5. and Annex C.

3.1.3. Deep dive: aluminium production

Aluminium production is one of the most important manufacturing industries in Norway (responsible for around 8% of manufacturing investments and around 19% of manufacturing emissions, see Figure 3.1). The vast majority of the GHG emissions in this subsector are due to the electrolysis process used to manufacture primary aluminium, whose emissions in turn depend on the production technology. Currently, industrial-scale electrolysis uses a reaction of aluminium oxide with a carbon anode to produce aluminium, at the same time releasing CO_2 as a by-product. Furthermore, depending on the technical details the electrolysis process may release perfluorocarbons (PFCs) which are likewise potent greenhouse gases. In addition to these process emissions, electrolysis leads to indirect GHG emissions through electricity consumption.

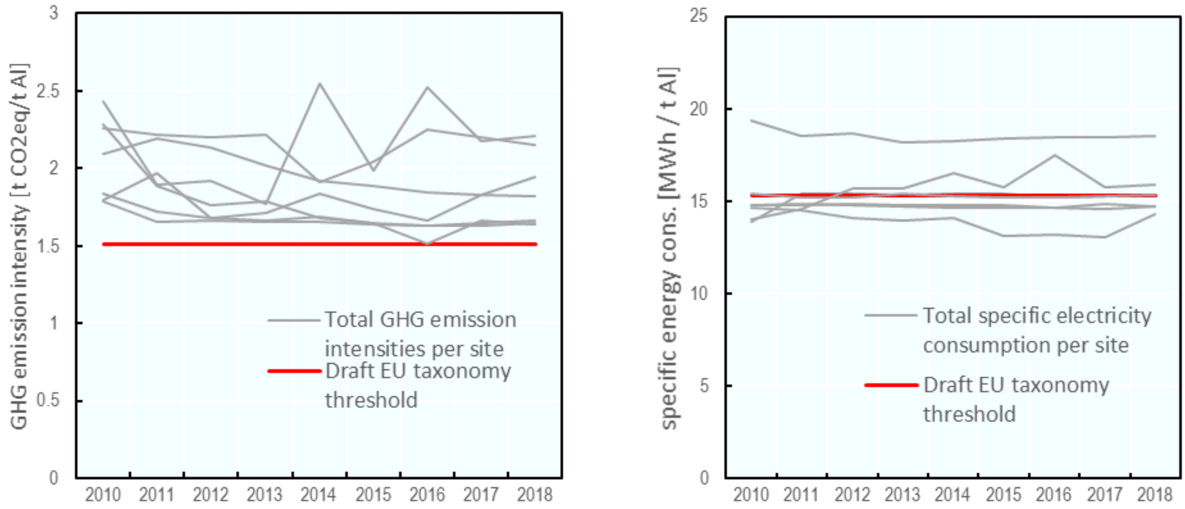
There are seven plants manufacturing primary aluminium in Norway, belonging to and operated by two companies: Norsk Hydro ASA (headquartered in Norway, see Box 3.1) and Alcoa Norway (a subsidiary of Alcoa Corporation, headquartered in the USA). In addition, secondary aluminium is produced by recycling post-consumer scrap or scrap from other production processes. The aluminium sector further includes downstream processing of primary and secondary aluminium in particular at rolling mills and extrusion plants.

The main challenge for reducing GHG emissions from aluminium production in Norway lies with the process emissions from electrolysis: The electricity used both in the aluminium production and in the downstream processing does not have a significant GHG footprint, thanks to the predominance of renewables in electricity production (see section 2.1). In countries with a higher CO_2 intensity of electricity, indirect GHG emissions from electrolysis can be several times higher than the total GHG emissions from the same process in Norway (see Figure 3.3).

For measuring the eligibility of investments in primary aluminium manufacturing with respect to the technical screening criteria of the draft EU taxonomy for sustainable finance, installation-level emission intensities and electricity consumption were compared to the thresholds defined in the draft taxonomy (Figure 3.6). The granularity of available data sources for GHG emissions (N-PRTR, EU ETS) does not allow emissions for individual production steps (in this case, electrolysis) to be distinguished; hence, a precise statement of which installations comply with the draft EU taxonomy thresholds is not possible at this stage. Under the very conservative assumption that all GHG emissions are due to electrolysis, none of the Norwegian primary aluminium plants are below the draft EU taxonomy threshold of 1.514 t CO2eq / t primary aluminium in 2018 (Figure 3.6).

In practice, while the majority of emissions is due to the electrolysis process, other processes such as casting or anode production also contribute to the total GHG emissions of primary aluminium plants[7]. Hence, a few installations, whose total emissions are close to the threshold, will likely be EU-taxonomy-compliant if publicly available GHG emission data would be granular enough to apply the criteria for the electrolysis process alone. As this cannot be done, corresponding investment volumes are labelled as “not addressed” in Figure 3.4. Most primary aluminium plants in Norway fulfil the second draft EU taxonomy threshold, which requires electricity consumption below 15.29 MWh per ton of primary aluminium.

Figure 3.6. Comparison of emission intensities and energy consumption to climate change mitigation criteria under the draft EU Taxonomy



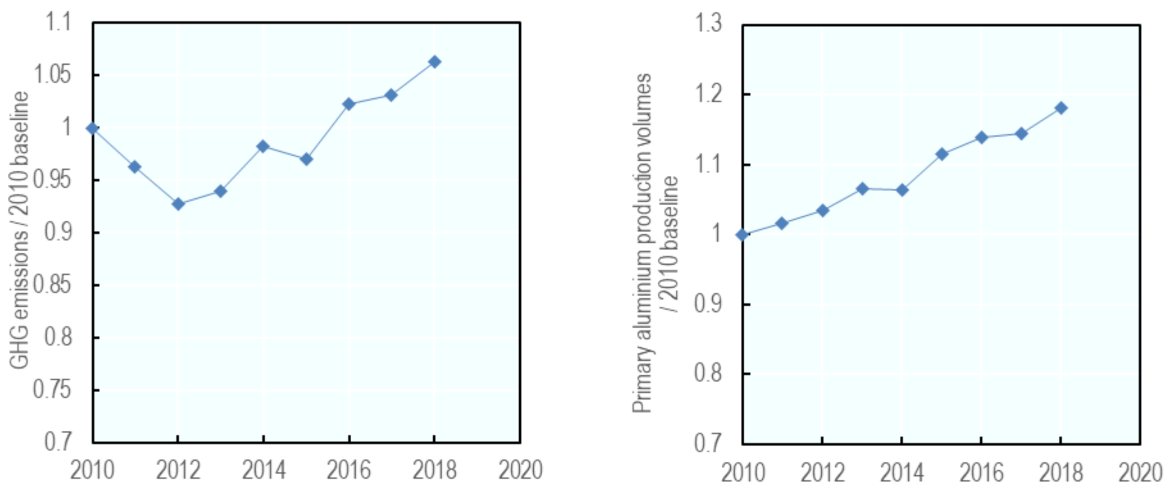
Note: Thick red lines indicate the draft EU taxonomy thresholds for the electrolysis process only. Thin grey lines indicate the intensities implied by total GHG emissions, total electricity consumption, and primary aluminium production volumes of each primary aluminium production plant in Norway. While the majority of GHG emissions at primary aluminium production sites is due to the electrolysis process, total GHG emission volumes used here also include emissions from other processes such as casting and, where relevant, anode production. Hence, the GHG emission intensity calculated here overestimates the electrolysis GHG emission intensity, to which the EU taxonomy threshold applies. Similarly, the total electricity consumption overestimates the electricity consumption for electrolysis.
Source: Emissions and production volumes were sourced from the N-PRTR.

[7] The precise share of electrolysis emissions in total emissions varies from plant to plant depending e.g. on whether anodes are produced on-site or imported. An expert opinion indicates that for some plants, electrolysis emissions are around 90% of total emissions; however, this estimate cannot be generalised to all primary aluminium plants in Norway.

Secondary aluminium production (recycling) is considered sustainable under the draft EU taxonomy screening criteria, without further thresholds on GHG emissions intensity or energy consumption. This includes both secondary aluminium production from pre-consumer and from post-consumer scrap. Within the scope of this study, one facility was identified as dedicated to aluminium recycling. Capital investments relating to this facility were marked as taxonomy-consistent in Figure 3.4. Investments in remelters, which are combined with other facilities (e.g. primary aluminium production, or extrusion or rolling facilities), could not be isolated and were labelled as “not addressed”.

Figure 3.7 shows the evolution of total GHG emissions, and primary aluminium production volumes, over the period considered. The strong growth in GHG emissions in 2015-2018 may in part be due to production volumes growing faster than expected, and does not necessarily indicate a lack of investment in energy efficiency and emission reductions (see Section 3.1.2 for further discussions on this). The GHG emission trajectory for the aluminium subsector could not be quantitatively compared to a mitigation scenario or objective due to the lack of a suitable reference point. Specifically, a comparison to the IEA 2° scenario was not meaningful, since the emission trajectories reported for the aluminium subsector in the 2013 NETP cover combustion emissions only, and not process emissions from electrolysis.

Figure 3.7. Aluminium sector GHG emissions



Note: Emission volumes include all GHG emissions from installations in the aluminium sector. In particular, they cover primary and secondary aluminium production, casting processes, and anode production where relevant. However, the majority of emissions is from the electrolysis process used for production of primary aluminium.
Source: N-PRTR, UNFCCC NIRs.

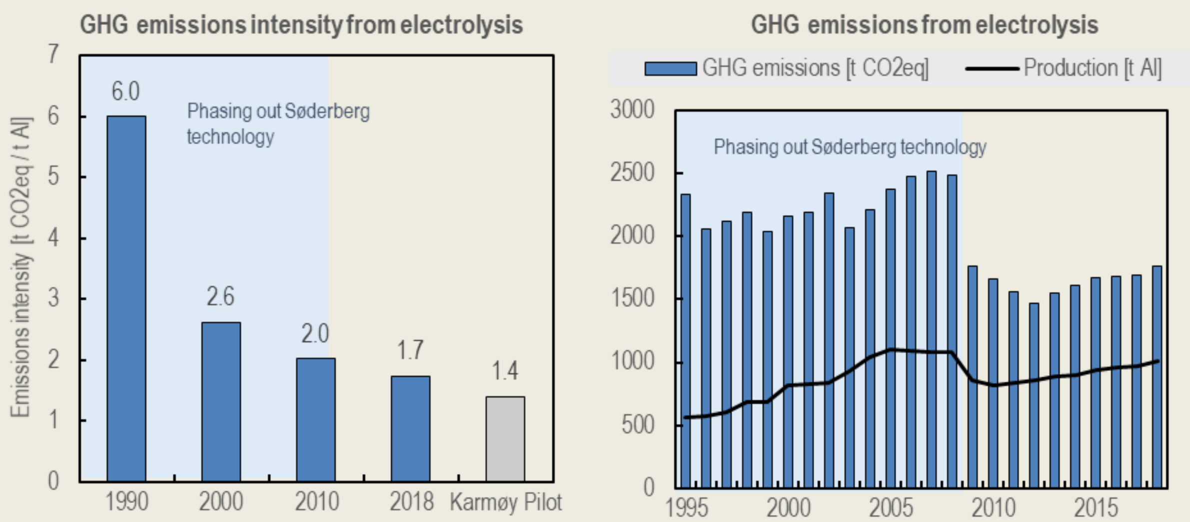
While aluminium production is energy intensive and emits significant amounts of GHG in the production phase, the inherent properties of aluminium can contribute to significant reductions in energy consumption, and thus lower GHG during the use phase. When evaluating the sustainability of aluminium production, it is thus important to look at the life cycle of the material, including raw materials, indirect emissions from electricity consumption as well as use phase benefits. While the current proposal for taxonomy criteria under EUs sustainable finance framework to a certain degree considers emissions from electricity consumption, raw materials and the use phase are not included. This limits its relevance for a broad evaluation of GHG emissions from aluminium production and use. Similarly, the above comparison of GHG emissions to mitigation scenarios may profit from being complemented with a full life-cycle impact assessment.

Box 3.1. Norsk Hydro: investments in reducing the GHG intensity of aluminium production

Norsk Hydro ASA ("Hydro") is the largest aluminium producer in Norway, responsible for over three quarters of Norway's primary aluminium production in 2010-2018. For over twenty years, Hydro has worked consistently to reduce the greenhouse gas emissions and electricity consumption from the aluminium production process. The motivations for doing so relate both to improving the economic profitability of the company and in reducing its environmental footprint.

In the early 2000s Hydro made a step change by phasing out traditional Søderberg smelting technology at its Norwegian plants, corresponding to 260,000 metric tons of annual capacity. With a NOK 6.5 billion (approximately USD 0.7 billion) investment, these capacities were replaced by adding 300,000 metric tons of annual capacity based on pre-baked carbon anodes at Hydro's existing Sunndal plant. As illustrated in Figure 3.8, this resulted in a halving of GHG emission intensity compared to Søderberg technology. Since then, Hydro has been searching for the next step-change.

Figure 3.8. Progressive reduction in the GHG emission intensity from electrolysis at Norsk Hydro



Note: Emission and production volumes refer to the electrolysis process across Hydro's primary aluminium production in Norway. Direct emissions of CO_2 and of other GHG such as PFCs are covered. These figures include extraordinary emissions during e.g. start-up of curtailed capacity. Without this, the 2018 intensity would be 1.6, which is comparable to figures in Hydro's annual reports.
Source: Norsk Hydro ASA.

Hydro's technology pilot at its Karmøy primary aluminium plant is a result of this. Construction of the pilot started in 2016; in 2018, it reached its full capacity of 75,000 metric tons, corresponding to around 6% of Hydro's total capacity in Norway. Although still in a verification phase, it is now producing primary aluminium in a particularly climate and energy-efficient way (see Figure 3.8). The total capital investment cost for the project was NOK 4.3 billion. Enova contributed NOK 1.6 billion toward the total cost. Hydro financed the remainder from retained earnings and funds available from previously raised capital, i.e. no new debt or equity was issued.

The technology pilot's production cells use Hydro's HAL4e technology, where the target is to operate with energy consumption that is 12%-17% lower than the global average of 14 kWh per kg aluminium. Total direct emissions from the electrolysis are expected to be 1.4 kg CO_2 equivalents/kg aluminium, which is more than 30% lower than the current world average. An important rationale for the technology pilot is to validate the new physical technology elements and control systems. This may enable Hydro to implement the new spin-off technology elements efficiently at its other primary aluminium plants to improve performance and financial robustness. Hydro will make the technology available on commercial terms for production within EU and the European Economic Area.

Hydro evaluates total GHG emissions in a life-cycle perspective based on internal and external studies (Norsk Hydro ASA, 2019[46]), (IAI/IFEU, 2016[47]). Based on these evaluations, Hydro assesses that it is on track to reach its ambition to be carbon neutral by 2020 in a life cycle perspective. Going forward, the company will continue to direct aluminium to products where the benefits are highest in the consumer use phase, invest in reducing emissions from its own production and set stricter requirements to suppliers of sourced metal, aiming at reducing total emissions – based on its current portfolio – by 30% by 2030.

Source: Largely based on inputs from and bilateral communication with Norsk Hydro ASA.

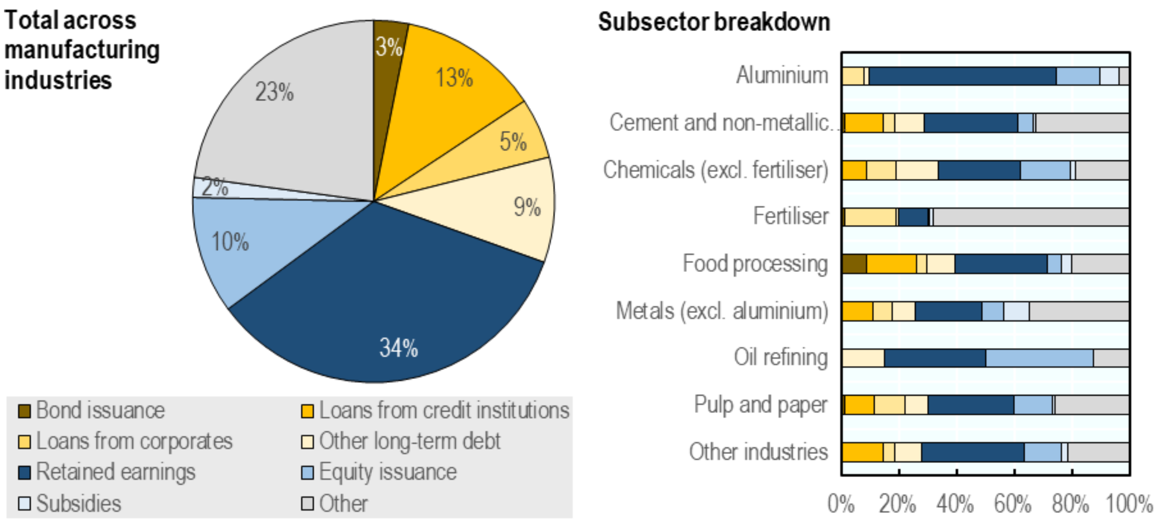
3.2. Sources of finance and public support

In general, corporate investments may form part of the company balance sheet, or they may be separated from other company activities via dedicated project finance vehicles. Based on screening available commercial databases (Thomson Reuters, IJGlobal), there was no relevant project finance activity in the manufacturing industries in Norway within the period considered. Instead, the majority of investments in the scope of this study were financed from the balance sheets of private (unlisted) industrial companies. This makes it difficult to link investments mapped in Section 3.1.1 with underlying sources of finance. To nevertheless do so, the approach taken here is to link investments by companies to coinciding increases of the same company's long-term liabilities, year-by-year. This was done based on financial statements filed by Norwegian companies at the Brønnøysund Register Centre. Figure 3.9 shows an overview of the sources of financing identified in this way.

The most important source of financing identified through this approach are retained earnings from companies' operating activities. These covered approximately 34% of the investments analysed in this study. The second important financing mechanism is issuance of new debt, covering 30% of total investments. Here, new debt consists mostly of long-term loans and other long-term liabilities. Bond issuance did not play a significant role (only 3% of total investments). The third important source of finance is contribution of new equity capital, corresponding to approximately 10% of analysed investments. Finally, approximately 23% of investments could not be linked to a concurrent increase in long-term liabilities. Such investments could have been financed via the sale of other assets or via short-term liabilities.

In terms of public financing, grants from major subsidies providers (ENOVA and Innovasjon Norge) covered about 2% of total investments tracked in the present study. Major focus areas were aluminium production for ENOVA (also see Box 3.1) and food processing for Innovasjon Norge. In addition, part of the debt financing was provided by public organisations. Loans from Innovasjon Norge and the Nordic Investment Bank amounted to approximately 7% and 6% of the total debt financing volume, respectively. In both cases, the loan financing was provided mainly to the food-processing subsector.

Figure 3.9. Sources of financing for investments in tangible fixed assets (2010-2017)

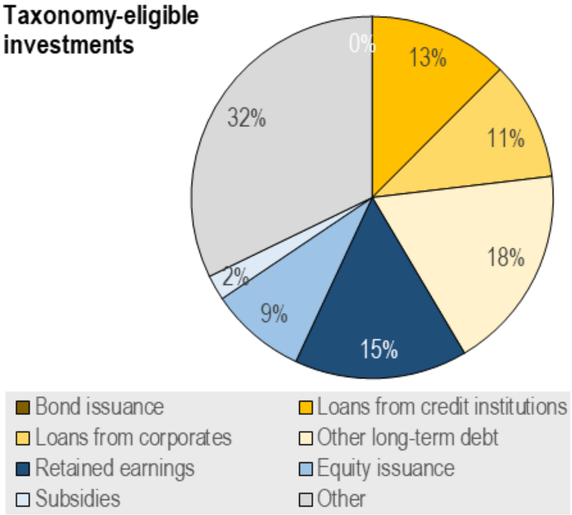


Note: Investments are matched with increases in long-term liabilities occurring in the same year or carried over from previous years. Pension obligations, deferred tax, and other provisions are excluded. “Other long-term debt” includes uncategorised long-term liabilities as well as subordinated and convertible loans. “Other” is a residual position from investments, which could not be linked to a corresponding increase in long-term liabilities. Such investments could have been financed e.g. via the sale of existing assets, or via short-term debt such as deferred payments to suppliers.
Source: Companies’ financial statements provided by the Brønnøysund Register Centre, data on subsidies from ENOVA and Innovasjon Norge.

The relevance of each source of finance varies across different subsectors. Figure 3.9 shows that the food processing and the chemical industries relied more heavily on debt financing than other subsectors. In particular, issuance of bonds occurred almost exclusively in the food-processing subsector. On the other hand, the aluminium and the oil refining industries were least dependent on external debt. In particular, bank loans correspond to less than 1% of investments in these subsectors during the time period considered. Such variation across subsectors may be linked in particular to structural differences in the capital intensity and operating margins of different industries. However, it may also indicate challenges for financing future investments in certain industries.

Figure 3.10 shows the structure of financing for investments providing a significant contribution to climate change mitigation, as per the analysis based on the current draft EU taxonomy in section 3.1.2. Compared to all investments in the scope of this study (Figure 3.9), the share of debt is higher (42% versus 30%) and the share of retained earnings is lower (15% versus 34%) for taxonomy-compliant investments. This may indicate an increased relevance of debt for financing “green” investments. On the other hand, the contribution of public subsidies of around 2% is the same for taxonomy-compliant investments as for the overall investments in the scope of this study. However, this analysis is not fully conclusive since the taxonomy-compliant investments are concentrated on less than 20 companies. Hence, it is difficult to attribute such differences in financing structure to the “green” nature of the investment, as opposed to other characteristics of the company or of the subsector.

Figure 3.10. Sources of financing for investments complying with the draft EU taxonomy technical screening criteria (2010-2017)



Note: Investments are matched with increases in long-term liabilities occurring in the same year or carried over from previous years. Pension obligations, deferred tax, and other provisions are excluded. “Other long-term debt” includes uncategorised long-term liabilities as well as subordinated and convertible loans. “Other” is a residual position from investments, which could not be linked to a corresponding increase in long-term liabilities. Such investments could have been financed e.g. via the sale of existing assets, or via short-term debt such as deferred payments to suppliers.
Source: Companies’ financial statements provided by the Brønnøysund Register Centre, data on subsidies from ENOVA and Innovasjon Norge.

4. Financing future mitigation actions

The analysis in section 3.1 highlights that in some subsectors, a share of investments during the considered time period was consistent with the reference points for climate change mitigation considered here. Nevertheless, further reductions of emissions and emission intensities appear necessary to reach the ambitious national and international mitigation objectives (section 2.1). This highlights the need of addressing the investments identified as potentially inconsistent, in order to avoid locking in GHG emissions for the future.

For the subsectors where financing could be a potential barrier to implementing GHG emission reductions, tailored public interventions (incentives or direct financial support) to scale up financing may be appropriate. The current financing mix presented in section 3.2 highlights different available sources of finance. Currently, retained earnings are the main one; debt financing (in particular lending by commercial banks) plays a limited role.

Even when ample financing is available, companies may delay or de-prioritise investments in short-term emission abatement measures for different reasons, such as:

- Prioritisation of growth and capacity expansions in investment decisions,
- Lack of business case given the current economic and policy environment, e.g. current level of carbon pricing, uncertainty about the nature and scale of public support,
- Expectations of mid- to long-term technological changes or breakthroughs, which may make short-term incremental measures obsolete.

In the longer-run, global and domestic demand trends as well as technological developments will influence the evolution of manufacturing in Norway. Materials use, in particular for metals and non-metallic mineral products such as cement, is expected to increase over the next decades (OECD, 2019[48]). Meeting this demand while simultaneously reducing emissions in line with ambitious climate targets will require more than incremental energy efficiency improvements. In addition to technologically mature emission abatement measures, achieving drastic GHG reductions in emission-intensive industries requires investments in new break-through production technologies ((IPCC, 2014[49]), (McKinsey, 2018[50])**.** Such break-through technologies could include ((Axelson, 2018[51]), (Wyns, Khandekar and Robson, 2018[52])):

- Carbon capture and storage, which is actively being piloted and researched in Norway (Box 4.1)
- Aluminium production using inert anodes instead of carbon anodes, which would eliminate direct GHG process emissions (Pawlek, 2016[53]). This includes for example the ELYSIS technology currently being piloted by Alcoa and Rio Tinto (European Aluminium, 2019[54]).
- Production of chemicals using renewable feedstocks ((IEA, 2018[55]), (Christensen, 2008[56]))
- Replacement of fossil coal in the production of iron and ferro-alloys by alternative reduction agents. These could include charcoal (Elkem's Carbon Neutral Metal Production initiative (Elkem, 2019[57]), (SINTEF, 2009[58])) or hydrogen (SINTEF, 2017[59]).

Such technologies are still being researched. Hence, reliable estimates of required investment needs are not available at this stage. Norway supports research and development of new environmentally beneficial technologies in particular through the following institutions:

- ENOVA: Investment aid and conditional loans for energy and climate technologies.
- Innovasjon Norge: Environmental Technology Scheme.
- Forskningsrådet: R&D programmes for energy, energy efficiency and carbon capture and storage.

Box 4.1. Carbon capture and storage

Carbon capture and storage (CCS) prevents the release of CO_2 into the atmosphere and is one of the strategies that can contribute to reaching climate change mitigation goals. In recent years, its conceptual scope has expanded with the emergence of the concepts of carbon capture, storage and utilisation (CCSU) and of bioenergy (i.e. biomass conversion to heat, electricity, liquid or gas fuels) with CCS (BECCS). Large-scale investments, deployment and project pipelines remain limited globally, in great part due to economic and financial considerations, (see for instance (Budinis et al., 2018[60]) (Leung, Caramanna and Maroto-Valer, 2014[61])).

However, as highlighted by the IPCC in its 2018 Special Report, most international-level scenarios compatible with the climate change mitigation goals of the Paris Agreement rely on CCSU and BECCS, although to very varying degrees. More specifically, for the industry sector, the IPCC states with high confidence that "*emissions reductions by energy and process efficiency by themselves are insufficient for limiting warming to 1.5°C with no or limited overshoot*" (IPCC, 2018[28]). This is for instance underlined by the IEA's Clean Technology Scenario (CTS), under which CCUS contributes almost one-fifth of emissions reductions needed in the industry, most notably in the cement, steel and chemical subsectors (IEA, 2019[62]).

CCS is one of Norway's priority areas for enhanced climate policy efforts beyond its current NDC, both in the oil and gas, and industrial sectors, which has translated in a range of public support, investments and financial support. In 2005, the government established both Gassnova, a state owned research organisation focused on CCS, as well as CLIMIT, a national programme providing financial support for both research and development, and for project demonstration. Further, the Technology Centre Mongstad (TCM) opened in 2012, becoming the world's largest facility for testing and development of carbon capture technologies. CCS projects at Equinor's Sleipner (as early as 1996, following the introduction of a carbon tax in 1991) and Statoil's Snøhvit (in 2008) petroleum fields in Norway remain the only commercial-scale ones currently in operation in Europe.

Norway initiated two CCS test projects at Norcem's Brevik cement plant and Yara's Porsgrunn fertilisers plant. The Brevik test phase involved a EUR 12 million (about USD 13.5 million) budget funded 75% by CLIMIT. In 2018, the Norwegian government postponed the final investment decision, dropped the Yara project, and announced an overall public budget cut for CCS. Norcem's vision of zero emissions from concrete, seen in a life cycle perspective, by 2030, requires industrial-scale investments in CCS, which in turn remains dependent on both public support and on the expected contribution of CCS in Norway's decarbonisation strategy.

In addition to such support, technological shifts require co-ordination between different industries as well as with public sector actors. This highlights the importance of a dependable roadmap for all involved stakeholders, with clear timelines and responsibilities, taking into account the industry's views on possible steps towards long-term climate change mitigation (In Norway, see (Norsk Industri, 2019[63])). Such planning helps clarifying where investment in short-term incremental abatement measures is necessary and meaningful, despite potential long-term technological changes.

5. Implications for data, methods and further tracking efforts

This study has been completed largely using publicly available data. The financial data available for Norway from Eurostat statistics (structural business statistics, GFCF statistics) provided an overview of investments on reasonably granular subsector level.

Furthermore, this analysis used firm-level financial statements from the Brønnøysund Register. While individual financial statements are publicly accessible, retrieving and processing them in bulk required a paid service from the Brønnøysund Register. Such data was crucial for multiple steps of the analysis:

- Due to confidentiality reasons, official statistics do not provide data for a range of subsectors where only few companies are active. For such subsectors, firm-level financial data can be used to fill data gaps on investment volumes.
- Firm-level data is required to evaluate the investments in installations complying with technical screening criteria (e.g. emission intensity thresholds from the draft EU taxonomy of sustainable activities), as opposed to subsector-wide totals.
- Companies' financial statements are the only identified data source that allows linking investments made from companies' balance sheets to sources of corporate financing such as retained earnings and debt (bond issuance or loan subscription).

GHG emissions data from specialised repositories (N-PRTR, EU ETS) provided the necessary starting point for an estimation of the climate-consistency of individual subsectors according to different criteria. Climate consistency was then measured based on two different reference points: the current draft EU taxonomy for sustainable finance, and the IEA 2° scenario for the Nordic countries. These inputs provide complementary perspectives in relation to climate change mitigation.

The choice of reference point affects significantly all aspects of the climate-consistency measurement: the proportion of total investments that can be addressed, the categories to classify investments as consistent and/or inconsistent, and the subsector-level assessment results. The use of the draft EU Taxonomy provides well-defined and stringent screening criteria. However, it only allows consistency conclusions for activities contributing significantly to climate change mitigation. Future evolutions of the taxonomy developments may address the distinction between truly climate-unrelated and potentially inconsistent activities. Evaluating the technical screening criteria also requires access to investment and GHG emissions data at a granular level (e.g. in the industry sector, individual production processes), which is rarely publicly available and might be confidential.

The IEA 2° scenario allows for an estimation of the climate consistency of investments for GHG-emitting subsectors. Such a scenario-based analysis makes it possible to classify a much larger share of total investments than captured by the draft EU taxonomy. In particular, it allows identifying inconsistent investments, which is crucial for estimating lock-in effects. However, this analysis has its own limitations:

- A wide range of different transition scenarios (and underlying assumptions) may be compatible with a given set of long-term climate objectives, such as those in the Paris agreement

- Scenarios rely on uncertain assumptions on overall economic development and on the emission reduction measures implemented in different sectors/geographies. These assumptions, as well as the scope and detail of modelling are subject to change when a scenario is updated.
- Global or supranational scenarios, such as those of the IEA, are often not granular enough to match country- and subsector-level investment and GHG data accurately. Country-level scenarios can reflect national circumstances more accurately. However, they would typically also only yield an aggregate evaluation of consistency per (sub)sector rather than for individual installations or investment projects.
- Comparing actual GHG emissions to emission reduction scenarios only addresses economic activities, which have a significant GHG footprint.
- Identifying the underlying reasons for consistency or inconsistency of a subsector with the chosen scenario is not straightforward. Inconsistencies could be linked to insufficient investment in technology improvement, but also increased demand and increased production. Likewise, consistency of total emissions with emission reduction trajectories could also be due to decreases in output volumes or shifts to other locations, i.e. carbon leakage. Decomposing these aspects would require more granular data on emission intensities of individual production processes, as well as global product-level demand and production data.

Further, neither the benchmarking for direct GHG emission reductions nor the draft EU taxonomy criteria take into account indirect GHG emissions (or their reductions) based on the full product life cycle. However, incorporating the sourcing of raw materials and the use phase of manufactured products would require a cross-sectoral measurement at international level, as well as pose challenges with respect to the attribution of GHG emissions to (sub)sectors and underlying investments across the life cycle.

The approach pursued in this study further identifies the sources of financing underlying the measured investments. However, establishing the role of financing conditions in investment decisions would require detailed data on financial transactions from companies and/or finance providers. In addition to analysing companies' annual reports as done here, it would require looking at loan terms and interest rates, as well as the expected revenues and operating expenditures associated with investments. Such data is commercially sensitive and frequently confidential.

Drawing more general and robust conclusions on data and methods to measure progress more systematically across countries (e.g. in the context of OECD work to produce indicators) and at international level (e.g. to inform finance-related elements of the UNFCCC Global Stocktake in 2023) requires further research work and discussions in research and policy communities. Such work can go in three parallel but complementary directions.

First, in order to test the availability of data in different contexts, the exploratory approach taken in this study could be further trialled and replicated for other sectors in other countries. On the investment and financing side, this would shed further light on the availability and relevance of official statistics and firm-level data from business registers, as well as on the need for complementary data collection and the use of estimation methods. Similarly, the availability of GHG reduction objectives, scenarios and potentials, as well as of established criteria to classify activities as climate-beneficial and detrimental, will likely vary across sectors and geographies. In any case, the Norwegian pilot highlights the relevance of considering different complementary viewpoints rather than relying on a single criteria for measuring the climate consistency of investments.

Second, the geographical scope can be extended to analyse the climate-consistency of a given sector – in this case, manufacturing industries – across multiple countries or globally. It would be a first step towards international-level tracking of climate-consistency of investments and financing, to produce aggregates and, where appropriate, draw comparisons between countries. This would also address some of the limitations and methodological issues that characterise the present country-level analysis. For instance, one could distinguish whether decreases in production and investment volumes in one country or region (such as observed here for the pulp and paper industry) indicate a global decreasing demand trend, or a shift in production capacities and underlying investments to other geographic regions ("carbon leakage", which can otherwise only be captured through demand- and consumption-based GHG accounting). Conversely, investments in increased production capacity in a country with relatively low GHG emission intensity (such as Norway) can be beneficial to global mitigation efforts even if they lead to absolute emission increases in the confined territory of that country. Further, whether within the scope of future country or supranational level pilots, additional elements could be analysed, such as investments in intangible assets, as well as the value of stocks of existing assets and of flows corresponding to their depreciation and decommissioning.

Third, similar work as conducted and proposed for climate change mitigation, also needs to be initiated in relation to measuring the consistency of investments from the perspective of climate resilience. To do so, the general approach explored in the present report may remain relevant. However, the collection of investment data as well as the choice and use of relevant reference points of consistency and inconsistency will necessarily involve further efforts and challenges. Such work would in any case enable links to the analysis of climate-related risks – including physical climate risks – that different public and private sector actors are increasingly undertaking.

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Annex A. Sector, sub-sector and technology coverage

The scope and sub-sector delineation of the present study is based on the European NACE classification. Its scope and granularity is largely equivalent to the subsectors in the international ISIC classification. The national Norwegian SIC classification (which is used e.g. by Statistics Norway) is equivalent to NACE on the level of granularity used for this project (4-digit subsectors). The SIC adds higher granularity to some NACE subsectors[8] in a national context, which, however, is not required here.

The overall scope of the study are the manufacturing industries as covered by Section C of the NACE, SIC and ISIC classifications. Investments and financing are covered on the granularity of 4-digit NACE subsectors for several reasons:

- The 2-digit granularity typically used for national accounts statistics is not sufficient to distinguish crucial subsectors from an emissions and investment viewpoint (e.g. 24.42 Aluminium production, 24.10 Manufacture of basic iron and steel and of ferro-alloys).
- The 4-digit granularity is the highest internationally harmonised granularity, and the highest granularity for which e.g. structural business statistics are available. Further breakdown, e.g. on 5-digit level, is only available in a national context (e.g. in the Norwegian SIC classification).

Within this scope, not all 230 4-digit NACE subsectors are relevant in terms of emissions and investment. Furthermore, economic and emission scenarios are usually presented on a more aggregate level. Table A.1 shows the aggregation applied in section 3. , as well as how it relates to the sectors used in the consistency analysis inputs. The minor scope differences between the aggregate sectors used here and those used by the IEA 2° scenario do not affect the results and correspond to less than 3% of the total investment volumes.

Table A.1. Aggregate sector definitions

Aggregate sector	Included NACE codes	IEA 2° scenario sector
Food processing	10, 11	Other industries
Pulp and paper	17, 18	Pulp and paper
Oil refining	19	Not covered
Chemicals (excl. fertilisers)	20 (excl. 20.15)	Chemicals and petrochemicals
Fertilisers	20.15	Chemicals and petrochemicals
Non-metallic mineral products (incl. cement)	23	Cement, other industries

[8] E.g. the SIC subdivides 24.42 Aluminium Production into 24.421 Production of primary aluminium and 24.422 Production of first transformation of aluminium

Metals (excl. aluminium)	24 (excl. 24.42)	Iron and steel[9]
Aluminium	24.42	Not covered[10]
Other industries	Rest of NACE section C	Other industries[11]

Based on these sector definitions, and on the data sources described in Annex B, Table A.2 shows the estimated gross investment volumes per subsector year-on-year. Table A.3 shows the corresponding volumes of GHG emissions, based on the data sources described in Annex C.

Table A.2. Estimated annual gross investment volumes per subsector

Sector	2010	2011	2012	2013	2014	2015	2016	2017	Average
Aluminium	960	n/a	777	899	1117	1489	3421	3505	1738
Non-metallic mineral products (incl. cement)	957	n/a	1366	1224	1171	1367	1414	1586	1298
Chemicals (excl. fertilisers)	2339	n/a	2567	2500	2262	n/a	2572	n/a	2448
Fertilisers	300	406	627	761	842	1114	1964	1471	936
Food processing	5744	n/a	6922	6151	7527	6067	7086	7813	6759
Metals (excl. aluminium)	636	n/a	1239	862	704	1405	951	1009	972
Oil refining	2643	477	800	311	994	822	1258	265	946
Pulp and paper	610	n/a	638	636	630	122	374	367	482
Other industries	3998	n/a	6831	7831	7982	n/a	6255	n/a	6884
Total manufacturing	**18187**	**n/a**	**21767**	**21174**	**23228**	**21904**	**25295**	**25687**	**22463**

Note: All values are in millions NOK. "Other industries" is a residual position, which is obtained by taking the difference of total manufacturing, and the subsectors tracked individually. n/a indicates data gaps.
Source: Eurostat structural business statistics, company annual financial statements via Brønnøysund Register Centre.

Table A.3. Estimated GHG emission volumes per subsector

Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Aluminium	2307	2222	2142	2167	2267	2239	2359	2381	2454	2261
Non-metallic mineral products (incl. cement)	1697	1667	1665	1657	1649	1587	1627	1764	1696	1664
Chemicals (excl. fertilisers)	2054	2106	2028	2153	2271	2265	2155	2112	2128	2143
Fertilisers	1186	1118	1150	954	908	1186	989	767	956	1032
Food processing	168	154	168	164	186	194	175	197	185	176
Metals (excl. aluminium)	1662	1766	1740	1839	1921	1756	1814	1963	1859	1808
Oil refining	2321	2591	2732	2727	2387	2593	2311	2734	2571	2549
Pulp and paper	404	306	221	219	177	152	169	162	170	226
Other industries	40	50	38	36	31	33	31	35	43	37
Total manufacturing	**11839**	**11981**	**11883**	**11917**	**11796**	**12006**	**11630**	**12115**	**12061**	**11896**

Note: All values are in kt CO_2 equivalents. Source: N-PRTR, EU ETS.

[9] Only NACE codes 24.10, 24.51, 24.52 are mapped to the IEA sector "Iron and steel", following the definition in the IEA World Energy Balances. The remaining sub-subsectors of NACE code 24 are mapped to "Other industries" when comparing to the IEA scenario projections.

[10] While the IEA NETP includes an emissions trajectory for the aluminium sector, it covers combustion emissions only which cannot be compared to total primary aluminium production emissions considered here.

[11] Except NACE code 21 "Manufacture of basic pharmaceutical products and pharmaceutical preparations" which is mapped to the IEA sector "Chemicals and petrochemicals", following the definition in the IEA World Energy Balances.

Annex B. Data sources on investments and sources of finance

The following data sources were used for the analysis of investment and financing in section 3.1.

- **National accounts.** The overall volume of investment, which this study attempts to track and classify, corresponds to the GFCF in tangible fixed assets, restricted to the industry sector in Norway. This aggregate figure is reported in the national accounts and available in Statistics Norway, Eurostat, and OECD databases.
- **Structural Business Statistics.** Investment volumes per industry subsector are mostly based on Eurostat Structural Business Statistics (SBS). The table sbs_na_ind_r2 provides the gross volumes of investment into tangible fixed assets on the level of NACE 4-digit codes. The only significant difference to the intended scope of tracking (and to the scope of the GFCF in tangible assets) is that the SBS investment volumes include purchases of re-sold existing assets. Based on the SBS data on sales of existing assets and on the aggregate GFCF data, the resulting difference is estimated not to exceed 10%. For subsectors with a small number of active companies, the Eurostat SBS (like other official statistics) does not provide data in order to preserve statistical confidentiality.
- Data on companies and their annual reports from the Norwegian Register of Enterprises (**Brønnøysundregistrene**). These were used for multiple purposes:
    - Estimation of volumes of gross investment in tangible fixed assets on company level. This is required, on the one hand, for obtaining subsector-level investment volumes for subsectors where the Eurostat SBS do not provide data due to confidentiality issues. On the other hand, company-level estimates of investments are required for measuring consistency with climate change mitigation reference points (see Annex C below). Company-level investments in tangible fixed assets were derived from cash flow statements. Where cash flow statements were not available, the investment volume was estimated from the difference in stocks of tangible fixed assets on the balance sheet, corrected by depreciation.
    - Estimations of sources of financing. In each year and for each company, investments on the one hand, and increases in different types of long-term liabilities[12] on the other hand were considered. Subsidies received in form of grants are listed as a separate source of financing, and subtracted from the increase in retained earnings. Where the sum of long-term liabilities' increases is larger than the investment volume, they are assumed to be the sources of financing for the investment in the same year, and attributed pro-rata shares. Where the sum of long-term liabilities' increases is less than the investment volume, the remainder of the investment volume is carried backward to the previous year and the procedure is repeated. In this way, investments can also be linked to financing, which was raised and not fully used in previous years. Nevertheless, there are cases where not the entire investment volume can be

[12] Long-term liabilities include, as reported in the balance sheet to the Register of Enterprises: paid-in equity, retained earnings, subordinated loans, convertible loans, long-term loans from banks, long-term loans from corporates, and other long-term debt.

linked to sources of financing in this way. Investments can take place without increasing long-term liabilities, for example by selling existing assets at the same time or by using (potentially revolving) short-term financing facilities.

- **Publicly available lists of projects financed by public organisations** (including ENOVA, INNOVASJON NORGE, and SIVA). Where the mapping to industry subsectors was not provided explicitly, it was derived from the company names via the Register of Enterprises company data. The publicly available data from these organisations does not provide details on the breakdown of tangible versus intangible assets within a single project, as well as on the breakdown of the financing/investment over time. In the present analysis, the entire volume of financing is allocated in the year when the loan was provided and assumed to be invested in tangible fixed assets[13].
- **Publicly available lists of projects financed by development banks** (including the European Investment Bank, the European Bank for Reconstruction and Development, and the Nordic Investment Bank). Within the sector and the period considered here, and focusing on investments in physical assets[14], only 11 projects (all by the Nordic Investment Bank) were identified as relevant. The publicly available data from development banks does not provide details on the breakdown of tangible versus intangible assets within a single project, as well as on the breakdown of the financing/investment over time. In the present analysis, the entire volume of financing is allocated in the year when the loan was provided and assumed to be invested in tangible fixed assets[15].
- **Commercial databases on project finance transactions** (including Thomson ONE and IJGlobal). No relevant project finance transactions have been identified in the time frame of the study.

[13] Specifically for financing provided by ENOVA, this assumption was confirmed to be valid since this organisation did not provide financing towards intangibles in the period considered here.

[14] In particular, financing provided purely for research and development, as well as financing provided purely for acquisitions of other companies, were excluded. On the other hand, financing provided for projects including both construction of physical assets (e.g. factories) and research and development was included.

[15] Unless the entire investment project is excluded due to being purely oriented on research and development, as described above.

Annex C. Sources of information to measure the climate consistency of investments

Granular data on GHG emissions is required for both the selection of relevant subsectors and for measuring consistency compared to different climate change mitigation benchmarks,. In the present study, historical GHG emissions on the level of individual industrial installations were sourced from the Norwegian Pollutant Release and Transfer Register (N-PRTR). This register covers more emission sources than the EU ETS system, and allows identifying the companies owning the installations in a straightforward way. For installations that are covered by the EU ETS and reporting to the N-PRTR, the two data sources were reconciled and were largely consistent. In a few cases (around 1% of the data points), evident data gaps or outliers[16] in the N-PRTR data were filled with the verified emissions data from the EU-ETS. The yearly aggregates of this installation-level data typically differ by less than 5% from the total volumes of direct GHG emissions from manufacturing industries as reported e.g. in the UNFCCC National Inventory Reports and in table 08940 by Statistics Norway.[17] Emissions from vehicles (e.g. the companies' vehicle fleet) are not included in the present analysis.

For measuring the eligibility according to the draft EU taxonomy, the main quantitative inputs are the emission intensities for the production of different goods. Where available, production volumes for relevant products were sourced from the N-PRTR. Certain installations produce multiple different products, especially in the chemical sector. Since a breakdown of GHG emissions by individual products is not available, the eligibility assessment was performed on installation level. Total GHG emissions per installation were compared to the sum of emission thresholds based on the volumes of products for which an intensity threshold is defined in the EU taxonomy draft. This is a conservative estimate, since it is equivalent to assuming a zero emissions threshold for products, which are not covered by the EU taxonomy at all. Note that the emission intensity thresholds in the draft EU taxonomy are set based on the benchmarking exercise prior to start of the ETS phase III in 2013, and are subject to revision in the future.

In cases where a company owns multiple installations, and only some of them are eligible according to the emissions intensity criteria above, the company-level investment data (see Annex B) was pro-rated based on the number of employees working in the corresponding installations. This may lead to imprecisions and

[16] Where the GHG emissions volume reported to the N-PRTR was less than 50% of the verified emissions volume as per the EU-ETS.

[17] However, these different sources of GHG emission data differ in how subsectors are delineated. Within the scope of this study, the main difference is the classification of ferrosilica and other silicium products. In the N-PRTR, emissions from ferrosilica are partially accounted for under NACE code "20.13 Manufacture of other inorganic basic chemicals" and hence in the chemicals sector. On the other hand, in the NIR and in the Statistics Norway table "08940: Greenhouse gases, by source, energy product and pollutant", such processes are accounted for under "Iron, steel and ferro-alloys" and hence part of the metals sector. In order to remain consistent with the available data on investment volumes, the consistency analysis performed here relies on the N-PRTR classification. Nevertheless, it was verified that the consistency measurement results remain largely similar if the Statistics Norway data on GHG emissions by source is used instead.

biases, since newer and more efficient facilities might require less employees to run and at the same time be more expensive in terms of upfront investment. However, no data source for installation-level investment volumes providing sufficiently broad coverage could be identified.

For measuring the consistency of GHG emission volumes, the average (or total) emissions over 2010-2018 are rescaled to the 2010 baseline and compared between past forecasts and actual developments. This is more relevant than a comparison based on the last year only, since the global warming potential in a given forward-looking scenario largely depends on the cumulative GHG emissions ("carbon budget"). The analysis here takes into account if particularly large emissions e.g. in the last year of the considered period were compensated by below-expected emissions in previous years (or the other way around). This is slightly different for the consistency measurement based on the technical screening criteria of the current draft EU taxonomy for sustainable activities, where emission intensities are used. Such emission intensities fluctuate less year-on-year than absolute emission volumes, and hence the last available year (2018) is used in this part of the analysis.

For measuring consistency with the IEA 2° scenario, the subsector-level emissions forecasts from the 2013 Nordic Energy Technology Perspectives (NETP) were used. The time resolution in IEA scenarios is 5 years; intermediate values were interpolated linearly based on the data points for the years 2010, 2015 and 2020. Since the NETP covers the entire Nordic region and is not broken down by country, the emission volumes were rescaled to their 2010 values, i.e. the evolution of subsector-level emissions compared to their 2010 values was considered. The consistency measurement was based on comparing the rescaled average emissions for the period 2010-2018 in the IEA scenario versus the corresponding rescaled average emissions reported to the N-PRTR. Emissions data has intentionally been used until the last available year (2018) since a time lag between investments and potential emission reductions is expected. The NACE subsectors of the industrial installations were mapped to the subsectors in the IEA scenario according to Table A.1.