Nordic Council of Ministers

The impact of COVID-19 and recovery packages on emission pathways to 2030

Inputs to the UNEP Emissions Gap Report 2021 Final project report

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Glossary

Carbon dioxide equivalent (CO_2e). A way to place emissions of various radiative forcing agents on a common footing by accounting for their effect on climate. It describes, for a given mixture and amount of greenhouse gases, the amount of CO_2 that would have the same global warming impact when measured over a specified time period. For the purposes of this report, greenhouse gas emissions (unless otherwise specified) are the sum of the basket of greenhouse gases listed in Annex A to the Kyoto Protocol, expressed as CO_2e and assuming a 100-year global warming potential.

COVID-19 recovery-type measure. Fiscal, monetary or regulatory intervention by a government to reinvigorate economic activity in response to a crisis.

COVID 19 rescue-type measure. Immediate fiscal, monetary or regulatory intervention by a government to protect citizens' lives and socioeconomic well-being and/or to provide emergency support to businesses and the economy in response to a crisis.

Decarbonization. The process by which countries, individuals or other entities reduce or eliminate carbon dioxide emissions. Typically refers to a reduction in the carbon dioxide emissions associated with electricity, industry and transport.

EDGAR. A multipurpose, independent, global database of global anthropogenic emissions of greenhouse gases and air pollution. EDGAR provides independent emission estimates compared to what is reported by European Member States or by Parties under the United Nations Framework Convention on Climate Change (UNFCCC), using international statistics and a consistent IPCC methodology. EDGAR shows emissions as both national totals and grid maps at 0.1 x 0.1-degree resolution globally, with yearly, monthly and up to hourly data.

Emissions pathway. The trajectory of annual greenhouse gas emissions over time.

Greenhouse gases. The atmospheric gases that are responsible for causing global warming and climate change. The major greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Less prevalent, but very powerful GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Land use. The total of arrangements, activities and inputs undertaken for a certain type of land cover (a set of human actions). The term "land use" is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation, city dwelling). In national greenhouse gas inventories, land use is classified according to the IPCC's land-use categories of forest land, cropland, grassland, wetland, settlements and other.

Land-use change. Land-use change involves a change from one land-use category to another.

SSP2 or Shared Socioeconomic Pathways. Scenarios of projected socioeconomic global changes up to 2100. They are used to generate scenarios for greenhouse gas emissions with different climate policies. SSP2 represents "middle of the road" or the medium pathway and extrapolates from past and current global developments into the future. In such a setting, income trends in different countries diverge significantly.

Abstract

ENGLISH

This report analyses the potential impacts of the COVID-19 pandemic and associated rescue and recovery packages on greenhouse gas emissions to 2030, focusing on three main aspects:

1. What happened to activities and greenhouse gas emissions in 2020, and what are the preliminary estimates for 2021?
2. How did the 2020 and 2021 emissions changes affect pathways through to 2030?
3. What is the expected impact of fiscal recovery packages on emissions through to 2030?

Following an unprecedented dip in global CO_2 emissions in 2020 due to the COVID-19 crisis, global emissions are experiencing a strong rebound, and 2021 emissions are only expected to be slightly below the record high of 2019. Very few pathways point to a reduction in CO_2 emissions in 2022, and the recovery of oil use will play a central role in this regard. If policies that can limit the recovery of oil use by favouring alternatives that are rapidly implemented, then CO_2 emissions growth in 2022 and afterwards could potentially be avoided.

Based on the modelling of current policy scenarios both excluding and including the impacts of COVID-19, the pandemic may lead to a reduction in global GHG emissions of about 3.5 $GtCO_2$ (equivalent to 9%) by 2030 compared with the pre-COVID-19 estimates. The majority of the reductions will come from the energy supply sector (2 $GtCO_2$), followed by the industry sector (1 $GtCO_2$) and the transport sector (0.5 $GtCO_2$).

Globally, the opportunity to use COVID-19 fiscal rescue and recovery spending to accelerate the low-carbon transition has largely been missed so far: the share of low-carbon fiscal spending ranges between 0.5%–2.5% in studies considering both rescue and recovery spending and 18%–30% for studies considering recovery spending alone. However, almost two-thirds of the low-carbon spending totaling USD 641 billion can be classed as enabling and catalytic low-carbon measures. This implies that the emission impacts of these expenditures will only unfold over a longer time horizon extending beyond 2030. Compared to other advanced economies, Norway, Finland and Denmark currently perform above average in terms of spending a significant share above 1% of GDP on fiscal recovery measures, and spending above 30% of all fiscal recovery funding on 'green' measures. In 2021, these countries were highlighted as leaders in low-carbon recovery.

DANISH

Denne rapport analyserer de potentielle effekter af COVID-19-pandemien og de relaterede økonomiske hjælpe- og genopretningspakker på drivhusgasudledninger frem til 2030, med fokus på tre hovedaspekter:

1. Hvad skete der med den økonomiske aktivitet og udledningen af drivhusgasser i 2020, og hvad er prognosen for 2021?
2. Hvordan påvirker de ændrede drivhusgasudledninger i 2020 og 2021 fremskrivningerne frem til 2030?
3. Hvad er den forventede virkning af COVID-19 genopretningspakkerne på udledningerne frem til 2030?

Efter et historisk fald i de globale udledninger af CO_2 i 2020 som følge af COVID-19-krisen er der et kraftigt opsving i de globale udledninger af drivhusgasser, og udledningerne i 2021 forventes kun at ligge en smule under det rekordhøje niveau i 2019. Meget få analyser peger på en reduktion af CO_2-udledningerne i 2022, og udviklingen i genopretningen af olieforbruget vil spille en central rolle i denne henseende. Hvis der hurtigt gennemføres politikker, der kan begrænse en stigning i olieforbruget ved at intensivere alternativer, kan en stigning i CO_2-udledningerne i 2022 og årene derefter potentielt undgås.

Baseret på modelscenarier for nuværende politikker henholdsvis uden og inklusive virkningerne af COVID-19 kan COVID-19-pandemien medføre en reduktion af de globale drivhusgasudledninger på ca. 3,5 $GtCO_2$ (svarende til 9 %) inden 2030 sammenlignet med prognoserne fra før COVID-19. Størstedelen af reduktionerne kommer fra energiforsyningssektoren (2 $GtCO_2$), efterfulgt af industrisektoren (1 $GtCO_2$) og transportsektoren (0,5 $GtCO_2$).

På globalt plan har man hidtil kun i begrænset omfang udnyttet muligheden for at anvende de fiskale COVID-19 hjælpe- og genopretningsmidler til at accelerere en grøn, lav-emissions omstilling: i undersøgelser, der inkluderer både hjælpe- og genopretningsmidler, udgør andelen af finanspolitiske COVID-19 midler, der fremmer en lav-emissions omstilling mellem 0,5 % og 2,5 %, mens den ligger mellem 18 % og 30 % i undersøgelser, der udelukkende ser på genopretningsmidler. Imidlertid kan næsten to tredjedele af allokeringerne til lav-emissionstiltag betragtes som katalytiske foranstaltninger. Det betyder, at effekterne af disse udgifter på drivhusgasudledningerne vil vise sig over en tidshorisont, der rækker ud over 2030. Sammenlignet med industrialiserede lande ligger Norge, Finland og Danmark i øjeblikket over gennemsnittet med hensyn til at bruge en betydelig andel på mere end 1 % af BNP på fiskale COVID-19 genopretningstiltag og bruge over 30 % af alle fiskale COVID-19 genopretningstiltag på "grønne" tiltag. I 2021 blev disse lande fremhævet som førende inden for lav-emissions COVID-19 genopretning.

Executive Summary

Keeping the temperature goals of the Paris Agreement within reach requires immediate and transformational action. Greenhouse gas (GHG) emissions must be reduced by 2.7% annually from 2020 to 2030 for the world to get on track to keeping global warming to below 2°C and 7.6% annually and thus achieve the 1.5°C goal. Emissions reductions of this magnitude are unprecedented.

The COVID-19 pandemic has had substantial impact on socioeconomic activities all over the world. Consequently, there was an unprecedented fall in global CO_2 emissions of 5.4% in 2020 compared to 2019 levels (UNEP, 2021). In response, countries have been looking at how to stimulate their economies since the outbreak of the pandemic in early 2020. The various economic recovery packages, if fully focused on low-carbon measures, could have a transformational effect on future emissions.

Against this background, this report analyses the potential impacts of the COVID-19 pandemic and associated rescue and recovery packages on greenhouse gas emissions to 2030, focusing on three main aspects:

1. What happened to activities and greenhouse gas emissions in 2020, and what are the preliminary estimates for 2021?
2. How did the 2020 and 2021 emissions changes affect pathways through to 2030?
3. What is the expected impact of fiscal recovery packages on emissions through to 2030?

Drawing and expanding on data and findings from the Emissions Gap Report 2021, this report seeks to provide policy-relevant information to global, EU and Nordic climate-change stakeholders.

Key findings of the report include:

I. Most recent emissions projections within "currently implemented policies" presented in the UNEP Emissions Gap Report 2021 show a significant dip in greenhouse gas emissions for 2020, but point to an increase towards 2030.

II. Based on currently available data, in 2021 fossil CO_2 emissions remained slightly below 2019 levels. However, oil use remained well below 2019 levels. This suggests, all else being equal, that emissions may rise again in 2022 as oil use continues to recover.

III. The impact of the COVID-19 pandemic is likely to lead to a reduction in global GHG emissions of 3.5 $GtCO_2$ (equivalent to 9%) by 2030 compared with pre-COVID-19 estimates.

IV. The majority of the emissions reductions come from the energy supply sector (2 $GtCO_2$, 9%), followed by the industry sector (1 $GtCO_2$, 12%) and transport sector (0.5 GtCO2, 6%).

V. The findings of the report point out that almost two thirds of the low-carbon spending (totalling USD 641 billion) can be classed as enabling and catalytic low-carbon measures. This means that the emissions impact of these expenditures will only unfold over a longer time horizon extending beyond 2030. Such findings suggest that governments have placed a distinct emphasis on measures to trigger transformational change over time within their low-carbon spending, and have not focused exclusively on measures to generate direct emission-reduction impacts.

VI. The report points to severe of shortcomings with regard to climate considerations, and especially the focus on the low-carbon transition in governments' fiscal responses to the global pandemic. The report shows that fiscal rescue and recovery spending since the beginning of the COVID-19 pandemic in early 2020 have only partially been reflected in governments' pledges to stage a "low-carbon recovery".

VII. Nordic countries are frontrunners in terms of fiscal recovery measures in respect of low carbon development. Indeed, compared to other advanced economies, the report's findings demonstrate that Norway, Finland and Denmark currently perform above average on both (1) spending a significant share above 1% of GDP on fiscal recovery measures, and (2) spending above 30% of all fiscal recovery measures on 'green' measures.

VIII. The report also demonstrates that, despite the overall scope of low-carbon fiscal spending across different areas, spending on worker retraining and educational initiatives have remained low across countries, pointing to an opportunity that can still be seized.

1 Background and objectives of the report

Keeping the temperature goals of the Paris Agreement within reach requires immediate and transformational action. Greenhouse gas (GHG) emissions must be reduced by 2.7% annually from 2020 to 2030 for the world to get on track to keeping global warming below 2°C and 7.6% annually and achieve the 1.5°C goal (UNEP, 2019). Emissions reductions of this magnitude have been unprecedented until now.

The COVID-19 pandemic has had a substantial impact on socioeconomic activities all over the world, and consequently global CO_2 emissions experienced an unprecedented fall of 5.4% in 2020 compared to 2019 levels (UNEP, 2021). In response, countries have been looking at how to stimulate their economies since the outbreak of the pandemic in early 2020. The various economic recovery packages, if fully focused on low-carbon measures, could have a transformational effect on future emissions.

The COVID-19 pandemic occurred at a critical time in the global climate policy process, with a new round of Nationally Determined Contributions due in 2021 and the global stocktake mandated under the Paris Agreement set to occur in 2023. Economic recovery packages and the associated fiscal spending can play a significant role in emission levels in 2030 and thereafter. As the world is about to enter the third year of the global COVID-19 pandemic, the lessons learnt from governments' experiences since early 2020 need to be reflected urgently in future fiscal spending and policy-making to keep the Paris Agreement's 1.5°C temperature goal alive.

The overall goal of this project is to contribute to raising the level of ambition of collective climate commitments in a new reality characterised by uncertainty surrounding the economic, social, climate and environmental implications of COVID-19 and the post-coronavirus recovery packages. Accordingly, the project focused on three milestones:

1. Enhanced understanding of the impact of COVID-19 and related recovery packages on greenhouse gas emissions to 2030. This milestone entails analysing the following questions and summarising the findings in a project report:
    - What happened to activities and emissions in 2020, and what are the preliminary estimates for 2021?
    - How did the 2020 and 2021 emissions changes affect pathways through to 2030?
    - What is the impact of recovery packages on emissions through to 2030?

2. Increased awareness of the policy implications and recommendations for green recovery post-coronavirus at global, EU and Nordic level. Building on Milestone (1), we further analyse the social, economic and environmental opportunities, benefits and potential trade-offs associated with green recovery packages. The findings and recommendations are published seperately in a policy brief.

3. Ensure broad and effective uptake of project findings by policy-relevant UNFCCC audiences through direct outreach, engagement and briefings of global, Nordic and EU policy stakeholders. The project's findings will also feed into and be disseminated as part of the 2021 edition of the UNEP Emissions Gap Report, widely recognised as the key international independent assessment report informing the UNFCCC negotiations.

A key outlet for this project's research findings was the 2021 edition of the UNEP Emissions Gap Report (EGR2021) (UNEP, 2021). The project's activities and deliverables were tailored to three groups of stakeholders: the UNFCCC community, climate policy stakeholders at the Nordic and EU levels, and peers in academia, to ensure that the project outcomes are taken on board and remain relevant beyond the project period.

This project report presents the findings related to Milestone (1) described above. Section 2 presents an analysis of emission trends for CO_2 and other GHGs in 2020 and 2021, as well as perspectives on 2022 and beyond. Section 3 presents a sector-level assessment of the impact of COVID-19 on future emissions up to 2030. Section 4 presents an updated analysis of COVID-19 fiscal rescue and recovery packages being implemented by national governments.

The project has been funded by the Nordic working group on Climate and Air (NKL) under the auspices of the Nordic Council of Ministers.

2 Analysis of emissions in 2020, 2021 and 2022

2.1 Introduction

In this section of the report, we focus on recent trends in GHG emissions. First, we cover GHG emissions data up until 2019 based on the latest EDGAR version 6 'fast track' dataset (see below). Second, using data from the Global Carbon Project and Carbon Monitor, we calculate fossil CO_2 emissions up until 2020. We then provide perspectives on fossil CO_2 emissions in 2021 and 2022, and assess what this may mean for the period up to 2030, which is further discussed in Section 3 of this report. Finally, we provided a more detailed analysis of selected Nordic countries.

The UNEP Emissions Gap Report (EGR) typically reports data up to and including the previous year; thus EGR2020 includes GHG emissions data up to 2019, and so on. Unfortunately, 2020 GHG emissions data was not fully available for EGR2021. The most recent version of EDGAR (v6) has GHG emissions data (carbon dioxide CO_2, methane CH_4 and nitrous oxide N_2O) up to and including 2018. The 'fast track' method typically used to update GHG emissions data until the most recent year was not completed for all GHG emissions in 2021 (Crippa et al., 2021). In 2021, the 'fast track' data extended CO_2 emissions through to 2020 and included fluorinated gases (hereafter 'F-gases') until 2018. This means there was no estimate of CH_4, N_2O or F-gases for 2019 and 2020. Feeding into the IPCC process, the Emissions Database for Global Atmospheric Research (EDGAR) non-CO_2 emissions data was extended by Minx et al. (2021) to 2019 using data from the previous EDGAR 'fast track' version (EGR2020), and more sector detail was provided. It is this dataset that is used in this report, as it has slightly more detail and has been peer-reviewed. The GHG emissions data is supplemented with data on CO_2 emissions from land-use change (Friedlingstein et al., 2021), which includes data up until 2020.

2.2 Greenhouse gas emissions from 1970 to 2019

For this report, we provide additional analysis that goes beyond what was published in the Emissions Gap Report 2021, based on the data published by Minx et al. (2021). Note that Minx et al. (2021) used CO_2 emissions data to calculate land-use change (LUC) from the Global Carbon Budget for 2020 (Friedlingstein et al., 2020) due to its late publication date, while this analysis uses LUC data from the Global Carbon Budget for 2021 (Friedlingstein et al., 2021). There was a major update of LUC emissions between the two different releases. The GHG emissions are weighted together using Global Warming Potentials (GWPs) from the IPCC AR5 with a 100-year time horizon.

Total GHG emissions reached 56.0 $GtCO_2$-e in 2019 (Figure 1). Total GHG emissions, averaged over the last decade, are dominated by fossil CO_2 emissions (67%), with methane (CH_4) (19%), land-use change (8%), nitrous oxide N_2O (5%) and F-gases (2%) making up the remainder. GHG emissions grew over the last decade by 1.0%

per year, fossil CO_2 emissions 1.3% per year, CH_4 emissions 0.8% per year, N_2O emissions 1.0% per year and F-gas emissions 4.2% per year, though land-use CO_2 emissions declined by 2.2% per year. Total CO_2 emissions – the sum of fossil fuels and LUC – has grown by 0.9% per year over the last decade. While the revision to LUC emissions changes the trend from increasing to decreasing in the last decade, total CO_2 emissions and GHG emissions have continued their upward trend over the last decade.

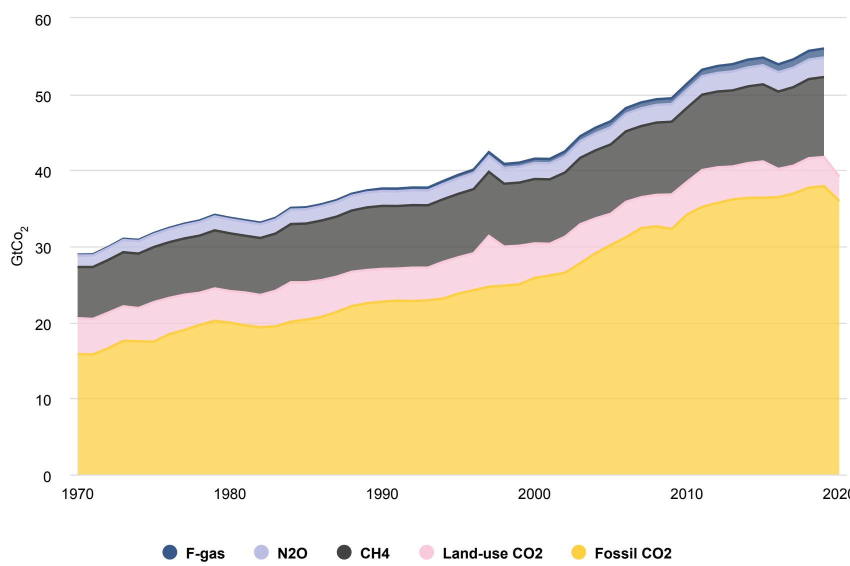


Figure 1. Greenhouse gas emissions data based on EDGAR version 6 'fast track', as published in Minx et al. (2021). Note that data for methane, nitrous oxide and F-gases are only available to 2019.

GHG emissions can be presented at different levels of sector aggregation. Here we show a five-sector aggregation (Figure 2) and a more detailed aggregation (Figure 3), both based on the IPCC sector classification. At the aggregated level, over the last decade, global GHG emissions have been dominated by the energy system (39%), industry (26%), transport (16%), buildings (6%) and agriculture (excluding LUC) 13%. Each sector has shown growth over the last decade: the energy system of 1.1% per year, industry 1.4% per year, transport 2.0% per year, buildings 0.7% per year and agriculture (excluding LUC) 0.7% per year.

At a more detailed level, the aggregated sectors are often dominated by a few subsectors. The energy system is dominated by electricity and heat generation, industry is more evenly spread across different industries, transport is dominated by road transport, buildings are dominated by residential use (e.g., gas use for heating and cooking) and Agriculture, Forestry and Other Land Use (AFOLU) is dominated by enteric fermentation.

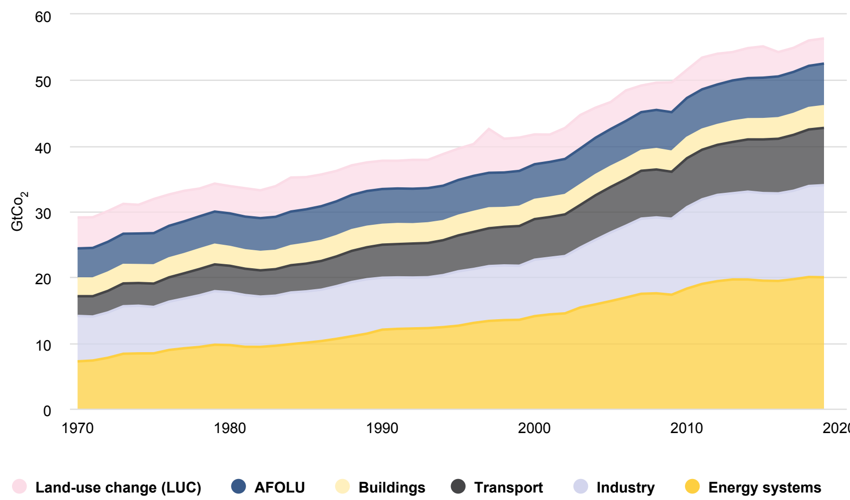


Figure 2. Greenhouse gas emissions data by aggregated sector based on EDGAR version 6 'fast track', as published in Minx et al. (2021).

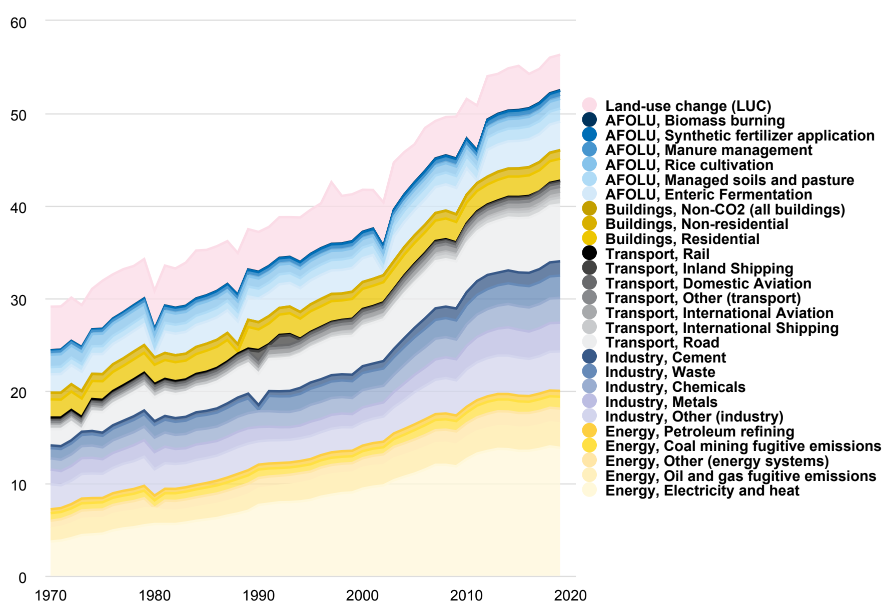


Figure 3. Greenhouse gas emissions data by detailed sector based on EDGAR version 6 'fast track', as published in Minx et al. (2021).

The top eight emitters cover about half of global GHG emissions (excluding LUC). In 2019, China emitted 27% of global GHG emissions, the USA 12%, the EU 7.3%, India 7%, and the Russian Federation 4.5%, with Brazil, Japan and Indonesia all at around 2% (see Figure 4). Adding LUC changes these numbers, particularly for Brazil and Indonesia, but it has little effect on the overall country rankings. There are also different ways of defining and allocating LUC emissions to countries, which makes a significant difference (Grassi et al., 2018). The ranking of countries changes dramatically when GHG emissions are allocated per person (see Figure 5). Of the top eight aggregated emitters, the USA and Russia dominate, with India and Indonesia both well below the global average. China's emissions per person are about the same as those of Japan.

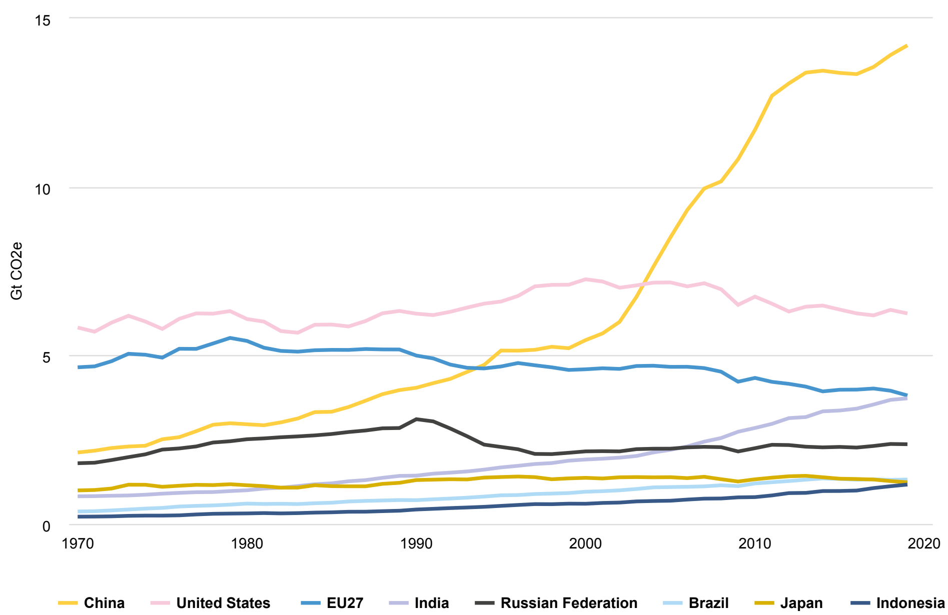


Figure 4. Greenhouse gas emissions for the top eight aggregated emitters based on EDGAR version 6 'fast track', as published in Minx et al. (2021).

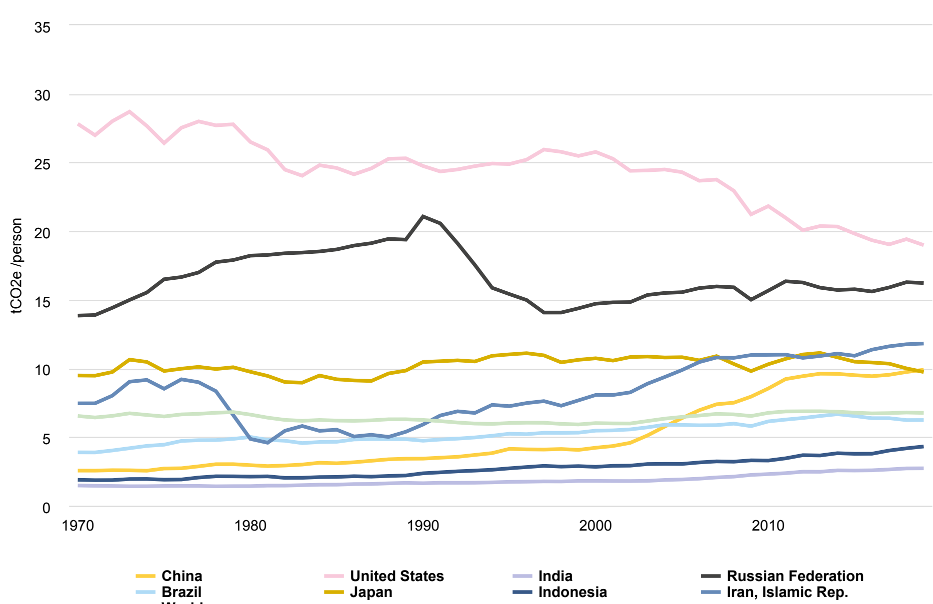


Figure 5. Greenhouse gas emissions per person for the top eight aggregated emitters based on EDGAR version 6 'fast track', as published in Minx et al. (2021).

2.3 Fossil CO2 emissions in 2020

Estimates of global fossil CO_2 emissions are produced and assembled from a range of underlying reporting mechanisms, generally official reporting of energy and industrial activity data. This reliance on the official reporting of comprehensive data introduces a necessary time lag between the end of the year of interest and when emissions estimates become available. Until recently the earliest such observation-based estimates of global emissions became available were those published by the oil company BP, usually in June or July, that is, with a lag of about six months. More robust estimates from the IEA came sometime later.

To reduce this lag, the Global Carbon Project began producing projections of global emissions for the current year (i.e., before the year was complete), thereby reducing the lag by more than six months. Recently the IEA has also begun to produce such projections, usually in the form of an early projection in March (Global Energy Review), followed by a revision around October (World Energy Outlook).

Given the nature of projections, the use of preliminary data and subsequent revisions, this can be seen as a continuum stretching from very early projections through to revised estimates some years later.

With the pandemic lockdowns in early 2020, three research groups recognised the demand for more frequent and more timely (with a lower lag) estimates of global fossil CO_2 emissions, their expectation being that significant changes in global activity will lead to significant changes in our emissions of this most important greenhouse gas. One method (Forster et al., 2020) is based largely on mobility data made freely available by Google, which is used as a proxy for all activity changes across the global economy, while the other two methods (Le Quéré et al., 2020; Liu et al., 2020) were more sophisticated, collating data ranging from high-frequency electricity generation to industrial production, in addition to mobility data from various sources. Of these, the work of Le Quéré et al. (2020) was designed specifically to show the effects of the pandemic response and therefore did not reflect other reasons for change, and it has since been discontinued. The work of Liu et al. (2020), by contrast, has been updated regularly and what were initially rather simple methods are being improved over time; this work is known as the Carbon Monitor. It remains to verify the results of such low lag estimates against more established estimates.

By drawing on four datasets that already report global fossil-fuel CO_2 emissions for 2020, we can compare estimated growth rates in 2020 both globally and for the countries and regions they have in common (Figure 6). At the global level the datasets are in very good agreement, with an emissions decline of between -5.4% and -6.3%, noting that BP only reports emissions from energy products, thereby excluding emissions from industrial processes such as cement production. BP also includes emissions from international bunker fuels, which is non-standard.

At the country and regional levels, there is more divergence. For example, Carbon Monitor's estimate of the decline in Russia's emissions is lower than the other datasets, while its estimate of the decline in Brazil is considerably higher. In particular, BP's estimated decline for the European Union (here including the UK) is somewhat higher than the other sources. For the UK, GCP relies on official published preliminary estimates, which indicate a lower decline than other sources.

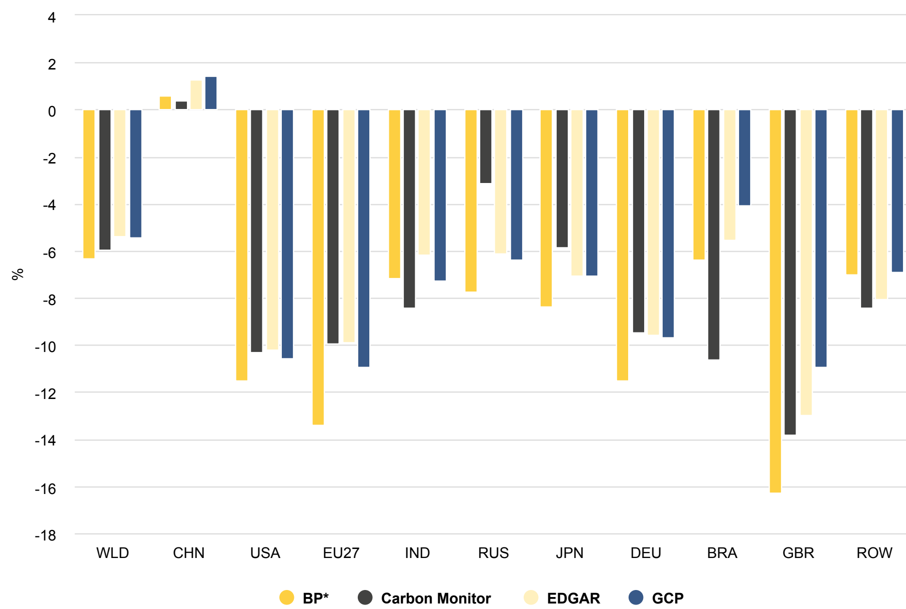


Figure 6. Estimated changes in fossil CO_2 emissions, both globally and by high-emitting countries, according to four different datasets. Sorted in order of emissions in 2020. Carbon Monitor data as available in December 2021.

Figure 6 shows the changes in global fossil CO_2 emissions by major sector as estimated by Carbon Monitor using proxy data. While by far the largest relative effect was in international aviation, down 56% in 2020 compared to the year before, this sector is responsible for a relatively small share of global emissions. A mere 3.4% decline in emissions in the global electricity sector resulted in a larger absolute decline in emissions. The largest absolute decline was in the ground transport sector (which is almost entirely road transport), with over 700 Mt CO_2 less being released in 2020, a decline of 10.9%. The declines in the power, industry and ground transport sectors were globally concentrated in the period of the strictest constraints on activity: March, April and May 2020. At the country level, this pattern is more mixed: in China the largest decline in emissions occurred earlier in the year. Estimated emissions in the residential sector show little change, despite people spending more time at home.

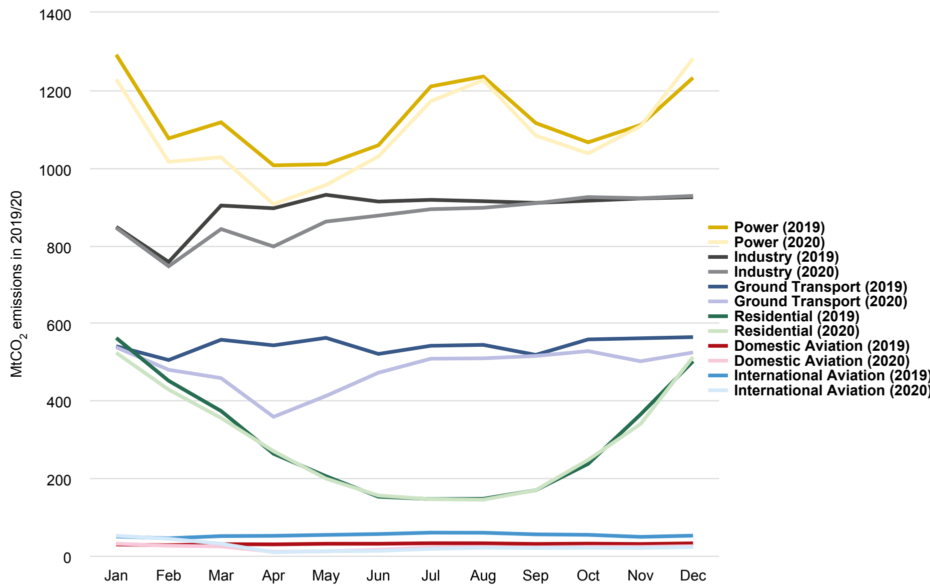


Figure 7. Global, monthly fossil CO_2 emissions by major sector in 2019 and 2020 as reported by Carbon Monitor. Dark lines show 2019, light lines 2020.

2.4 Perspectives for 2021

This section provides estimates for 2021 emissions, based on the latest available data. It builds on the analysis of monthly data discussed in more detail in the following section (Figure 12, Figure 13 and Figure 14, in addition to Chinese data, not shown). The monthly data are extrapolated forward using different techniques to arrive at an estimate of emissions in the current year. As an example, the original estimates published in November 2021 use monthly data up until July, August and September (depending on country), with the remaining part of the year extended forward to provide an estimate of total emissions in 2021. As time progresses, more monthly data becomes available and allows for updated projections.

Based on the Global Carbon Project (Friedlingstein et al. 2021), global fossil CO_2 emissions are expected to rebound by 4.2% in 2021 (range 3.5–4.8), after a reduction of 5.4% caused by the COVID pandemic in 2020 (Figure 8). The emissions increase in 2021 is projected to be 1.4 billion tonnes of CO_2 ($GtCO_2$), which is similar to that seen in 2010 after the global financial crisis of 2008–2009 (5.5%, 1.7 $GtCO_2$). Fossil CO_2 emissions in 2021 are estimated to reach 36.2 $GtCO_2$, remaining 1.5% below the pre-pandemic level of 2019, and slightly below the decade trend from 2010 to 2019. The projection reported here is an update of that first published in November (Friedlingstein et al. 2021). The original projection was for growth of 4.9% (range 4.1–5.7%), but it has been revised down particularly due to recent developments in China.

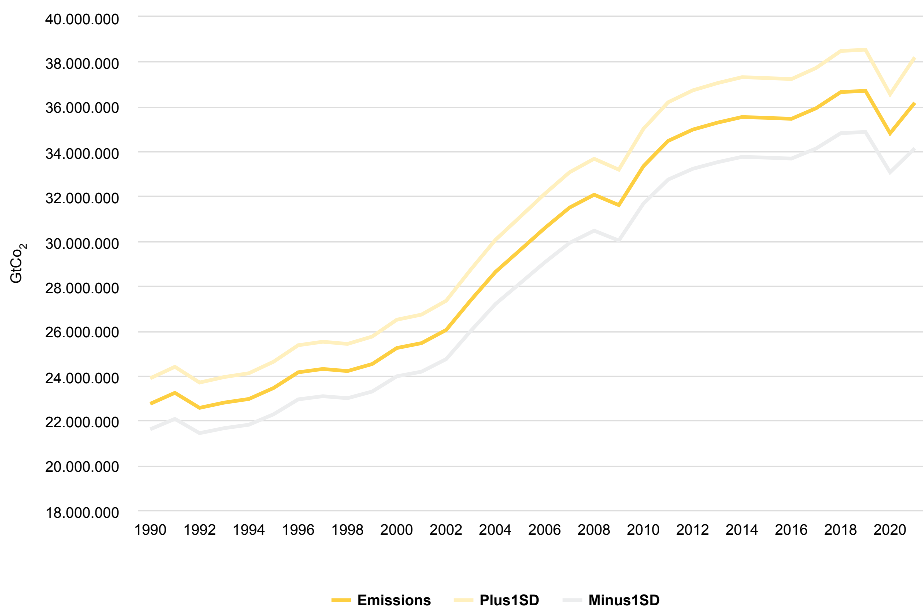


Figure 8. Estimates of global fossil CO_2 emissions in 2021. The projection was first published in November 2021, but was updated on 12 January 2022 using the latest available data.

Fossil fuels (see Figure 9). Emissions from coal use in 2021 are projected to be 0.5% above their 2019 levels, but still below their peak in 2014. Emissions from gas use are expected to rise 1.2% above their 2019 levels. CO_2 emissions from oil remained 6.2% below their 2019 levels in 2021. Coal and gas remained on their decade trend estimated from 2010 to 2019, while oil remains well below the decade trend.

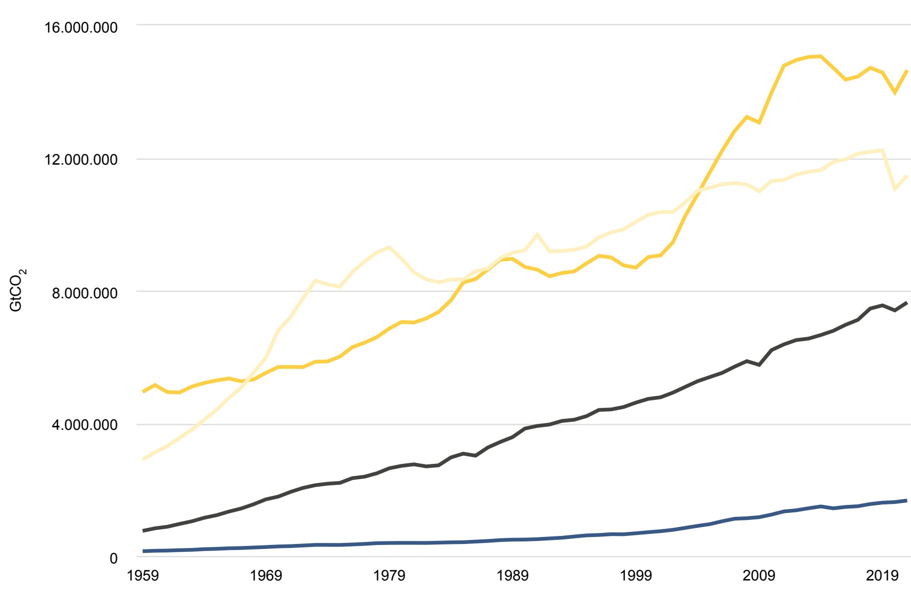


Figure 9. Estimates of global fossil CO_2 emissions in 2021 by coal, oil, gas, and cement. The projection was first published in November 2021, but was updated on 12 January 2022 using the latest available data.

Countries (see Figure 10). *China* was one of the only countries to have emissions growth in 2020 that has continued into 2021, with growth in all fossil fuels, and with coal potentially exceeding its 2013 peak. The *USA* and the *European Union* (EU27) both had similar declines in 2020 (~11%) and similar increases in 2021 (~6%), putting them 4–5% below 2019 levels. Both the US and EU are in line with pre-COVID trends. Emissions in *India* dropped 7% in 2020, but grew strongly in 2021, with coal up by 15% and total emissions now 3.8% above 2019 levels. The USA, EU27 and India have all returned to their decade trends from 2010 to 2019, while China is now (i.e., 2022) slightly above its decade trend in 2021. The aggregate of all other countries, ~40% of global emissions, is well below its 2010 to 2019 trend.

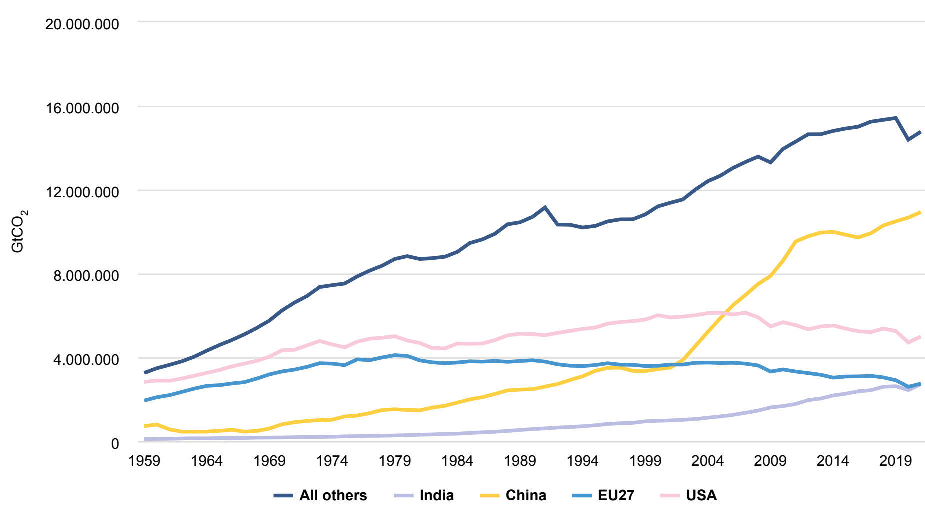


Figure 10. Estimates of global fossil CO_2 emissions in 2021 by top emitter. The projection was first published in November 2021, but was updated on 12 January 2022 using the latest available data.

Carbon Monitor. Carbon Monitor has just released (2nd February 2022) its first full-year estimate for 2021, and the results are compared with the Global Carbon Project in Figure 11. The Carbon Monitor data show a decline of 5.7% in 2020, an increase of 4.8% in 2021 and a decline from 2019 to 2021 of 1.2%. This compares to the Global Carbon Project's estimates of -5.4, +4.2, and -1.5% respectively. Both sets of estimates are preliminary, with the Global Carbon Project's estimates being based on monthly fossil-fuel data, while Carbon Monitor uses proxy data based on activity levels in different sectors (e.g., transport). As more data is released in the months and years ahead, these estimates will be refined.

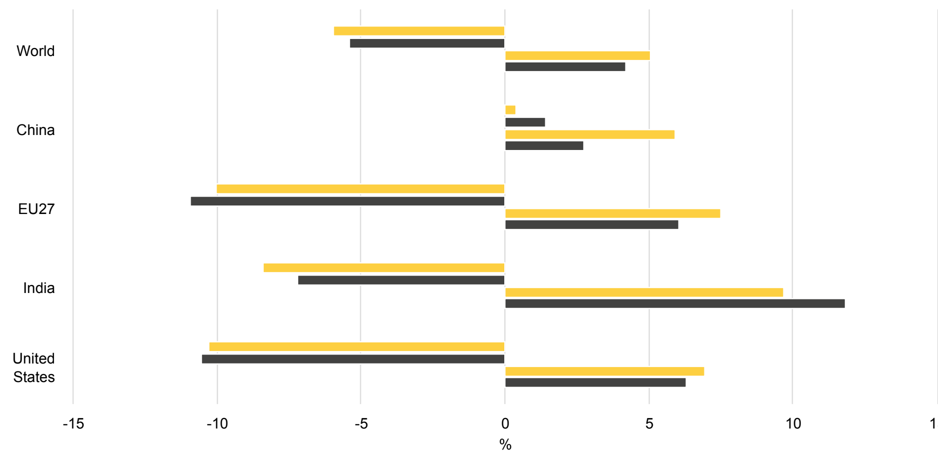


Figure 11. Data from the Carbon Monitor and Global Carbon Project showing a comparison of the growth in fossil CO2 emissions for top emitters from 2020 (left) to 2021 (right).

2.4.1 Monthly data

It is also possible to make estimates with a low lag using monthly energy-use data. The GCP projections ((Figure 12, Figure 13 and Figure 14) are based on monthly energy-use data, allowing a much finer resolution for fossil fuels. The method used for China is also based on monthly data, but it uses a statistical approach to estimate full-year emissions. The monthly data have a lag of several months – too long for the methods developed during 2020 to estimate the effects of COVID on emissions, but sufficient for most other applications. While methods based on the use of monthly energy data do not require the use of proxy data as with other methods, monthly data are still estimated and subject to later revisions (either revised monthly or revised implicitly when annual data are published). The Global Carbon Project produces sub-annual estimates for China (Friedlingstein et al., 2021), the EU (Andrew, 2021), India (Andrew, 2020) and the US (based largely on data from the US EIA).

Monthly emissions in the USA show the sharp decline in emissions from oil resulting from restrictions on activity and the consequent reduction in road transportation (see Figure 12). Emissions from natural gas, by contrast, do not exhibit such a dramatic fingerprint of the pandemic. Emissions from coal have been on a downward trend since the advent of the shale gas boom, but this has stalled since the pandemic began as a result of a complex range of issues, including the demands by shareholders of shale-gas companies to pursue profit over revenue and therefore not increase production despite rising demand.

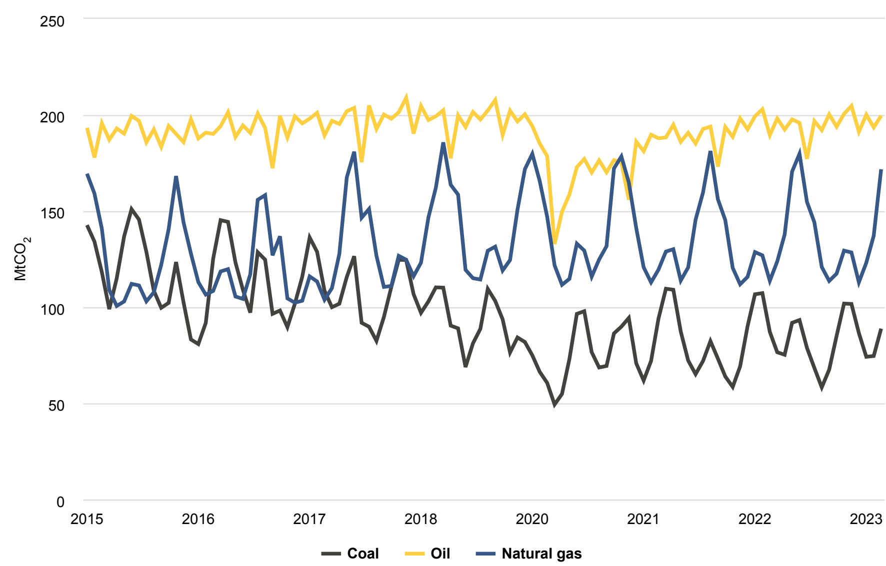


Figure 12. Monthly fossil CO_2 emissions in the USA as estimated and forecast by the Energy Information Administration. Source: January 2022 edition of the EIA Short-term Energy Outlook.

Figure 13 shows monthly emissions in the European Union, with a similar pattern to the US in 2020. It shows a sharp decline in emissions from oil resulting from the substantial constraints on transportation, little obvious difference in emissions from natural gas, and a (expected to be) temporary hiatus in the downwards trend in emissions from coal consumption.

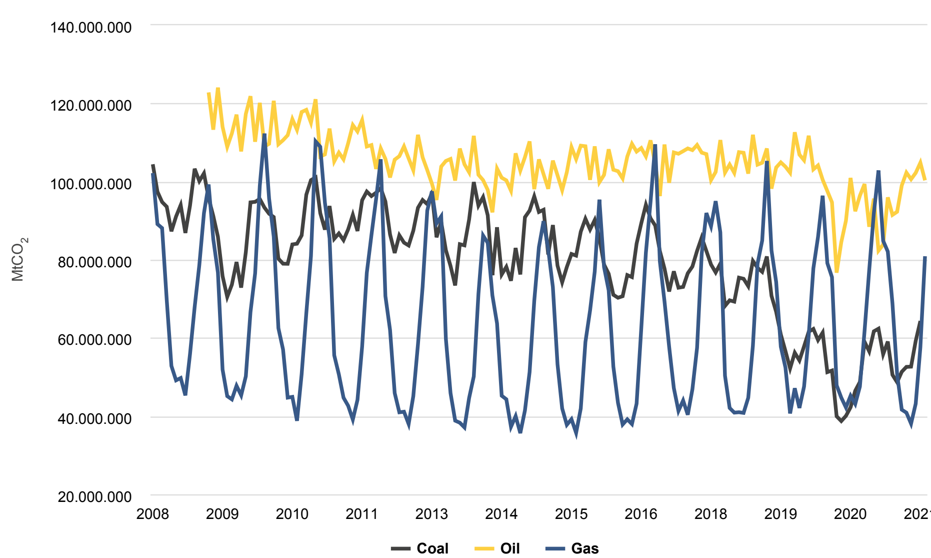


Figure 13. Monthly fossil CO_2 emissions in the European Union. Source: own calculations.

India's emissions from coal, oil and cement production declined sharply in the first half of 2020 following some of the strictest lockdowns in the world, announced with only four hours' notice. By the end of 2020, emissions had returned to their long-term trend. India's share of natural gas in its energy mix is substantially lower than in the EU and the USA, a result of very limited domestic resources and reliance on expensive LNG imports.

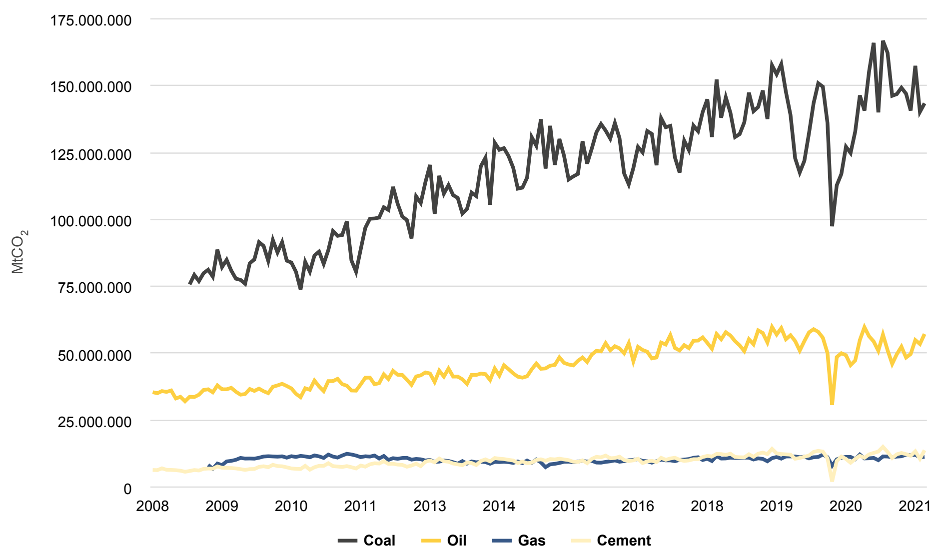


Figure 14. Monthly emissions in India, demonstrating substantial declines as a result of strict lockdowns in early 2020.

2.5 Perspectives for 2022 and beyond

Based on currently available data, 2021 fossil CO_2 emissions were slightly below 2019 levels, although uncertainty remains high. However, oil use was well below 2019 levels. This suggests, all else equal, that emissions may rise again in 2022 as oil use continues to recover. To provide some insights into potential emissions growth in 2022, we make some illustrative projections.

The simplest method to project emissions forward one year is to use estimated GDP growth and make assumptions on the reduction in CO_2/GDP. Here we have assumed CO_2/GDP declines at the same rate as in the last ten years and taken GDP estimates from the IMF World Economic Outlook from October 2021. The IMF estimates that GDP will grow by 4.9% in 2022, and when combined with a reduction in CO_2/GDP of 2.5%, fossil CO_2 emissions are estimated to grow by 2.4% in 2022 (see Figure 15).

It is also possible to make a projection using simple assumptions about the growth in coal, oil and gas. If it is assumed that coal use remains flat (IEA Coal 2021), oil use grows by 4% (EIA STEO) and gas and cement grow on trend, then fossil CO_2 emissions would increase by 1.8% in 2022 (see Figure 16). It is also worth exploring the consequences of some of the more stringent assumptions on growth. On the low side, coal goes down 1%, while oil, gas and cement remain flat, and fossil CO_2 emissions decline by 0.4%. On the high side, if coal goes up 1%, oil returns to 2019 levels, and gas and cement grow faster than trend, then growth will be 3.2%. If oil grows ~6% to reach 2019 levels, then coal would have to decline ~6% for there to be no growth in total fossil CO_2 emissions.

These examples indicate that fossil CO_2 emissions will probably increase in 2022. In other words, there are very few pathways that point to a reduction in CO_2 emissions. This is largely driven by the relatively slow recovery of oil use, which represents both a challenge and an opportunity. On the one hand, if oil use eventually returns to 2019 levels and continues to grow, it would suggest that COVID has done very little to effect 2030 emission levels. On the other hand, if policies are rapidly implemented that can limit the recovery of oil use by preferring alternatives, then CO_2 emissions growth in 2022 and afterwards could potentially be avoided.

Figure 15. A simple GDP-based projection for fossil CO_2 emissions in 2021.

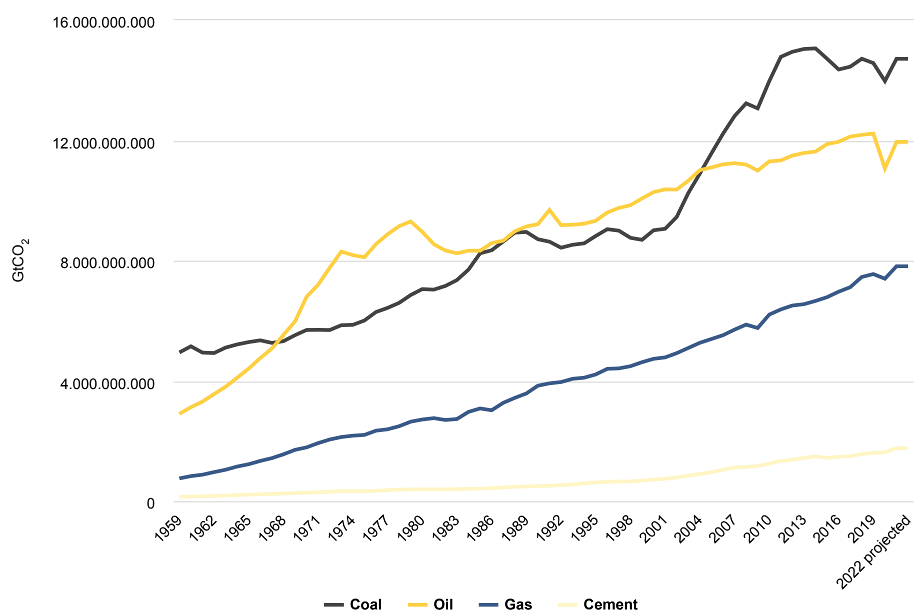


Figure 16. A projection of fossil CO_2 emissions in 2022 using simple and stylised information for the estimated growth of coal, oil, gas and cement in 2021.

2.6 Nordic countries

In this section, we focus on GHG emissions in those Nordic countries for which data are available. We first compare the UNFCCC and EDGAR data, before comparing these countries using the officially reported UNFCCC data.

2.6.1 EDGAR versus UNFCCC

Figure 17 gives fossil CO_2 emissions in Sweden, Finland, Norway, Denmark and Greenland as published by EDGAR and the respective national statistics offices (Greenland's emissions are reported by Denmark). Most global datasets of fossil CO_2 emissions produce poor estimates for Norway, particularly before 2000, a result of the poor 'supply-side' data for Norway (Andrew and Peters, 2021). The figure also demonstrates that EDGAR's estimates for Sweden are too high before about 2005, while those for both Denmark and Finland are relatively accurate. Greenland's emissions are too small to be clearly visible on this figure, but EDGAR's data show zero emissions before 2004.[1]

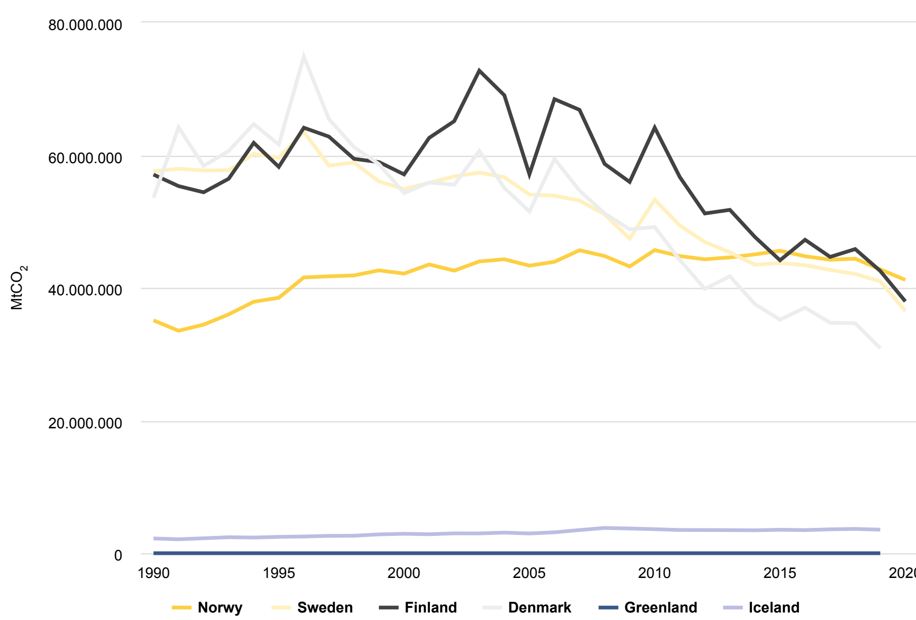


Figure 17. Comparison of fossil CO_2 emissions in selected Nordic countries as estimated by EDGAR, with official estimates from each country.

When looking at other greenhouse gases, more significant issues appear (Figure 18). Methane emissions reported by EDGAR for Sweden, Norway and Finland are significantly higher than official reporting. For some sectors, EDGAR uses the same method for all countries. For example, fugitive emissions of methane in the oil and gas sector are estimated based on the level of production of oil and gas. In the case of Norway this ignores the substantial effects of regulation on reducing such fugitive

1. The EDGAR 6 FT2020 dataset used here does not use 'no data', but in the full EDGAR 6.0 dataset Greenland's emissions before 2004 are indicated as absent with 'NULL'. This is because EDGAR relies on energy data from the IEA, which are absent prior to 2004.

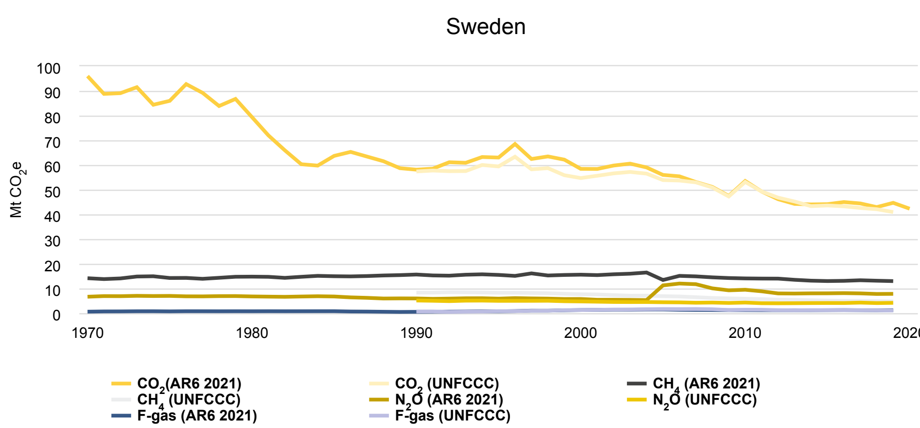
emissions. Instead, EDGAR's methane emissions estimates for Norway (solid blue line) follow the pattern of its total production of oil and gas.

Using the 2021 official reports to the UNFCCC, we can track the main reasons for EDGAR's divergences. Norway's fugitive emissions of CH_4 in the oil and gas sector are officially reported as 17.9 kt in 2019, while EDGAR estimates this as 639 kt. Sweden officially reports 29.8 kt CH_4 in the waste sector in 2019, while EDGAR estimates this at 279.8 kt CH_4. In the case of Finland, EDGAR reports 307 kt CH_4 fugitive emissions in oil and gas in 2019, while official reporting shows a tiny fraction of this at 1.05 kt CH_4. For the waste sector EDGAR reports 384 kt CH_4, while the official report shows 66.7 kt CH_4. These are very large divergences.

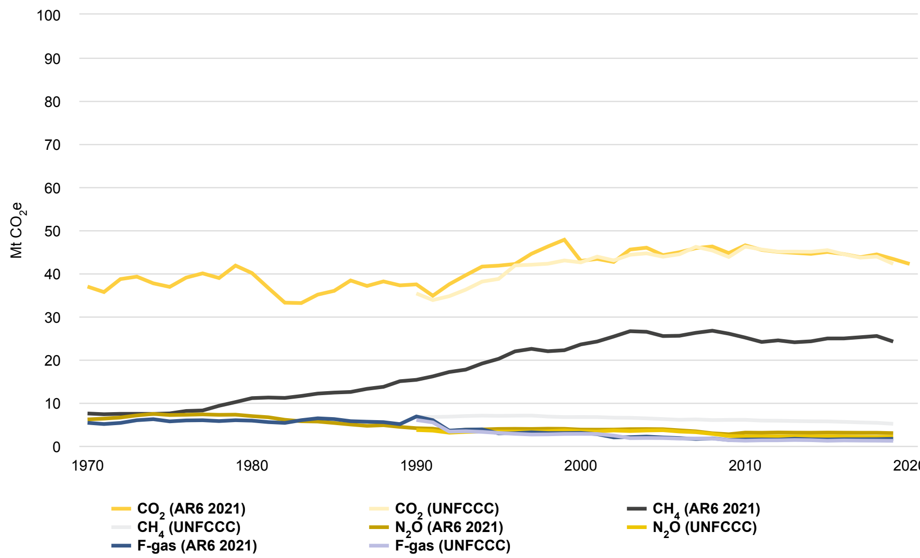
In Norway, Denmark and Finland, EDGAR's estimates of nitrous oxide appear to be relatively close to official estimates. EDGAR uses a Tier-1 method based on data published by the FAO, and many countries use also relatively simple factors in their official estimates of emissions of agricultural nitrous oxide. However, the case of Sweden shows a strange jump in emissions in EDGAR in 2005.

The correlation between EDGAR's and official estimates of F-gases is much higher, suggesting that EDGAR uses official submission data, perhaps from an earlier edition than that compared with in the figure, or uses a similar method.

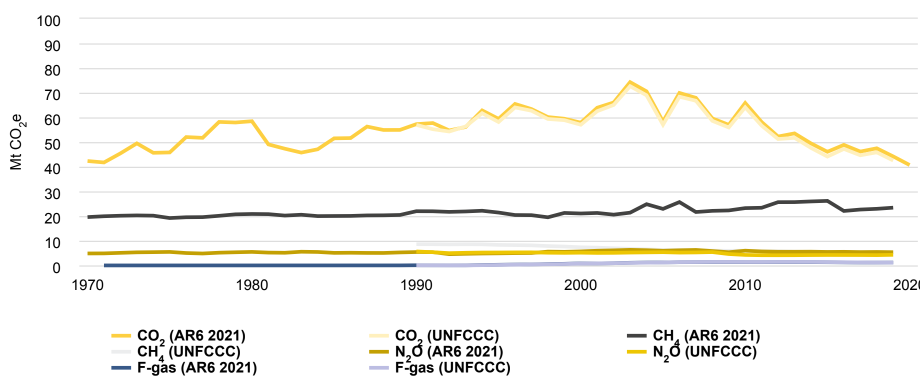
Figure 18. Comparison of greenhouse gas emissions officially reported by Sweden, Norway, Finland, Denmark and Iceland to the UNFCCC with those reported by EDGAR.



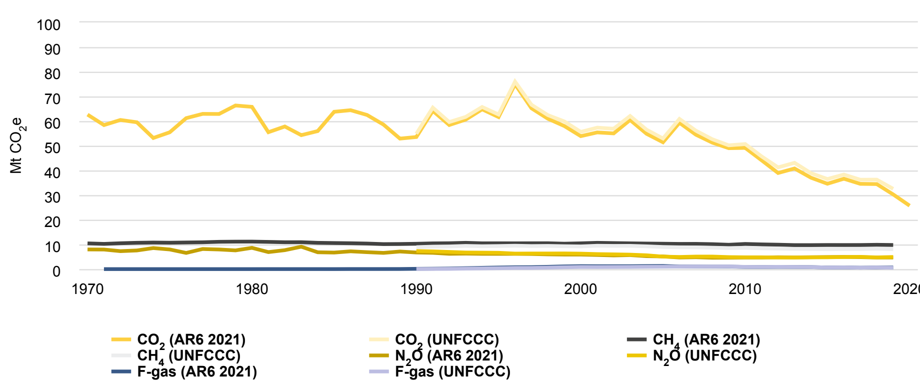
Norway

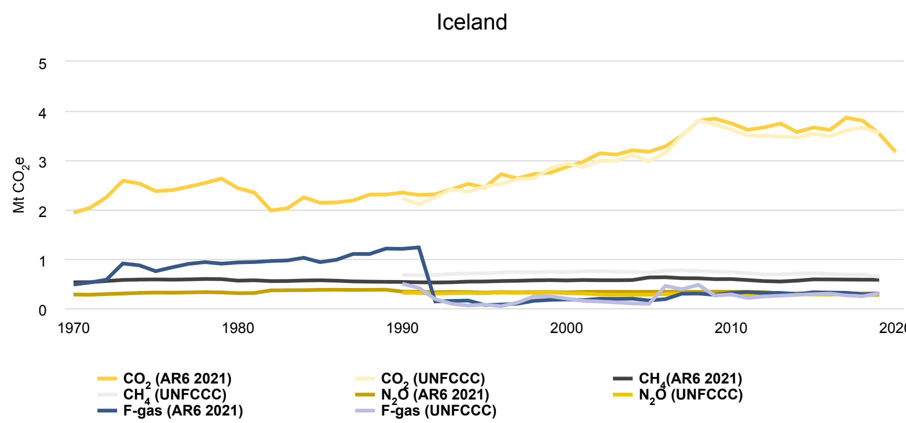


Finland



Denmark



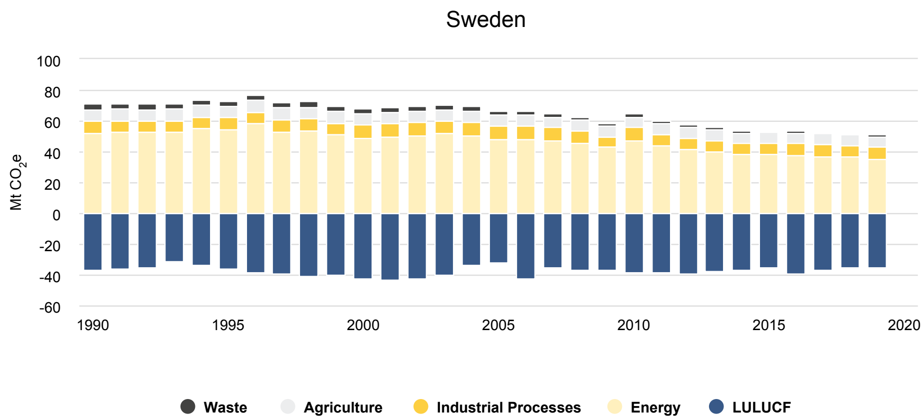


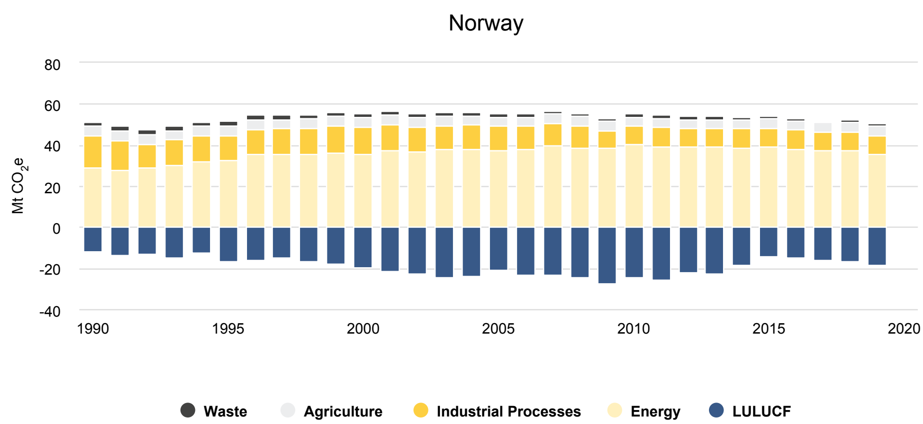
The EDGAR approach is to use a globally harmonised methods and sources of data, which means that country-specific detail is often replaced with global averages. In some countries and for some sectors or gases, these assumptions are clearly wrong. In the Global Carbon Project, it is assumed that the estimates reported by developed countries to the UNFCCC are more reliable than other independent estimates. Cross checks are still performed on the UNFCCC data to ensure it is consistent with other datasets, but it is assumed overall that the reviewed UNFCCC emission inventories are more reliable estimates given the data and resources behind them.

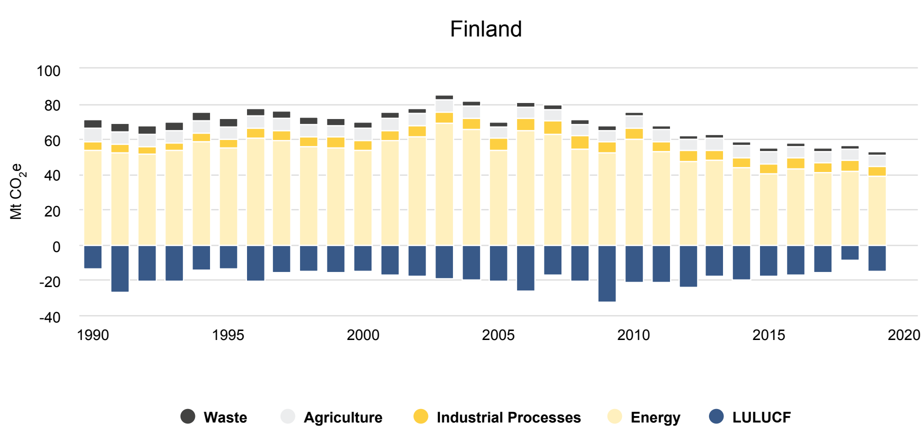
2.6.2 Comparison of the Nordic countries using UNFCCC data

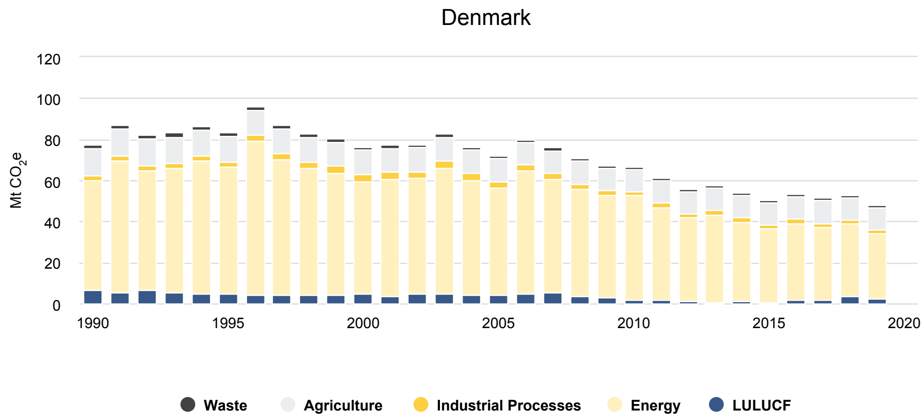
Figure 19 gives the UNFCCC country totals by sector for the different Nordic countries. Finland, Norway, Iceland and Sweden all have relatively large LULUCF sectors. Iceland's high emissions in LULUCF largely come from the continuous breakdown of carbon in drained wetlands. Finland exhibits more variability in energy and LULUCF because of its use of biomass in electricity, heating and industry. The energy sector is trending downwards in all but Norway, where the emissions are dominated by the oil and gas sector.

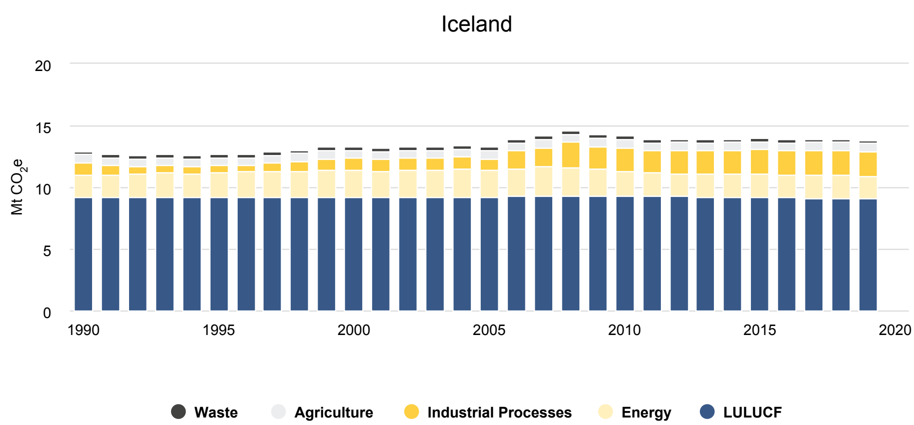
Figure 19. Emissions and sequestration of greenhouse gas emissions by IPCC sector for Sweden, Norway, Finland, Denmark (excluding Greenland and Faroes) and Iceland. Source: submissions to the UNFCCC (as of 11 June 2021). The bold black lines show total net emissions.











2.6.3 Extension of UNFCCC data to 2020

Both EDGAR and GCP make early estimates of final-year emissions before the more robust data become available, using extrapolation based on other sources of data. For example, GCP uses energy data from BP to extrapolate emissions from coal, oil and natural gas separately, combined with assumptions about other sources of emissions.

Three Nordic countries, Finland, Norway and Sweden, have published official, preliminary estimates of their territorial emissions. The statistical agency websites do not appear to present publication history, so it is not possible to determine when the data were first published, only when they were last published. However, we have been following the case of Norway closely, and the first preliminary estimates were published in June 2021, early enough for these to be incorporated into GCP's dataset published in 2021. No official estimate was found for Denmark.

Figure 20compares the declines in emissions in the official estimates with those published by EDGAR and the GCP for Norway, Sweden and Finland. Two things stand out. First, the decline in Norway was much less than those in Sweden and Finland. This is partly because of the nature of industry in Norway, with oil and gas production continuing, and with reductions in electricity demand not leading to emissions reductions because of Norway's near-100% CO_2-free generation. The second point is that the estimates produced by EDGAR and GCP using extrapolation show low skill for Sweden and Finland. Further analysis would be required to uncover the reasons for this.

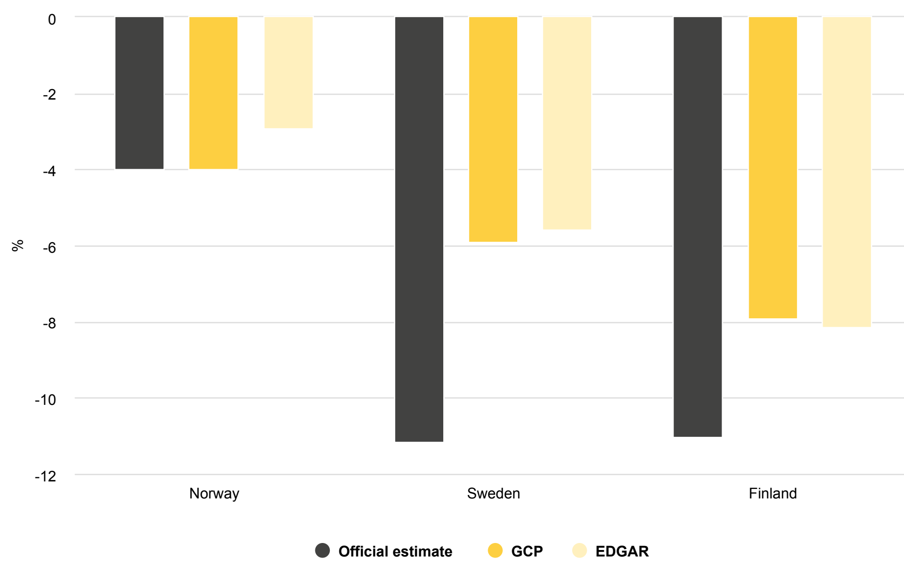


Figure 20. Estimated declines in fossil CO_2 emissions from 2019 to 2020 in Norway, Sweden and Finland, comparing official estimates with those reported by GCP and EDGAR.

3 Sector-level assessment of the impact of COVID-19 on future emissions up to 2030

3.1 Introduction

The COVID-19 pandemic has a substantial impact on socio-economic activities and energy use, and therefore on CO_2 emissions, as the previous section showed. To recover from the economic crisis, many countries have pledged large sums of money to stimulate the economy. The effect of COVID-19 on emissions up to 2030 is very uncertain. First, the depth and duration of restrictive measures and respective short-term economic effects have not been fully played out and may continue for longer. Second, future emissions will be affected by the extent to which low-carbon measures are integrated into economic responses. It is expected that emissions are likely to rebound if the COVID-19 crisis eases.

This section analyses what changes may stay in the trajectory to 2030. It evaluates the changes in 2020 that may persist into future years. Key sectors will be transportation and energy production. The chapter translates this change in activity into changes in future greenhouse gas emissions and explores the impact on global emissions by 2030 under current policies using the GDP projections of the OECD and IMF.

In this section, we explore the effect of the pandemic on greenhouse gas emissions to 2030 at the global level, at a sectoral level and for the four major emitting countries. We evaluate current policy scenarios excluding and including COVID-19.

The analysis presented here uses two scenarios:

1. current policies in a pre-COVID situation (*pre-COVID current policies*),
2. current policies including the impact of COVID (*post-COVID current policies*)

The analysis uses the IMAGE assessment model (Hof et al., 2022; Stehfest et al., 2014; van Vuuren et al., 2017, 2018). The *pre-COVID current policies scenario* includes all policies implemented before the cut-off date of November 2020, but does not account for the effect of the pandemic on GDP or activity levels. The effect of the pandemic is considered in the *post-COVID current policies* scenario. This scenario includes the drop in 2020 and the long-term macroeconomic impact but does not consider the effect of recovery measures, especially those implemented after the cut-off date. The *post-COVID current policies* scenario includes short-term (2020-2021) GDP growth rates based on official projections (including OECD, EC DG ECFIN and World Bank) by adjusting economic activity levels (consumer spending, investment, trade) and introducing sectoral shocks to reflect the observed COVID-19 impacts. Both scenarios assume that the same current climate policies are implemented, as described in more detail in Nascimento et al. (2021).

The modeling of the impact of COVID-19 on the key sectors builds on the work of Dafnomilis et al. (2021) using the IMAGE model. IMAGE's economic activity drivers are GDP per capita, Personal Consumption per capita and Value Added per capita for the following economic sectors: Industry (IVA), Services (SVA) and Agriculture (AVA). The information on economic activity drivers comes from the World Bank's World Development Indicators for the historic period. These are transformed into per capita values based on population data from the United Nations up to 2019 as available for each country. The values are then projected to 2100 using the SSP2 scenario growth rates established by GDP scenarios and population projections that are consistent with the SSP storylines. Section 3.2 describes the method in more detail. Section 3.3 describes the results and compares them with those of earlier studies.

3.2 Methods

3.2.1 MAGE model

For the PBL analysis, the integrated assessment model (IAM) was used in IMAGE 3.2 (Stehfest et al., 2014) to assess the impacts of national current policies and COVID. The IMAGE model is well suited for such an assessment given the relatively high degree of detail with which this model represents the activity levels in the different sectors and its focus on a physical description of activities (allowing a rather straightforward interpretation of the implemented policies). More specifically, the IMAGE model framework includes the TIMER energy model, where most of the COVID-19 policies were taken into account. The TIMER model has been developed to explore scenarios for the energy system in the broader context of the IMAGE global environmental assessment framework (van Vuuren et al., 2017; 2018) both globally and regionally. The TIMER energy model describes the energy demand in five different end-use sectors: industry, transport, residential sector, service sector and other, mostly on the basis of relatively detailed sub-models. In these sub-models, the demand for energy services is described for 26 world regions in terms of physical indicators (person-kilometres travelled; tons of steel produced etc.). Different energy carriers can be chosen to fulfil this demand based on their relative costs. The model can also decide to invest in energy efficiency instead. On the supply side, the model describes the production of primary energy for fossil fuels, bioenergy and several other renewable energy carriers. The costs of these primary energy carriers depend on depletion, technological development and trade. The demand and supply models are connected via several models describing energy conversion processes, such as the electric power and hydrogen production model.

The starting point for calculating the impact of climate policies is the latest SSP2 (no additional climate policy) baseline as implemented in the IMAGE model (van Vuuren et al., 2017). Current climate and energy policies in G20 countries, as identified in the CD-LINKS, COMMIT and ENGAGE projects (NewClimate Institute, 2019) and previous policy overview updates (Moisio et al., 2020), were added to that baseline (Roelfsema et al., 2018). PBL emissions projections consider two distinct mechanisms in accounting for the effects of COVID-19: reductions in GDP growth, and its short-term impact on activity levels in specific sectors (Dafnomilis et al., 2021), as described below.

3.2.2 Implementation of COVID-19 impact in IMAGE

The representation of COVID-19 in the IMAGE model has been arrived at in two steps: (i) the calculated impact of the changes in GDP and other macro-economic indicators in 2020 and near-term projections; and (ii) a reduction in demand to capture the impact of the COVID-19 crisis on specific sectors (Dafnomilis et al., 2022). More explicitly, changes to aviation and surface traffic were introduced, as well as reductions in manufacturing demand, especially in the cement and steel sectors. The residential buildings sector witnessed an increase in energy demand as people spent more time in their homes, contrary to the service and commercial sectors, which saw a decrease in energy demand. Impacts in the electricity sector were not taken into account individually, as it was assumed that they would be accurately represented by the fall in demand in the other sectors. After 2021, the IMAGE projections revert to pre-COVID growth rates, except for aviation traffic, which is assumed to return to typical growth rates in 2022 based on information from relevant organizations (IATA, ICAO, etc.) (Dafnomilis et al., 2022).

3.2.2.1 Adjustment in the economic activity drivers

IMAGE's economic activity drivers are GDP per capita, Personal Consumption per capita and Value Added per capita for the following economic sectors: Industry, Services and Agriculture. The information on economic activity drivers comes from the World Bank's World Development Indicators for the historic period. It is transformed into per capita values based on population data from the United Nations up to 2019 when data become available for each country. The values are then projected to 2100 using the SSP scenario growth rates established by GDP scenarios (Dellink et al., 2017) and population projections consistent with the SSP storylines. Dafnomilis et al. (2022) have updated GDP and added value projections, using the data from the OECD Economic Outlook from September 2020 (for non-EU countries, if available) (OECD, 2020), the IMF World Economic Outlook from June 2020 (IMF, 2020), the World Bank Global Economic Prospects report from June 2020 and the Autumn Economic Forecast from November 2020 (for EU countries) (European Commission, 2020) for the years 2020 to 2025. The original SSP growth rates will be resumed from 2026 onwards.

3.2.2.2 Sectoral activity levels

While IMAGE is partly steered by macro-indicators such as income and GDP, long-term policies and structural changes, the calculated impact of the changes to the macro-economic indicators is not enough to capture the pandemic's full effect on sectoral activity levels and the related CO_2 emissions. The sharp drop in aviation activity, road transport and industry was not so much a result of a loss of GDP but of strict lockdown measures or behavioral changes – flight and surface transport restrictions, decline in demand and production, and the increase in teleworking. To accurately capture the activity levels in different sectors, the reduction in activities was calculated based on respective data sources. Consequently, the IMAGE model's calculations were adjusted to simulate the additional drop in activity levels (on top of the drop due to GDP loss) in 2020 and the projections for short-term future activity levels.

3.3 Results

Figure 21 gives projections of global energy- and industry-related CO_2 emissions for both scenarios on the sectoral level. At the time of the evaluation, COVID-19 was projected to result in a drop in CO_2 emissions in 2020 of about 6% compared to 2019 levels, which is similar to the estimates in the literature (Friedlingstein et al., 2020; Le Quéré et al., 2020). The impact of the COVID-19 pandemic leads to a reduction in global GHG emissions by 2030 of about 3.5 $GtCO_2$ (equivalent to 9%) compared with pre-COVID-19 estimates (compared to a reduction of 2.7 $GtCO_2$ in 2020). If we focus on the different sectors, we see that the majority of the reductions comes the Energy supply sector (2 $GtCO_2$, 9%), followed by the Industry sector (1 $GtCO_2$, 12%) and Transport sector (0.5 $GtCO_2$, 6%).

The impact of COVID on the projected emissions of 3.5 $GtCO_2$ (equivalent to 9%) by 2030 is at the higher end of the range in the literature. The Climate Action Tracker (2020) finds a similar difference of about 2–4 $GtCO_2e$ between the post- and pre-COVID-19 current policies projections by 2030. UNEP (2020) posits a reduction in global GHG emissions by 2030 of about 2–4 $GtCO_2e$ (equivalent to 3–7 per cent) compared with the pre-COVID-19 estimates for OECD's single-hit and second-hit scenarios. Comparing the IEA's World Energy Outlook 2020's (IEA 2020) post-COVID-19 global energy and industry CO_2 emissions projections for their stated policy scenario (estimates published in 2019) suggests a similar difference of about 1.5–4 $GtCO_2e$ between the post- and pre-COVID-19 stated policies projections by 2030. Pollitt et al. (2021) found a difference of about 1.5 $GtCO_2e$ (about 3.5%).

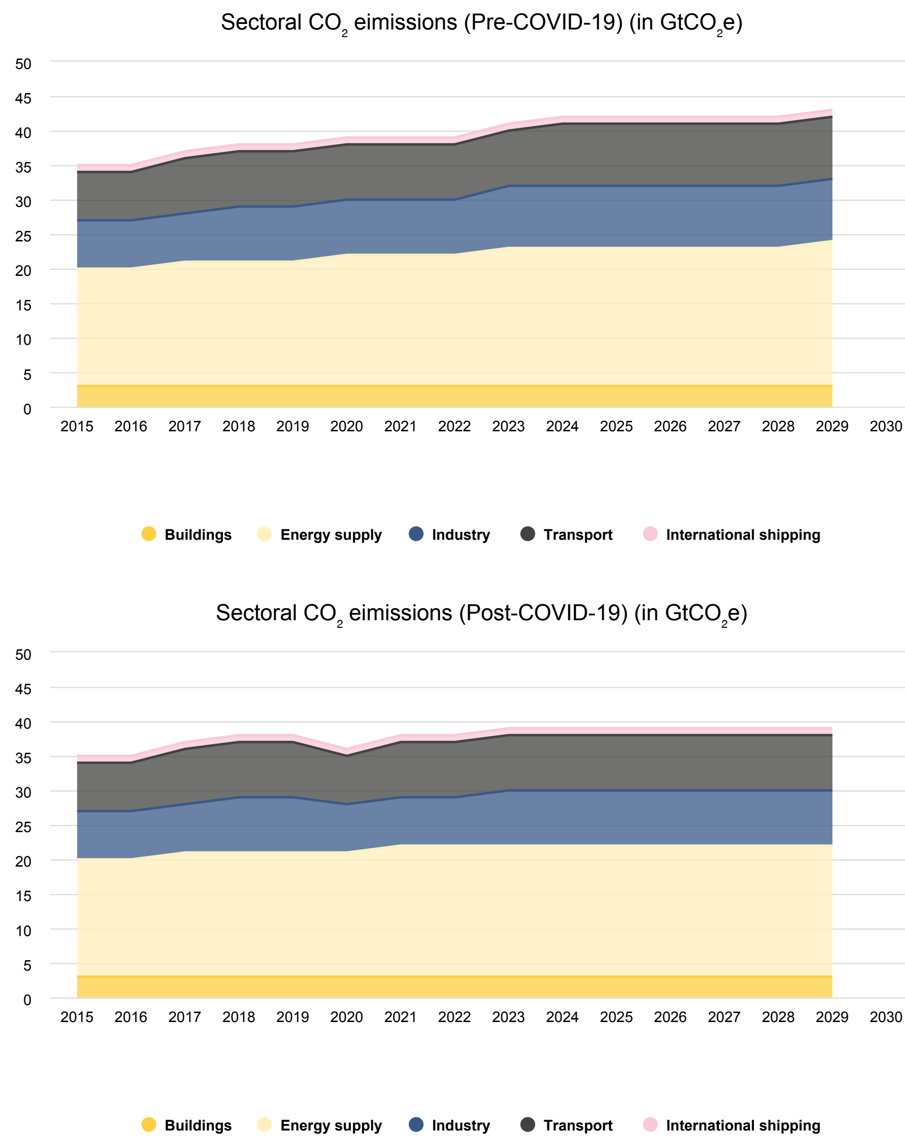


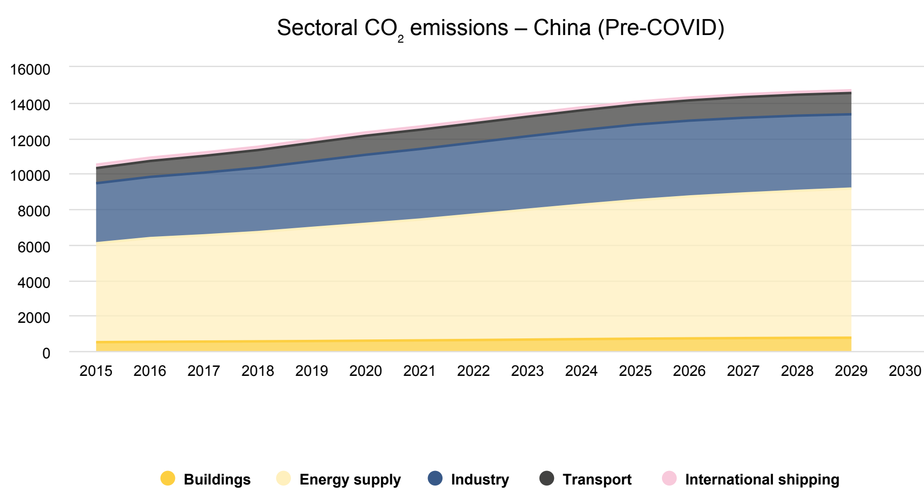
Figure 21. Sectoral CO_2 emissions projections for the world for the pre-COVID and post-COVID current policies scenarios. The pre-COVID current policies scenario shows the result of quantification based on recently implemented policies alone. The post-COVID current policies scenario shows the combined effect of these policies and the economic downturn resulting from the COVID-19 pandemic.

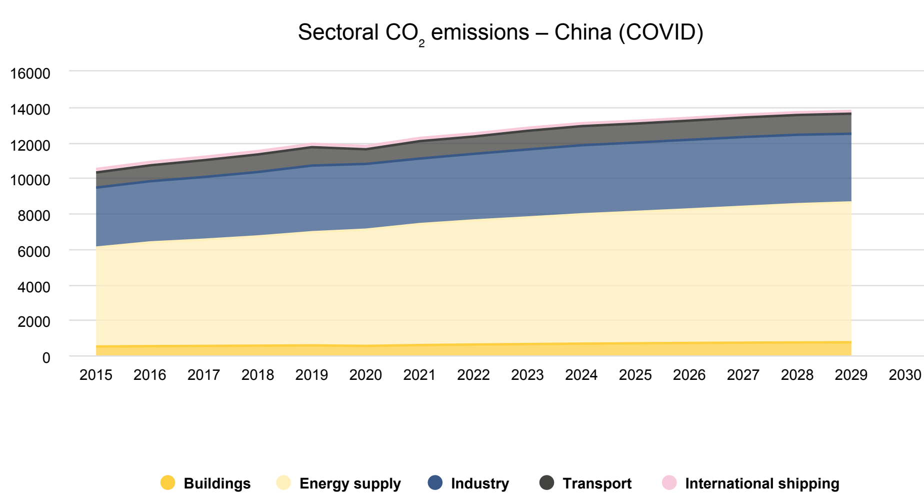
Figure 22 shows the impacts of COVID-19 on current policy emission projections for the energy- and industry-related CO_2 emissions of the four major emitting countries. It shows a range of emissions reductions of about -5% for China, the EU and the USA, but a much higher reduction of 13% for India. The contributions of the sectors are similar to the global level, with high contributions from the energy supply, industry and transport sectors (see Table 1). In the literature there are not that many studies showing the impact of COVID on a country level, except for Nascimento et al. (2021), who show the results of NewClimate and PBL (IMAGE). Their results are similar to those shown here.

Table 1. Overview of impact in energy-industry related CO_2 emissions compared to the pre-COVID current policies scenario

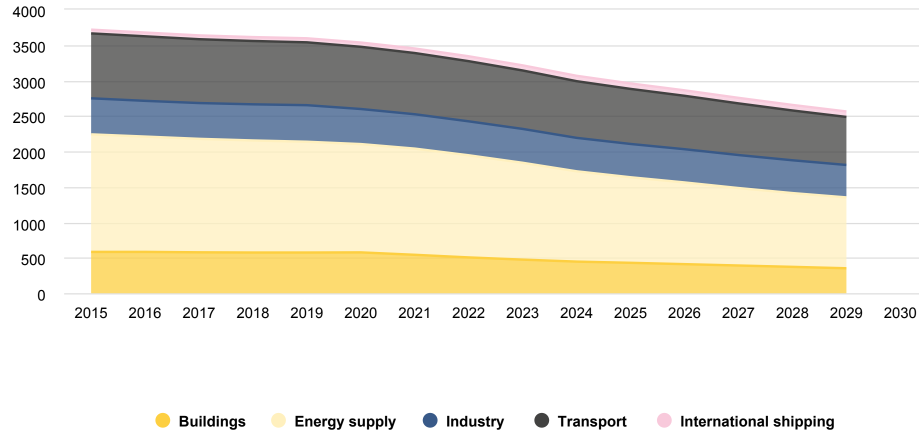
	World		China		EU		India		USA	
	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Buildings	-8%	-3%	-8%	-1%	-7%	0%	-11%	-3%	-10%	1%
Energy supply	-3%	-9%	-1%	-6%	-3%	-2%	-5%	-15%	-4%	-6%
Industry	-7%	-12%	-5%	-7%	-9%	-15%	-18%	-17%	-5%	-11%
Transport	-16%	-6%	-23%	-6%	-12%	-4%	-11%	-4%	-19%	-4%
International shipping	-6%	-5%	-2%	-1%	-5%	-1%	-15%	-5%	-3%	-2%
Total emissions	-7%	-9%	-4%	-6%	-6%	-5%	-10%	-13%	-10%	-5%

Figure 22. Sectoral CO_2 emissions projections (in $MtCO_2$) for China, EU, India and USA for the pre-COVID and post-COVID current policies scenarios.

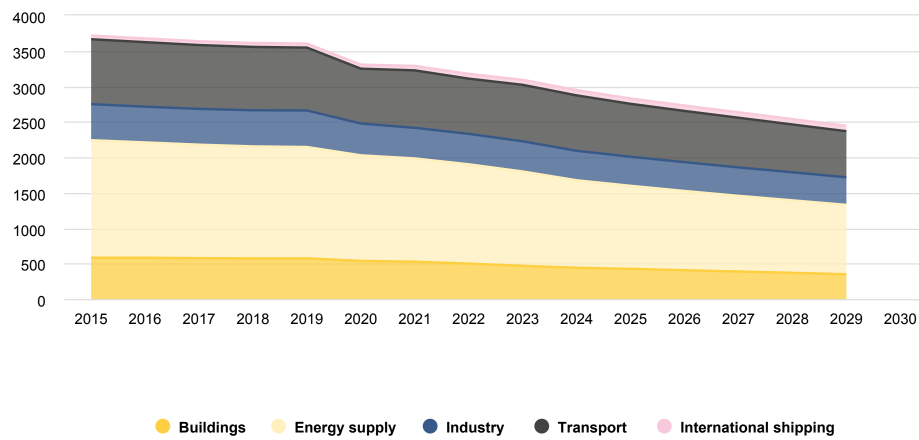




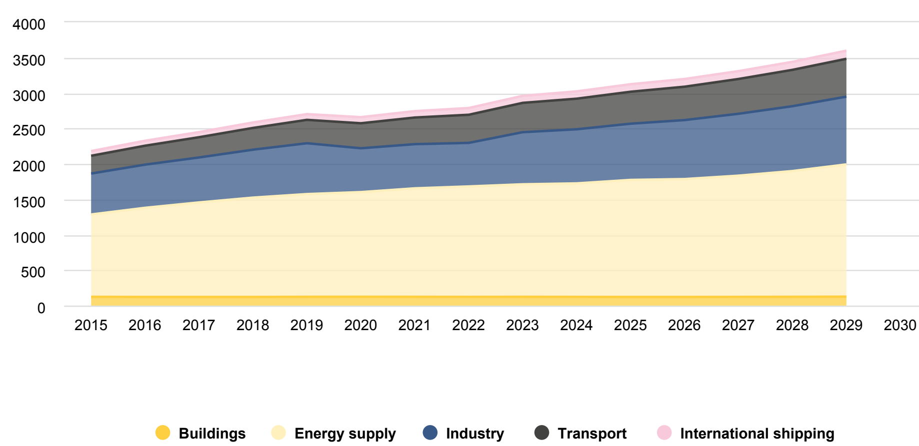
Sectoral CO_2 emissions – Europe (Pre-COVID)



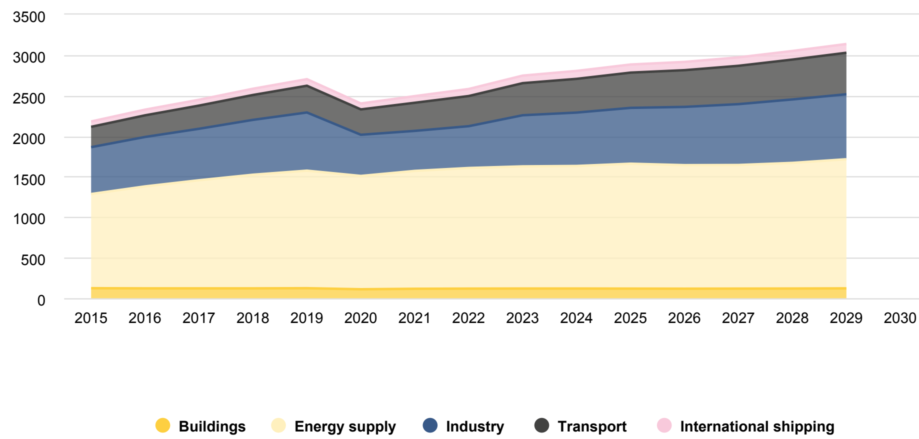
Sectoral CO_2 emissions – Europe (COVID)



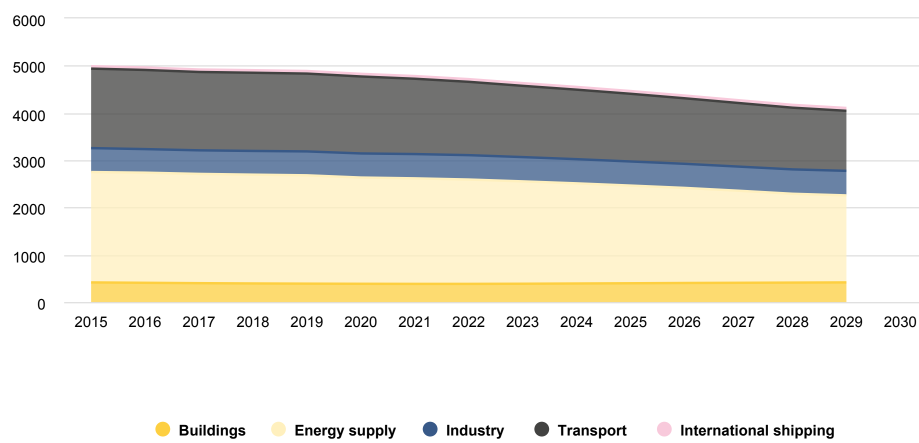
Sectoral CO_2 emissions – India (Pre-COVID)



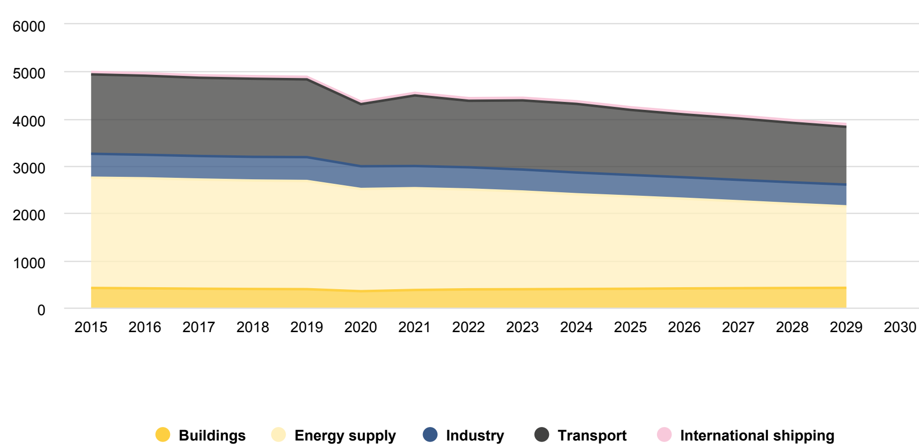
Sectoral CO_2 emissions – India (COVID)



Sectoral CO_2 emissions – USA (Pre-COVID)



Sectoral CO_2 emissions – USA (COVID)



4 Updated analysis of the COVID-19 recovery packages

4.1 Introduction

As described in Section 1, the COVID-19 pandemic hit the world at a critical time in terms of global climate policy, when actions needed to be urgently ramped up. Because drastic changes in finance flows are essential for rapid global decarbonisation, COVID-19 related economic recovery packages and the associated fiscal spending measures were identified as important opportunities to realise the required changes (IEA, 2020).

The world is about to enter the third year of the global COVID-19 pandemic. The lessons learnt from governments' experiences since early 2020 need to be reflected urgently in future fiscal spending and policy-making in order to keep the Paris Agreement's 1.5°C temperature goal alive.

This section of the report presents an updated assessment of how COVID-19-related fiscal responses and measures that have been implemented to date are aligned with the Paris Agreement's long-term temperature goal. The analysis was conducted globally for the EU and, where data is available, also for selected Nordic countries. This section summarises the findings presented in the UNEP Emissions Gap Report 2021's Chapter 5 (Brian O'Callaghan *et al.*, 2021), which reviewed and synthesised recent research reports, as well as in the authors' own analysis (Hans *et al.*, 2022). The latter assessed the extent to which major emitting economies seized or missed opportunities to support low-carbon recovery from the pandemic.

4.2 The nature of economic recovery spending to date and its implications on future greenhouse gas emissions

Most recent findings show that fiscal rescue and recovery spending since the beginning of the COVID-19 pandemic in early 2020 has only partially reflected governments' pledges regarding the low-carbon recovery (Brian O'Callaghan *et al.*, 2021; Global Recovery Observatory, 2021; Green Recovery Tracker, 2021b; IEA, 2021; O'Callaghan and Murdock, 2021; OECD, 2021b; Hans *et al.*, 2022).[2]

The share of low-carbon spending ranges between 0.5% and 2.5% in studies considering both rescue and recovery spending and between 18%and 30% for studies considering recovery spending only (see Table 1 for a complete overview). These findings indicate a severe shortcoming of climate considerations and a focus on the low-carbon transition in governments' fiscal responses to the global pandemic. This becomes especially relevant in the context of the existing emissions gaps for 2030 of around 25–30 $GtCO_2e$ between governments' existing conditional and unconditional targets and trajectories in line with the 1.5°C goal of global warming (den Elzen, Portugal-Pereira and Rogelj, 2021). Most recent emissions

2. We treat the term 'green' used in the referenced studies as synonymous to 'low-carbon' throughout this policy brief.

projections under currently implemented policies presented in the UNEP Emissions Gap Report 2021—which have not yet accounted for specific rescue and recovery packages implemented by governments—show a significant dip in emissions for 2020, but increasing emissions levels towards 2030.

Table 2. Overview of recently published analyses on the nature of fiscal rescue and recovery spending since the outbreak of the COVID-19 pandemic in 2020 (Brian O'Callaghan *et al.*, 2021; Global Recovery Observatory, 2021; Green Recovery Tracker, 2021b; IEA, 2021; O'Callaghan and Murdock, 2021; OECD, 2021b; Hans *et al.*, 2022)

		Key findings	Measure type covered	Coverage	Cut-off date
UNEP EGR 2021 Chapter 5 (Brian O'Callaghan et al., 2021)	**0.5%**	**Highly positive / Positive (~USD 77.01 billion)**	Rescue **and** recovery spending	G20 countries	10/2021
	82.7%	Relatively neutral (~USD 13,706.29 billion)			
	4.1%	Highly negative / Negative (~USD 682.14 billion)			
	12.7%	Unclear (~USD 2,112.94 billion)			
Global Recovery Observatory (April 2021)	**18%**	**'Green' spending (~USD 341 billion)**	Recovery spending **only**	50 largest economies	04/2021
	72% '	Non-green' spending (~USD 1,364 billion)			
	2.5%	**'Green' spending (~USD 368 billion)**	Rescue **and** recovery spending		
	97.5%	'Non-green' spending (~USD 14,352 billion)			
Global Recovery Observatory (October 2021)	**21%**	**'Green' spending (~USD billion not provided)**	Recovery spending **only**	24 'Annex 2' countries	10/2021
	3%	**'Green' spending** (~USD billion not provided)	Rescue **and** recovery spending		
Green Recovery Tracker (2021b)	**30%**	**Positive / Very positive (~EUR 198 billion)**	Recovery spending **only**	15 EU Member States	05/2021
	8%	Negative / Very negative (~EUR 53 billion)			
	26%	Not assessable (~EUR 173 billion)			
	36%	No likely GHG impact (~EUR 237 billion)			
OECD (2021b)	**17%**	**Likely positive (~USD 336 billion)**	Rescue **and** recovery spending, but only few rescue measures	43 countries and the EU27	04/2021
	17%	Negative or mixed (~USD 334 billion)			
	66%	No likely GHG impact (~USD 1,304 billion)			

		Key findings	Measure type covered	Coverage	Cut-off date
IEA (2021)	**2%**	**Clean energy spending** * (~USD 470 billion)	Rescue **and** recovery spending	more than 50 countries	10/2021
	12%	Other recovery spending (~USD 2,300 billion)			
	86%	Other rescue spending (~USD 16,900 billion)			
Hans et al. (2022)	**22%**	**Low-carbon (~USD 641 billion)**	Rescue and recovery spending with **potential GHG impact only**	10 key emitters plus 16 EU Member States	05/2021
	35%	'Supporting status quo' (~USD 1,040 billion)			
	4%	High-carbon (~USD 105 billion)			
	40%	Unclear (~USD 1,169 billion)			
		No likely GHG impact (~USD 8,127 billion)			

*'Clean energy spending' as used by IEA cannot be compared directly to 'green' or 'low-carbon' spending in other studies given that it focuses more narrowly on spending in energy-related sectors such as power generation or transport but does not include other forms of spending, e.g. on nature-based solutions.

Fiscal rescue and recovery spending to date will likely not trigger substantial emissions reductions towards 2030 but might support them beyond 2030 given substantial investments in measures that are considered *enabling* and *catalytic* in nature.

In the medium-term, for example, the IEA's Sustainable Recovery Tracker estimates energy-related CO_2 emissions to have fully rebounded to 2019 levels throughout 2021 and to continue increasing towards 2023, taking into account the existing fiscal rescue and recovery measures of more than 50 countries until October 2021 (IEA, 2021). These measures include USD 470 billion clean energy spending representing around 2% of all rescue and recovery spending tracked by the IEA.

Low-carbon fiscal rescue and recovery spending to date will likely unfold its emission reduction impact only over a longer time horizon towards 2030 and beyond (Hans *et al.*, 2022). The assessment of the likely impact on greenhouse gas emissions (GHG) for 2,500 measures of 26 key emitters representing 67% of global GHG emissions, excluding LULUCF, in 2019 suggests that only one-third of all low-carbon spending of the total of USD 230 billion goes to direct low-carbon measures with a rather immediate emission reduction impact (see Figure 23). Almost two thirds of the low-carbon spending of the total of USD 641 billion can be considered as funding *enabling* and *catalytic* low-carbon measures. This implies that the emissions impact of these expenditures would only unfold over a longer time horizon beyond 2030. These findings suggest that governments have put a distinct emphasis on measures triggering transformational change over time within their low-carbon spending, not just focusing exclusively on measures generating direct emissions reductions.

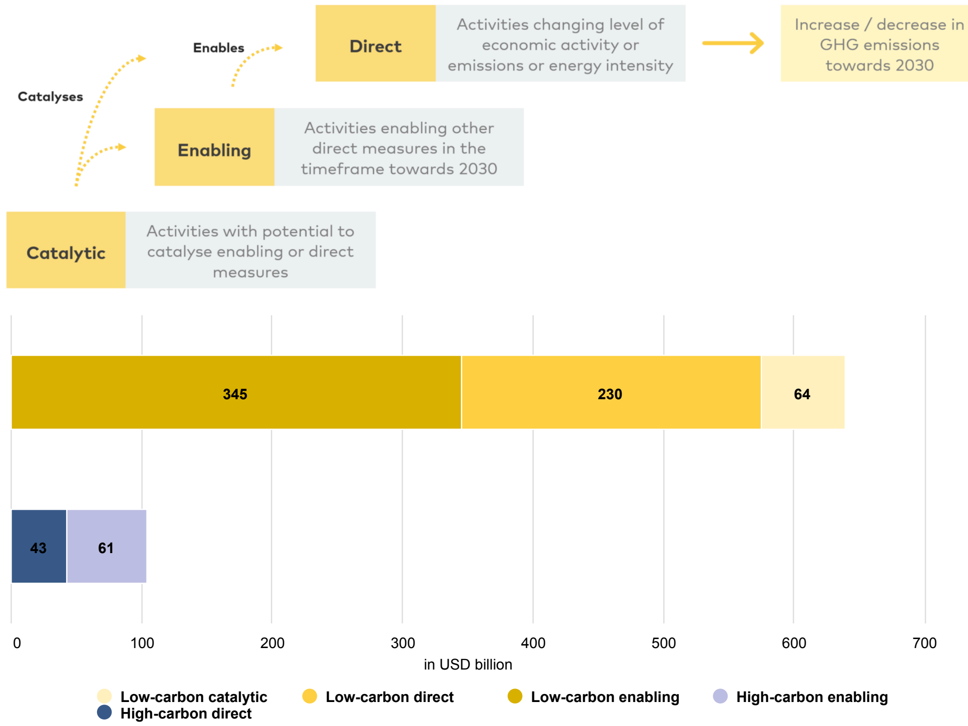


Figure 23. Conceptual differentiation between direct, enabling and catalytic measures (upper part) and total low-carbon and high-carbon fiscal rescue and recovery spending as of May 2021, differentiated by type of emissions impact in USD billion (lower part) (Hans *et al.*, 2022).

4.3 Green recovery spending in total COVID-19 response spending by Nordic countries

Fiscal rescue and recovery spending by Nordic countries (Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland) has been covered to varying extents in existing analyses (B. O'Callaghan *et al.*, 2021; Energy Policy Tracker, 2021; Green Recovery Tracker, 2021a).

Most prominently, the Global Recovery Observatory shows that Norway (55%), Finland (58%), Denmark (63%) and Sweden (42%) were all spending above 40% of their fiscal recovery spending on low-carbon measures as of December 2021 (B. O'Callaghan *et al.*, 2021). In the case of Finland, the Green Recovery Tracker (2021a) confirms this finding showing that 59% of all recovery spending can be considered either very positive (27%) or positive (32%). However, the Energy Policy Tracker (2021), which focuses on energy-related spending only, identifies larger shares of *conditional* and *unconditional* fiscal spending on fossil-fuel measures in Norway (94.7% of USD 13.9 billion), Finland (59% of USD 4.7 billion) and Sweden (37.4% of USD 4.1 billion).

The OECD Green Recovery Database tracked all low-carbon fiscal stimulus spending for Nordic countries as of April 2021 (OECD, 2021b), identifying USD 14.8 billion for Norway (3.7% of GDP in 2019), USD 4.7 billion for Finland (1.7%), USD 4.5 billion for Sweden (0.8%), USD 1.6 billion for Denmark (0.5%) and USD 80 million for Iceland (0.3%).

Compared to other advanced economies, recent findings show that Norway, Finland and Denmark currently perform above average both on (1) spending a significant share of above 1% of GDP on fiscal recovery measures, and (2) spending above 30% of all fiscal recovery measures on 'green' measures. The Oxford Global Recovery Observatory considered these countries to be 'leaders' in low-carbon recovery in 2021 (Brian O'Callaghan *et al.*, 2021).

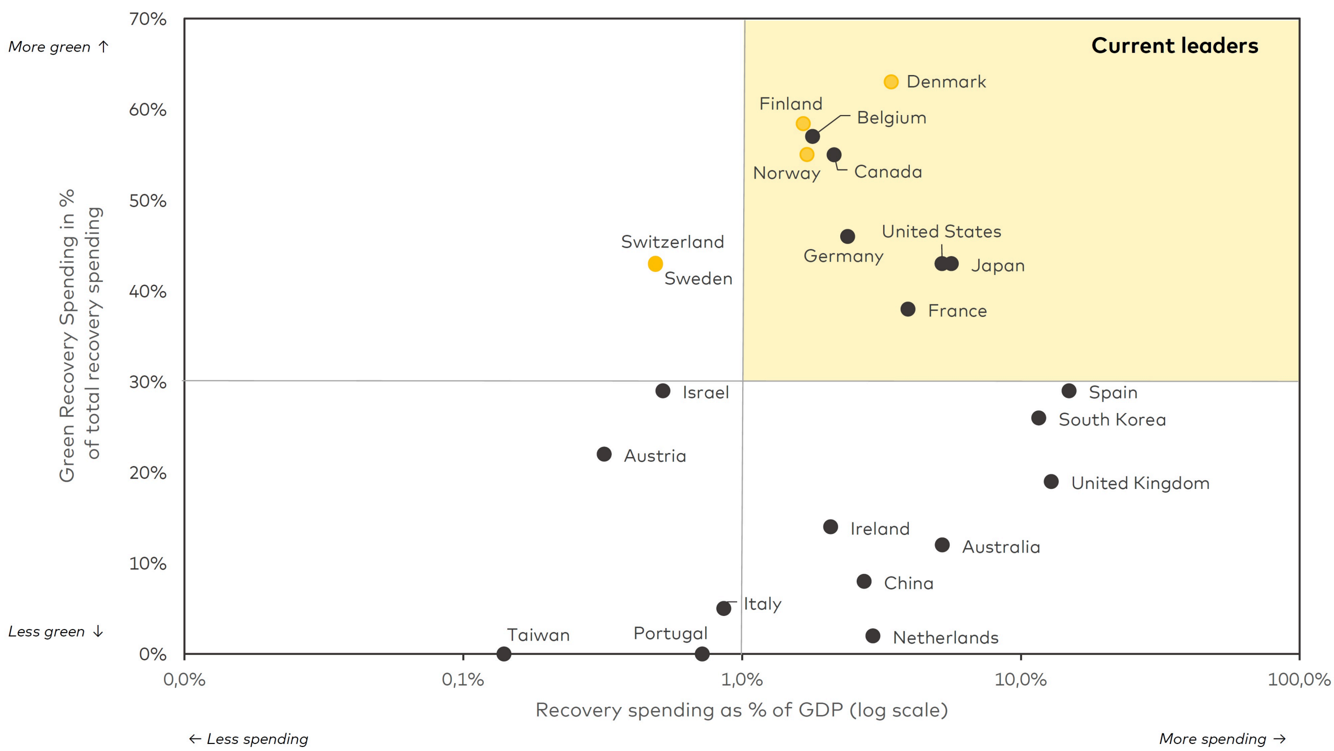


Figure 24. Green recovery spending as a percentage of total recovery spending versus recovery spending as a percentage of GDP as of March 2022 (Brian O'Callaghan *et al.*, 2021), unpacking the 'seized' and 'missed' opportunities in global economic recovery efforts.

Since the early days of the pandemic, a vast range of academic literature and policy advocacy provided guidance to policy-makers on how best to capitalise on the opportunity for low-carbon and climate-resilient fiscal spending for both the initial *rescue* phase and the subsequent *recovery* phase (Brian O'Callaghan *et al.*, 2021). The landscape of fiscal rescue and recovery spending presented in Section 2 allows initial conclusions to be drawn on how governments have 'seized' or 'missed' these opportunities since early 2020.

4.3.1 'Seized' opportunities

Governments have introduced over 500 low-carbon rescue and recovery measures worldwide (Brian O'Callaghan *et al.*, 2021). These measures cover most emerging and established low-carbon industries, such as clean energy generation, clean transport and natural capital investments (see Figure 25).

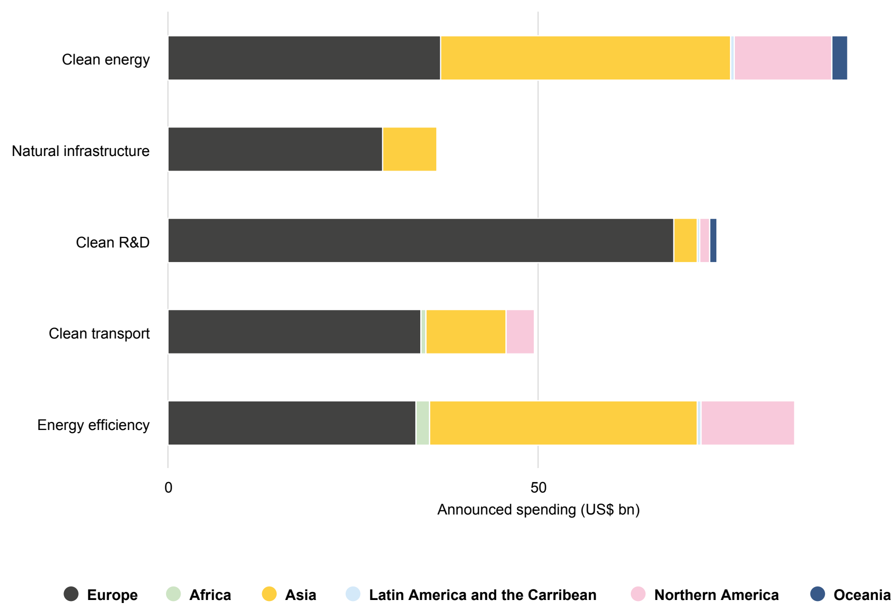


Figure 25. Global recovery spending in low-carbon initiatives as of May 2021 across sectors by regions in USD billion (Brian O'Callaghan *et al.*, 2021).

Despite the overall scope of low-carbon fiscal spending across areas, spending on worker retraining and educational initiatives has remained low across countries. Although a few promising examples exist such as Denmark's provision of educational benefits to provide unemployed individuals with an opportunity to learn new skills aligned with the new job functions and competencies of the low-carbon transition (Brian O'Callaghan *et al.*, 2021, Annex B.2), overall this indicates an insufficient focus on long-term human capital development.

Table 3. Examples of measures considered 'low-carbon' in Nordic countries. Source: Global Recovery Observatory (B. O'Callaghan *et al.*, 2021) and OECD (2021a), based on the framework of Hans et al. (2022).

Country	Measure	Type	Explanation
Iceland	VAT reduction for green transport	**'Low-carbon' measure**	**Description** In 2020, the government introduced a number of VAT reductions for environmentally friendly transport modes (OECD, 2021a). The VAT reductions will be phase out in 2023. **Explanation** Measure considered 'low-carbon', given the provision of specific conditions to support low-carbon development of the transport sector.
Denmark	Loans for environmental projects and financial support of small and medium-sized enterprises (SMEs)	**'Low-carbon' measure**	**Description** The government signed a EUR 60 million ten-year loan agreement with the Danish Ringkjøbing Landbobank (RLB) for the financing of environmental projects and SMEs in Denmark. This initiative was part of the Nordic Investment Bank's (NIB) special support programme for sustainable businesses during the COVID-19 pandemic (Nordic Investment Bank, 2020; B. O'Callaghan et al., 2021). **Explanation** Measure considered 'low-carbon' given the provision of specific conditions for a low-carbon transition attached to loan conditions
Finland	Phasing out oil heating in residential and municipal buildings	**'Low-carbon' measure**	**Description** EUR 45 million in grants to phase out oil heating in both households and municipal buildings (Finnish Government, 2020; B. O'Callaghan et al., 2021). **Explanation** Measure considered 'low-carbon' given direct support to replace fossil fuel heating infrastructure with low-carbon alternatives.
Norway	Low-emission research funding	**'Low-carbon' measure**	**Description** NOK 75 million allocated to strengthen work on low-emission research. The funding will promote research, development and innovation of new solutions that can lead to Norway reducing greenhouse gas emissions while stimulating business development (Norwegian Government, 2020; B. O'Callaghan et al., 2021). **Explanation** Measure considered 'low-carbon' given support for the development of low-carbon technologies with catalytic potential.
Sweden	Improved energy efficiency in buildings	**'Low-carbon' measure**	Funds to support retrofitting and energy efficiency improvements of residential homes, with SEK 900 million allocated in the 2021 budget, SEK 2.4 billion in the 2022 budget, and SEK 1.0 billion in the 2023 budget (Government of Sweden, 2020; B. O'Callaghan et al., 2021) **Explanation** Measure considered 'low-carbon' given support for roll-out of low-carbon technologies with direct potential.

4.3.2 'Missed' opportunities of fiscal spending on high carbon measures and measures supporting the status quo

Missed opportunities to achieve a low-carbon and climate-resilient recovery comprise both distinct fiscal spending on high-carbon measures (e.g., spending on fossil fuel infrastructure) and measures supporting the status quo (e.g., corporate bailouts without conditions for net zero transition). As for the former, specifically high carbon investments have mainly been undertaken in the traditional fossil fuel-based transport sector and high-carbon energy sector (see Figure 26).

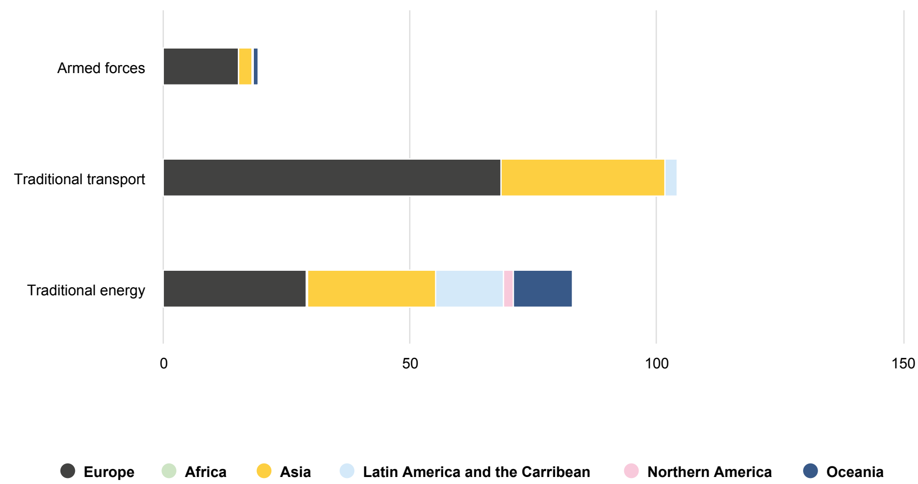


Figure 26. Global recovery spending on high-carbon initiatives as of May 2021 across sectors by regions in USD billion (Brian O'Callaghan *et al.*, 2021).

As for the latter, measures supporting the status quo cannot be explicitly coded as high-carbon or low-carbon but substantiate current business-as-usual practice (Hans *et al.*, 2022). Such measures would have presented an opportunity for policy-makers to implement accompanying distinct conditions for a low-carbon transition coupled with the respective fiscal rescue and recovery spending item.

Across 26 key emitters as of May 2021 representing 67% of global GHG emissions, excluding LULUCF, in 2019, around 35% of fiscal spending can be considered to support the status quo and not to have met the pledges to focus economic rescue and recovery measures effectively on low-carbon activities (Hans *et al.*, 2022).

Such measures comprise, among others, corporate liquidity support for airline companies and other large corporates without specific conditions for a low-carbon transition, and VAT reductions without a specific focus on low-carbon products (see Table 4 for examples in Nordic countries). This suggests that governments might have pursued other socio-economic considerations, especially during the initial rescue phase, and that they showed limited capabilities or willingness in the immediate socio-economic crisis to align all emissions-relevant fiscal spending with the Paris Agreement's objectives.

Table 4. Examples of measures considered 'high-carbon' or 'supporting the status quo' in Nordic countries. Source: Global Recovery Observatory (B. O'Callaghan *et al.*, 2021) and OECD (2021a), based on the framework of Hans et al. (2022).

Country	Measure	Type	Explanation
Sweden & Denmark	Unconditional liquidity support for SAS airline	**'Supporting the status quo' measure**	**Description** EUR 300 million liquidity support to the aviation company Scandinavian Airlines System (SAS) in the form of loans from the Swedish and Danish governments of EUR 150 million each (B. O'Callaghan et al., 2021; European Commission, 2021) **Explanation** Measure considered 'supporting the status quo' given no further specific conditions for a low-carbon transition of SAS attached as loan conditions (to the best of the authors' knowledge)
Finland	Interest rate for adjusted payment arrangement for VAT reduced	**'Supporting the status quo' measure**	**Description** Business support measures to unconditionally reduce the business tax burden to reduce government revenue by EUR 753 million in 2020 (Finnish Government, 2020; B. O'Callaghan et al., 2021). **Explanation** Measure considered 'supporting the status quo' given no further specific conditions for a low-carbon transition of targeted businesses.
Norway	Deferral of taxes related to oil and gas production	**'High carbon' measure**	**Description** The Norwegian government introduced a temporary easing of the tax rules for oil and gas companies totalling to around USD 10–11 billion in April 2021 (Energy Policy Tracker, 2021; Solsvik and Adomaitis, 2021). **Explanation** Measure considered 'high-carbon' given direct support of the domestic fossil fuel exploration industry.

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