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Is Norway on the pathway to a Green Economy? Evidence on decoupling between GDP and environmental pressure

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Declaration

I, Fernanda Miranda Cunha Tenório, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged, and a reference list has been appended. This work has not been previously submitted to any other university for the award of any academic degree.

Signature…………………………………….....

Date……………………………………………

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I would like to thank my family for their love and support that was crucial to getting me through these challenging times and my friends, who always believed in me and reminded me of how capable I am. I also want to thank all the NMBU professors and colleagues for sharing valuable knowledge and contributing to my personal and professional development. Especial thanks to my supervisor Erik, who sparked my interest in the subject since the start of the study program, provided me rich guidance throughout the thesis process, inspired me, and lifted my mood to conclude this work.

Abstract

Since the 1970s', the concepts of ecological limits, environmental impacts, and human pressure have been central in the debate over the relationship between economic growth and the environment. Green Growth advocates argue that economic growth boosts technological development, which will allow economic activity to decouple from environmental impact through resource substitution and efficiency. In this research, we use data published by Statistics Norway to investigate if Norwegian economic growth has been decoupling from energy use, GHG emissions, and material consumption. We found that there have been efficiency improvements for energy and GHG emissions, but no absolute decoupling for any of the indicators, and less so a sufficient absolute decoupling to meet global sustainability targets. Overall environmental pressure is increasing in Norway, and per capita consumption and pollution are way above what is considered sustainable.

Keywords: Green growth; Decoupling; Environmental pressure; Norway

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1. Introduction

Since the middle of the 20th century, the world has experienced unprecedented economic growth, accompanied by accelerating resource extraction, increasing waste, pollution, loss of biodiversity, and climate change (Steffen et al., 2015a). According to Earth system scientists, these are indicators that the human activity is going towards planetary boundaries – having crossed some of them – defined by sustainable resource use and pollution levels that the Earth's systems can support within its productive and assimilative capacities (Rockström et al., 2009; Steffen et al., 2015a, 2015b).

The notion of *Green Growth* gained traction after the Rio+20 conference in 2012 in response to the growing concern and search for solutions to the world's environmental degradation and reoccurring economic crises (Bina, 2013). Green Growth theory asserts that technological progress will increase resource efficiency, decoupling economic growth from environmental degradation (OECD, 2011, 2019, 2020; UNEP 2011, 2012; World Bank, 2012). The idea that economic growth accelerates technology development and improves environmental conditions is promoted as a pathway to sustainability by most governments and leading institutions, such as the United Nations Environmental Program (UNEP), the World Bank (WB), and the Organization of Economic Cooperation and Development (ibid).

However, Green Growth is seen by critics as almost business as usual and as greenwashing of conventional development models (Bina, 2013, Unmüßig et al., 2012). Questioning its capacity to deliver real environmental sustainability, many scientists have raised the question, "Is Green Growth possible?". Empirical evidence has shown that decoupling GDP growth from environmental degradation may be feasible in high-income countries for limited periods. Still, projection models indicate that this is impossible to maintain long-term (Hickel and Kallis, 2019). Therefore, efficiency improvements alone have not been enough to achieve sufficient absolute decoupling, which is the decoupling necessary to keep economic activity within planetary boundaries (Parrique et al., 2019).

According to Earth system scientists, three of the nine planetary boundaries defined by Rockström et al. (2009) have already been transgressed: climate change, biochemical flows, and biosphere integrity (Steffen et al., 2015b). Despite the increasing share of renewables, total energy consumption would continue to grow for all fuels other than coal because global energy demand is rising (IEA, 2020a), and global material extraction is estimated to reach 218 Gt/year by 2050 (Krausmann et al., 2018).

As the impacts of climate change, resource depletion, and other environmental challenges we face become more imminent, it is crucial to understand which policies can bring us closer to a more sustainable economy that operates within the ecological safe space. Is green growth capable of delivering its promise? If so, is it probable that sufficient decoupling will happen in time to avoid environmental collapse?

In this research, we build on the debate on whether Green Growth is possible, using Norway as a case study. Specifically, this paper discusses the following questions:

· Is economic growth in Norway decoupling from environmental impact?

· Are the green growth policies promoted by the Norwegian government bold enough to achieve environmental sustainability?

2. Background

In 1972, the Club of Rome's publication *The Limits to Growth* expressed concerns around the sustainability of economic growth on a finite planet. The study used a computer model to simulate the social and environmental consequences of continued economic growth on Earth (Jackson, 2016). The results showed increasing population, food production, industrial activity, pollution, and declining ecological resources, eventually leading to collapse (Meadows et al., 1972) - which resonates with earlier ideas on the limits to growth expressed by Malthus in the 19th century.

The Earth Summit Stockholm 72 took place in the same year, and the United Nations Environmental Programme was created. The summit declaration called for governmental action to halt environmental degradation and promote equality and dignity (Gómez-Baggethun and Naredo, 2015). In 1974, the Cocoyoc declaration by UNEP and UNCTAD made a strong case for the need for immediate redistribution of wealth instead of prioritizing economic growth, emphasizing the planet's physical limits and pointing to possible alternative development pathways (UNEP/UNCTAD, 1974).

However, the sustainability discourse started to shift by the 1980s and the beginning of the 1990s. The report *Our Common Future*, best known as the *Brundtland Report*, coined the term **sustainable development**, defined as development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987:7). Poverty is given as the culprit of environmental degradation, and developing nations were presented as those having the most ecologically harmful practices. In contrast, developed countries would be environmentally conscious (ibid). With the emergence of the sustainable development discourse and the publication of the Brundtland Report in the Earth Summit Rio 1992, the growth imperative was revitalized (Gómez-Baggethun, 2019).

Growing the economy and preserving the environment were gradually presented as two compatible goals, achievable through improved efficiency, financial and environmental accounting, and ecological taxation (Elkins, 1999). In 2002, the Johannesburg declaration focused on the importance of markets and green investments to achieve sustainability (UN, 2002). The term Green Growth was assimilated into the international policy agenda in 2005, at the 5th Ministerial Conference on Environment and Development in Asia and the Pacific, in Seoul, South Korea. The declaration recommended several ways of improving environmental sustainability while growing the economy, including incorporating ecological costs into market prices, enhancing cleaner production, and improving environmental performance and accountability in public and private sectors (MCED, 2005).

In the following years, especially after the economic crisis of 2008-2009, international organizations intensified their efforts towards green growth as a strategy to boost growth and recover from the recession (G8, 2009). UNEP's call for a Global Green New Deal (GGND) raised the visibility of the green economy concept and recommended a package of policies and public investments to kick-start the green transition and reinvigorate the economy (UNEP, 2009). In 2011, UNEP published *Towards a Green Economy*, a reference document in the current sustainability debate. The report points out green growth's potential to alleviate poverty and generate green jobs, arguing that the way to sustainability is through investment in renewables, efficiency improvement, market mechanisms, investments in natural capital, etc. (UNEP, 2011). More than ever, growth is presented not as the root cause of environmental degradation but as a solution.

The period from the 1970s to 1990s was hence marked by a transition from recognizing the limits to growth to the idea of growth for the environment. The role of the state was downplayed and replaced by market mechanisms for achieving sustainability (Gómez-Baggethun and Naredo, 2015). Hence some authors suggest that this process reflects a shift towards a neoliberal policy agenda, where social and environmental conflicts are depoliticized. At the same time, a technocratic discourse attributes negative impacts to market failures, resource inefficiency, and technological underdevelopment (ibid).

On the other hand, ecological economists claim that highly developed countries had already achieved good levels of welfare and reached a 'threshold point' around the 1960s' and 1970s', when further economic growth contributed to a decrease in welfare, resulting from rising social inequalities and environmental impacts (Daly, 2000; Jackson, 2009; Max-Neef, 1995). Herman Daly named this point *economic limit*, arguing that growth beyond this point promotes a more significant decrease in resources and human wellbeing than it promotes welfare improvement. Ecological Economics defined this phenomenon as *uneconomic growth*. Such theory is supported by the consolidated economic theory of diminishing marginal utility as GDP rises (Daly, 1999).

Degrowth advocates argue that GDP is an inappropriate indicator of welfare, as it measures the marketed economy and does not differentiate benefits from expenditure in defensive costs (Bleys and Whitby, 2015; Cobb et al., 1999; Constanza et al., 2014). For instance, wars, drug trafficking, prostitution, and cleaning up oil spills or other pollutions are all activities that contribute to an increase in GDP but are related to a decrease in welfare (Kubiszewski et al., 2013; Stiglitz et al., 2009). Therefore, GDP was designed to be an indicator of the size of the economy rather than the quality (Kuznets et al., 1934). For these reasons, economic growth as measured by GDP should not be an end in itself (Dale, 2012; Jackson, 2016; Kallis, 2018; Stiglitz et al., 2009; Unmüßig et al., 2012).

3. Theory

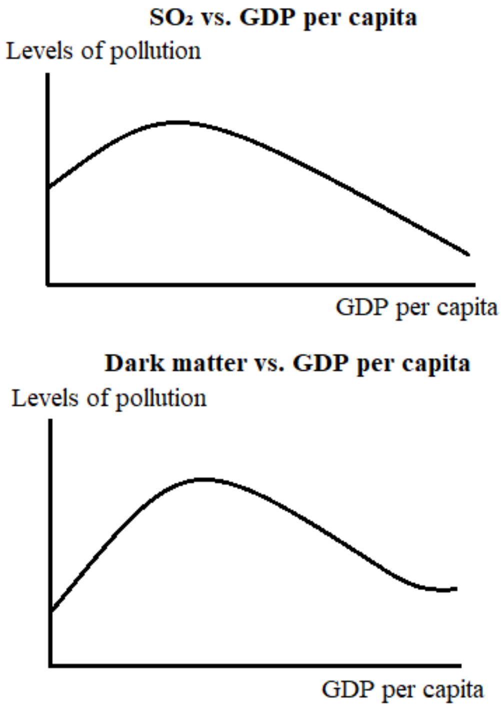
Green Growth and the Green Economy

UNEP defines Green Economy as "one that results in improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2012:4). OECD and the World Bank approach the same idea through a Green Growth perspective, which means "fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our wellbeing relies" (OECD, 2011:11). The World Bank argues that "Greening growth is necessary, efficient, and affordable. It is critical to achieving sustainable development and mostly amounts to good growth policies" (The World Bank, 2012:1).

Despite presenting different definitions of Green Growth, UNEP, OECD, and WB all agree on the mechanism for achieving it: "…technological change and substitution will improve the ecological efficiency of the economy…" (Hickel and Kallis, 2019:2). Such technological achievements would allow economies to become more and more efficient, gradually decoupling economic growth from resource use and pollution.

The decoupling theory is at the core of the Green Growth framework. Its origin dates back to the Brundtland report, and it was later formalized in the early 1990s' through the hypothesis of the Environmental Kuznets Curve (EKC). According to the EKC, environmental degradation increases as the economy grows, up to a certain point – a tipping point – where further economic growth will diminish environmental impacts (Grossman and Krueger, 1995). Figure 1 shows the relationship between GDP and air pollution observed by a study on the NAFTA trade, which inspired the creation of the EKC (Grossman and Krueger, 1991).

Figure 1. Levels of sulfur dioxide and dark matter versus GDP per capita

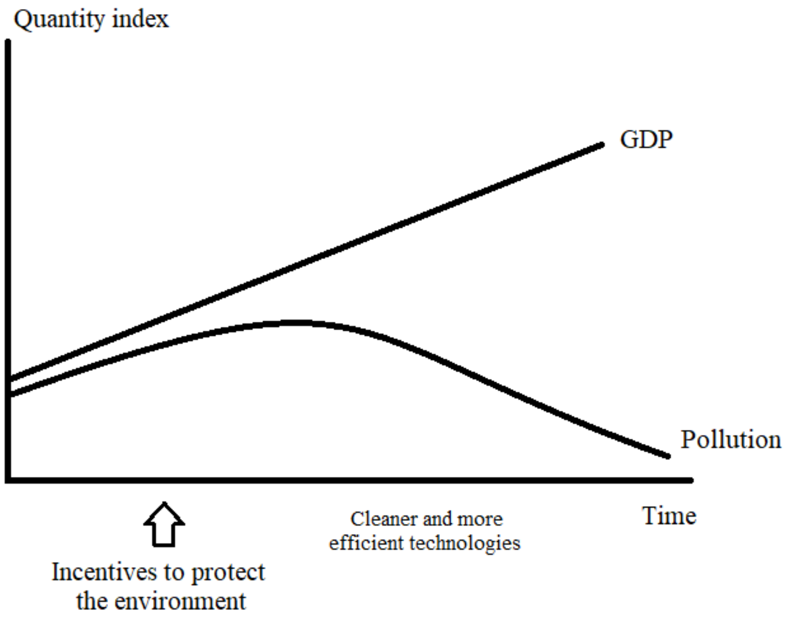


This figure shows the relationship between sulfur dioxide/dark matter and GDP per capita found in 42 countries from NAFTA

Source: Grossman and Krueger, 1991.

The EKC reinforced the idea that growing the economy can be a means to improve environmental conditions, a shift in thinking that was already underway since the publishing of *Our Common Future* (Stern, 2004). The report stated that limits are not absolute, but rather limitations that can be removed or pushed further as “technology and social organization can be both managed and improved to make way for a new era of economic growth” (WCED, 1987:16). Efficiency, technology, and substitution become the solution to the world’s environmental issues, all of which can be achieved through the growth and enrichment of the countries: “As incomes rise, the demand for improvements in environmental quality will increase, as will the resources available for investment” (World Bank, 1992:39). Figure 2 illustrates the continued economic growth with decreasing pollution after the introduction of incentives to protect the environment.

Figure 2. GDP growth and pollution throughout time



Source: World Bank, 1992.

In *Green Growth* debates, the decoupling theory branches into **relative decoupling** and **absolute decoupling**. Relative decoupling occurs when resource use or pollution decreases per unit of GDP, but because the overall size of the economy increases, the total resource use and pollution still increase (Hickel and Kallis, 2019). Absolute decoupling takes place when resource use or pollution decreases overall, despite GDP growth (Jackson and Victor, 2019; Parrique et al., 2019).

UNEP indicates a moderate trend in relative decoupling between GDP and resource use over time, but it remains a challenge to realize growth that is absolutely decoupled from materials and energy use (UNEP, 2011). It stated that it "is not enough to simply minimize environmental impact – we must rapidly reduce it down to safe limits" (ibid:2). The OECD recognized that efficiency improvements had not been accompanied by a decrease in environmental pressure, which requires strategies to prevent increased resource use (OECD, 2011).

Later on, scientists proposed the notion of **sufficient absolute decoupling**, which is decoupling that is sufficient to keep economic activity within planetary boundaries (Fedrigo-Fazio et al., 2016). The planetary boundaries (PB) framework defines boundaries for human activity not to transgress the safe operating space of the ecological processes critical to the functioning of the Earth's systems. From nine boundaries initially stipulated (Rockström et al., 2009), seven have been quantified, from which three are estimated to had already been transgressed: climate change, biochemical flows, and biosphere integrity (Steffen et al., 2015b).

The linkage between the PB and the Green Growth framework is somewhat hazy, as PB acknowledges the idea of limits, a concept that was carefully avoided in the Rio +20 declaration (Bina, 2013) and is not sufficiently discussed in other official documents. However, the emergence of the notion of sufficient absolute decoupling linked the Green Growth theory to ecological limits and planetary boundaries, by highlighting the need for decoupling to reach levels of environmental pressure that are sustainable for the planet.

Critiques to Green Growth

Since the Rio+20 conference put green growth more firmly into the policy agenda, a mounting number of studies have reviewed empirical evidence on whether absolute decoupling is happening or whether it is likely to happen, "...and if so, is it possible at a rate sufficient for returning to and staying within planetary boundaries?" (Hickel and Kallis, 2019:3).

A review of 835 national and global studies on decoupling concluded that empirical evidence of absolute decoupling with continued economic growth is scarce, despite the growing number of researches in this matter (Haberl et al., 2020). Although modern economies are becoming more efficient, total pollution and resource consumption are increasing (Jackson and Victor, 2019). Cases of relative decoupling can be found in many countries, but there is no evidence of absolute decoupling – which matters the most- at the global level (ibid).

An even more considerable increase in production often offsets efficiency improvements regarding resource use and pollution. This trend was first observed during the Industrial Revolution by the economist William Stanley Jevons. At the time, technological developments helped improve the efficiency of coal-fueled factories in England, but contrary to intuition, total coal consumption increased. A link was established between improved efficiency and reduced relative costs, which consequently drove a rise in demand (Missemer, 2012). This relationship was named the *Jevons paradox*, nowadays most commonly known as the rebound effect. For this reason, some authors argue that efficiency improvements alone are not sufficient to reduce environmental impact, as they accelerate economic growth, further increasing the demand for resources (Alcott, 2008). Several case studies have shown that, in practice, sufficient absolute decoupling is not happening and that the benefits of efficiency improvement are a “myth” (Hoffman, 2016).

Material extraction is an indicator that thus far has been highly coupled with economic growth. There had been relative decoupling of global GDP from raw materials for a long time, but this trend was reversed in the last two decades by a rematerialisation of the economy (Bithas and Kalimeris, 2018a; Giljum et al., 2014; Krausmann et al., 2018).

The increase in productivity and a continuous shift to cleaner energy sources have also not been enough to compensate for the rapid growth of emerging economies, and global carbon emissions are still increasing (Mathai et al., 2018; Mardani et al., 2019). The fact that absolute decoupling has taken place in a few developed countries (Mardani et al., 2019; Wu et al., 2018) can be partly attributed to the allocation of manufacturing industries to developing nations with cheaper labor and more flexible environmental regulations (Potter et al., 2018). By comparing production-based and consumption-based indicators, it is possible to observe that efficiency improvements in some countries are often due to the outsourcing of production, and relative decoupling is achieved at the expense of resource-intensive production elsewhere (Bithas and Kalimeris, 2018b; Global Carbon Project, 2020; Moreau and Vuille, 2018; Moreau et al., 2019; Wiedmann et al., 2015)

Hickel and Kallis (2019) argue that the empirical data suggest that absolute decoupling from resource use may be possible in the short term but is not feasible on a global scale and is not possible to maintain in the longer term. Several pieces of research have shown that the Green Growth theory in terms of decoupling lacks empirical support (Hickel and Kallis, 2019; Haberl et al., 2020; Moreau and Vuille, 2018; Moreau et al., 2019; Parrique et al. 2019).

Degrowth advocates have expressed these concerns and showed skepticism of whether absolute decoupling is achievable within the current framework of development based on unlimited economic growth (Hickel and Kallis, 2019; Jackson and Victor, 2019; Kallis, 2018; Mathai et al., 2018; Parrique et al. 2019). From this perspective, the current social and ecological issues cannot be solved by more growth, as this is precisely the root of such problems (Kallis, 2018).

4. Methodology

4.1. The case study of Norway

Since the discovery of oil and gas on the Norwegian shelf in the 1960s, petroleum exploration has contributed significantly to Norway's economic growth (Regjeringen, 2013). In 1996, the Norwegian government started investing the revenues of the oil industry in a pension fund. The Government Pension Fund Global, best known as *The Oil Fund*, went from a total market value of 23 billion US dollars in 1998 to 1,275 trillion dollars in 2020 (Norges Bank Investment Management, 2021).

Under the so-called fiscal rule, transfers are made from *The Oil Fund* to the fiscal budget without drawing on the fund's capital, which allowed the financing of the Norwegian welfare state (Norsk Petroleum, 2020). Between 1960 and 2020, Norwegian GDP raised from 5 billion U$ to 362 billion U$, and life expectancy increased ten years (World Bank, 2021). Today, Norway has one of the highest GDP per capita globally and scores 1st place in the Human Development Index (UNDP, 2021).

However, a new methodology for measuring development that also accounts for environmental pressure, proposed by UNDP, places Norway in 121st place (UNDP, 2020). The planetary pressures–adjusted Human Development Index (PHDI) suggests that Norway had already transgressed five planetary boundaries: carbon dioxide emissions (production), nitrogen flows, freshwater use, change in forest area, and material footprint (ibid).

In Norway, the sustained growth in the real income from the past decades has gone hand in hand with increased household consumption. A study of the carbon footprint of Norwegian families showed that between 1999 and 2012, carbon emissions increased 26%, with transport, food, and housing as the main contributing categories (Steen-Olsen et al., 2016). Norway has the second highest (only after Luxembourg) actual consumption – of goods and services - per capita in Europe, 25% above the European Union average (Statistics Norway, 2019).

Norway has often been criticized for its environmental footprint and for allocating environmental costs to other countries through oil exports and manufactured product imports (Reinvang and Peters, 2008; Steen-Olsen et al., 2021). A significant amount of GHG emissions is embodied in Norwegian household consumption, and imported products are increasingly from developing countries (Peters and Hertwich, 2008a). Since 2005, Norway's consumption-based emissions (which account for carbon embedded in imported products) exceed domestic emissions by an average of 9% (Global Carbon Project, 2020), which shows that the Norwegian carbon footprint is higher than that measured by territorial (production-based) emissions.

A recent study showed that from the Nordic countries (Denmark, Finland, Sweden, and Norway), only Norway had not yet achieved absolute decoupling from GHG emissions (Stoknes and Rockström, 2018). Despite all of them becoming more carbon-efficient, Norway's improvement has been countered by offshore operations of oil and gas (ibid). Data from the Norwegian statistics bureau suggests that the government has not invested enough to shift from fossil fuels to renewables and prioritized other environmental sectors. For example, from 2013 to 2019, environmental subsidies increased by 300% for *environmental protection*, 532% for *resource management,* and 167% for *wild flora and fauna management*. In the same period, subsidies for *renewable energy* decreased by 15% (Statistics Norway, 2020a).

Larger investments in the energy transition have started only recently. Historically, the fossil fuels sector has had the most significant share of investments in research and development, just recently overtaken by energy efficiency in 2014 and renewables in 2019 (IEA, 2019a). Such achievements had a drawback during the Covid-19 pandemic when oil production rose again, and investments in renewables dropped (ibid).

Presented as both an "oil giant" and a "climate leader" (The New York Times, 2017), Norway has practiced controversial climate policies. It is the greatest contributor to the UN-REDD+ Programme, having pledged over ten times more funds than the whole European Union (Climate Funds Update, 2021), and has also initiated an intensive process of electrification of its transport system (Kristensen et al., 2018; Ruter, 2015, 2019). In 2017, The Norwegian Water Resources and Energy Directorate also issued a decision banning fossil oil for heating from 2020, making Norway the first country to do so (European Commission, 2017).

The manufacturing industry has historically dominated energy consumption in Norway, followed by the transport sector and oil, gas, and minerals extraction. An overview of energy use in 2020 shows that 58,8% of total energy consumed was from manufacturing, 15,5% from transport, and 13,4% from extraction activities. Electricity and oil products are the primary energy sources in Norway, representing 54% and 29% of the total final energy consumption in 2019, respectively. However, there has been a transition towards increased use of natural gas, which gradually replacing oil. The

Norwegian electricity production is prevenient of clean sources, with 93,4% coming from hydropower, 4,1% from wind power, and 2,5% from thermal energy (Statistics Norway, 2021b).

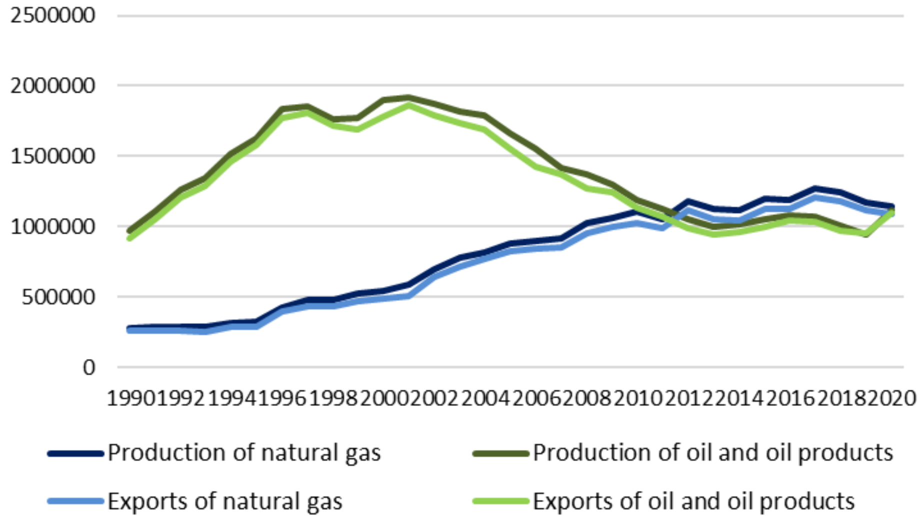
Transportation in Norway is today one of the most significant sectors in terms of environmental impacts (Steen-Olsen et al., 2021), being responsible for the biggest share of GHG emissions (32%) (Statistics Norway, 2021c) and the second-biggest share of energy consumption (15%) - only after manufacturing and mining industries (58%) - (Statistics Norway, 2021a).

From 1990 and onwards, the Norwegian Electric Vehicle policy has offered increasing incentives for electric cars, including tax reduction and exemption, provision of public electric chargers, free use of toll roads, and public parking, among others (Kristensen et al., 2018). Norway holds today the most extensive fleet of electric cars per person in the world (European Environmental Agency, 2020). In 2016, 5% of the vehicles sold in Norway were electric, while in 2020, the percentage reached almost 75% (Norwegian Road Federation, 2021).

In 2015, Ruter, the public transport company from Oslo, adopted a plan to have all public transportation emission-free by 2028 (Ruter, 2015). By April 2020, all the Nesodden ferries were electric, and during the same year, 78% of the energy used in all Ruter's trips was renewable (Ruter, 2020). Other cities in Norway, including Bergen, Trondheim, Drammen, Hamar, Lillehammer, Stavanger, Tromsø, and Bodø have also started implementing initiatives towards increasing the fleet of electric buses (Norsk elbilforening, 2019).

Still, Norway is one of the most significant energy producers and exporters among Europeans, as it is one of the world's largest oil and gas exporters (BP Global, 2020). Oil and gas remain the largest economic sector in terms of added value, government revenues, investments, and export value (Norsk Petroleum, 2020). The International Energy Agency expects gas production to remain stable in Norway while the rest of Europe will experience a decline of 40% in production in the next five years (IEA, 2020b). In the global scenario of oil price fluctuations and market instability, natural gas is taking over the oil's role in the Norwegian economy. Of all petroleum produced, 75% was oil and 16% was natural gas, while in 2020, these percentages were 43% and 49%, respectively (Norsk Petroleum, 2021). Figure 3 shows the production and export of oil and gas from 1990 to 2020.

Figure 3. Production and export of natural gas and oil in Norway, in GWh



This figure shows the annual production and exports of natural and oil and oil products in Norway from 1990 to 2020. Oil products do not include biofuels.
Source: Statistics Norway, 2021a.

Diminishing fossil fuel revenues and climate change are making the future of the oil industry more uncertain (IEEFA, 2019), which was aggravated by the recent Covid-19 pandemic. Still, the Norwegian government keeps issuing new petroleum exploration licenses every year (Norsk Petroleum, 2021), and in 2020 offered incentives to the oil industry by approving a significant tax cut to new oil investments (Stortinget, 2020). The proposal included the postponement of tax payments in the order of initially NOK 100 billion for new investments in petroleum exploration up to 2024 (ibid). The Socialist Left Party, the Green Party, and the Red Party made a series of remarks against the tax cut, highlighting that these new investments will lock carbon in the economy for many years and that such money could be invested in green transition projects instead (ibid).

Before the UN Framework Convention on Climate Change in Paris in 2015, Norway submitted its target of reducing GHG emissions by 40% by 2030 compared to 1990 levels (Regjeringen, 2015). In 2020, the Norwegian government stepped up this target to at least 50% reduction, towards 55% (Regjeringen, 2020).

Some criticize the contradictory Norwegian climate policy as a cost-effective way to mitigate climate change in countries in the global South while avoiding taking action at home (Benjaminsen and Svarstad, 2021). It is cheaper, for example, to pay developing countries to preserve their forests through REDD+ than to quit oil production (ibid). In an interview to the New York Times, Thomas Nilsen, a Norwegian journalist who has extensively covered oil drilling in the Arctic region, declared: “We do understand that climate change is caused by burning fossil fuels. At the same time, we depend so much on the income from the oil. […] we do want to stop, but we don't know how." (The New York Times, 2017).

4.2. Analytical framework

In this research, we use decoupling as the guiding concept to analyse if the Norwegian economy is greening. The two primary dimensions of decoupling between growth and environmental pressure discussed in the literature are resource use and carbon emissions (Hickel and Kallis, 2019). Through the lens of the second law of thermodynamics - which teaches us that energy cannot be recycled - (Georgescu-Roegen, 1971), energy is also a particularly relevant indicator, not least considering that global energy consumption is still increasing. It is worth mentioning that oil exploration, the primary industry in Norway, is highly associated with three ecological indicators: energy consumption, raw materials extraction, and GHG emissions. These are also some of the most widely reported indicators of environmental pressure by governments and international agencies. Therefore, in this research, we analyse if the Norwegian GDP is decoupling from the three indicators: i) energy consumption, ii) material consumption, and iii) GHG emissions.

We prioritised data provided by Statistics Norway (Norwegian: Statistisk sentralbyrå, abbreviated to SSB), the Norwegian statistics bureau, and we analysed the evolution of each indicator from 1990 to 2020. The choice of the period was based on the availability of the data, as there is no comprehensive data for these indicators in Norway prior to 1990. Figures for material flows (extraction, import, and export) for 2020 have not been published by the date of this study. Data for Norwegian GDP was sourced from the World Bank (World Bank, 2021).

Raw materials were measured through the indicator known as Domestic Material Consumption (DMC), calculated by adding all material imports and domestic material extraction, subtracting all material exports (Eurostat, 2021). Despite accounting for material imports, those do not include GHG emissions embodied in materials/products. Therefore, DMC is only a conservative approximation of the actual environmental impact of consumption. Data for GHG emissions is also production-based and not footprint-based. Production-based indicators account for GHG emissions taking place within the national territory and its offshore areas (IPCC, 2006), while footprint (or consumption-based) indicators account for emissions embodied in the products imported (Peters and Hertwich, 2008b). Consumption-based accounting was formulated to consider *carbon leaka*ge, a situation characterized by higher territorial emissions in developing countries due to production that developed countries consume (Boitier, 2004; Peters and Hertwich, 2008b). However, carbon emissions are traditionally calculated using the territorial-based approach (Lenk et al., 2021).

Notwithstanding critiques of production-based indicators for neglecting environmental impacts embedded in imports (Wiedmann et al., 2015), these are the only ones systematically collected and provided by the Norwegian statistics bureau. Calculating the footprint for such indicators is a methodologically complex study, and the production of primary data for developing such indicators is beyond the scope of this paper.

In this research, we also use a resource productivity approach for assessing decoupling between GDP and GHG emissions. The European Commission defines resource productivity as GDP divided by resource consumption, which is also used by Eurostat monitors, the European Union, OECD, and UNEP in their green growth strategies (Wiedmann et al., 2015). If productivity is increasing, then **relative decoupling** is taking place. If productivity is rising in addition to absolute consumption/pollution decreasing, **absolute decoupling** is taking place.

Sufficient absolute decoupling is defined as absolute decoupling that is necessary to keep economic activity within planetary boundaries. To assess absolute decoupling, we used quantified biophysical parameters established by previous research on planetary boundaries (Cazassa et al., 2016; Dittrich et al., 2012; O'Neill et al., 2018). As this research is based on a case study of Norway, global parameters are adjusted to per capita quotas to compare Norwegian environmental pressure to sustainable levels. As of 2020, the Norwegian population was 5.367.580 inhabitants (Statistics Norway, 2021d).

For GHG emissions, the calculations were based on the goal of the Paris Agreement of limiting global warming to 2 °C above 1990 levels (UNFCCC, 2015). To reach that goal, it is highly probable (>66% chance) that cumulative emissions should not exceed 1000Gt (O'Neill et al., 2018; Rogelj et al., 2016). As the world's population is approaching the mark of 8 billion people (UN, 2019), each person could emit approximately 1,25t of CO_2 per year if human activity is to stay within planetary boundaries.

Although the nine planetary boundaries initially defined by Rockström et al. (2009) do not include raw materials and energy consumption, these are generally considered critically important indicators of environmental pressure, and sustainable consumption rates have been stipulated for both (Cazassa et al., 2016; Dittrich et al., 2012). Some scientists have called energy consumption *the tenth planetary boundary*, arguing that the dynamics of the Universe depend on energy availability (Cazassa et al., 2016). They stipulated a lower and an upper threshold for energy consumption. If we are to return to 1750 consumption levels, the reference value is $3.17*10^{11}$ W, but if we are to reach the limits of total appropriation of Net Primary Production - the basic energetic building block of the biosphere - the value is $7.50*10^{13}$ W (ibid). These values correspond to, respectively, 39,625 W and 9.375 W per person per year. Therefore, to stay within the boundary, per capita consumption should remain within this range.

When it comes to resource use, research suggests that global material extraction should not surpass 50 Gt per year (Dittrich et al., 2012), which allows for per capita consumption of 6-8 t by 2050 (UNEP, 2014). However, more recent studies considering higher population growth stipulated that material consumption must stay below 5 t per capita per year if we are not to exceed the boundary (Bringezu, 2015).

These boundaries are a gross estimation, as the elements involved, such as population growth, carbon sinkers, biodiversity loss, etc., are constantly changing, which would set up new boundaries and sustainable consumption/pollution quotas for each person in the globe.

We calculated Norwegian environmental pressure per capita per year for the three indicators analysed to measure if Norwegian economic activity is within the planetary boundaries and if **sufficient absolute decoupling** is happening or is likely to happen. For DMC, we adopted the targets of 8t and 5t of raw materials per capita per year, an optimistic and a conservative scenario, respectively. For GHG emissions, the reference value is 1,25 t of CO_2 per capita per year, while for energy consumption is between 39,625 W and 9.375 W per person per year.

As the central premise of the Green Growth framework is that efficiency improvements will lead to reduced environmental impact overall, we considered that **absolute decoupling** signals a *greening* of the economy, while **sufficient absolute decoupling** signals a *green* (sustainable) economy. This assumption goes in the same direction as other researchers' understanding that efficiency improvements alone are not enough to achieve sustainability and that genuine green growth occurs when an increase in economic output lowers the total environmental footprint (Stoknes and Rockström, 2018: 42). The indicators and units used in this research to assess different decoupling trends are summarized in table 1.

Table 1. Indicators used to measure decoupling

Indicator		Unit	What does it measure?	Timeframe	Source
Energy use	Total energy consumption	GWh	Absolute decoupling	1990-2020	Statistics Norway
	Energy consumption per unit of GDP	USD/GWh	Relative decoupling		
	Energy consumption per capita	W/capita	Sufficient absolute decoupling		
DMC	Total material consumption	Tonnes	Absolute decoupling	1990-2019	Statistics Norway
	Material consumption per unit of GDP	USD/Tonnes	Relative decoupling		
	Material consumption per capita	Tonnes/capita	Sufficient absolute decoupling		
GHG emissions	Total GHG emissions	Tonnes	Absolute decoupling	1990-2020	Statistics Norway
	GHG Emissions per unit of GDP	USD/Tonnes	Relative decoupling		
	GHG emissions per capita	Tonnes/capita	Sufficient absolute decoupling		

4.3. Definitions

Biomass includes crops, crop residues, fodder crops, grazed biomass, wood, wild fish catch, aquatic plants/animals, hunting, and gathering.

Metal ores are mineral aggregates containing metals, such as iron, copper, nickel, lead, zinc, tin, gold, silver, platinum, bauxite, aluminum, uranium, and thorium.

Non-metallic minerals are marble, granite, sandstone, porphyry, basalt, other ornamental or building stone, chalk, dolomite, slate, chemical and fertilizer minerals, salt, limestone, gypsum, clays and kaolin, sand, and gravel.

Fossil energy materials are coal, lignite, hard coal, oil shale, tar sands, peat, crude oil, and natural gas.

Raw products are raw materials produced by primary industries such as agriculture, forestry, fishing, and mining

Semi-manufactured products are products that are further processed but do not yet constitute finished products

Finished products as products that are finalized i.e. are not processed or transformed anymore.

Energy sources include electricity, oil, biofuels, natural gas, coal, waste, and district heating.

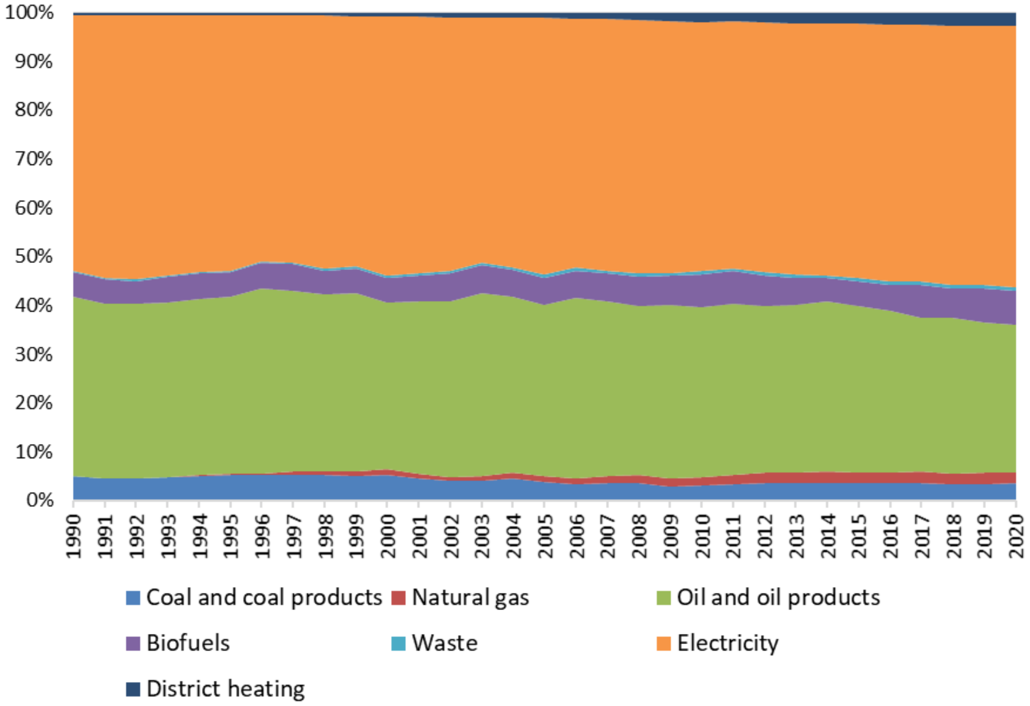
Sources of GHG emissions in Norway are petrol and kerosene, wood, coal, fuel oil and waste oil, gas, waste, heating oils, and other unknown sources.

5. Results

5.1. Energy use

Between 1990 and 2020, total energy consumption decreased 16% for coal and 5% for oil but increased 17% for electricity, 54% for biofuels, 221% for waste, and 548% for district heating (Figure 4). The most significant increase came from the natural gas sector, which was inexistent in 1990, increasing 137-fold by 2020 compared to 1994.

Figure 4. Energy consumption in Norway, by source



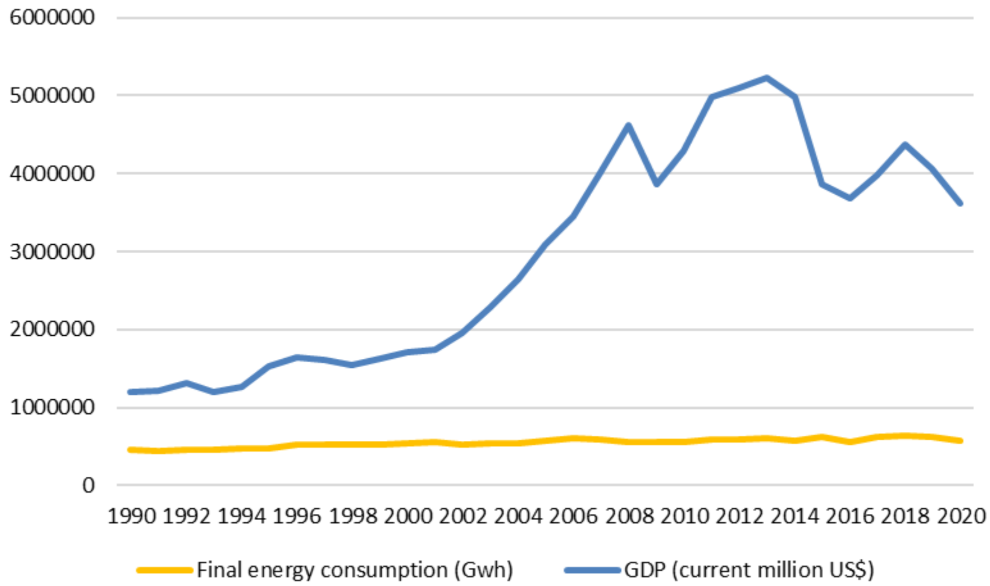
This figure shows the evolution of energy consumption through the different energy sources available in Norway from 1990 to 2020. Energy sources include coal, natural gas, biofuels, waste, electricity, oil, and district heating.
Source: Statistics Norway, 2021a.

Compiled data indicate that from 1990 to 2020, between 86% and 91% of the total energy produced in Norway has been exported. In the same period, energy production increased 76%, energy exports increased 86%, energy imports rose 63%, and final energy consumption grew 15%. The total energy consumption of Norwegian households increased 9,8%, while the total energy consumption of the Norwegian industry increased 29,3%.

During the study period, energy efficiency in Norway more than doubled. In 1990, GDP per unit use was 2.6, while in 2020, it was 6.3. However, total energy consumption increased by a yearly average of 0,9%, and total energy consumption in 2020 was 26,8%

higher than in the base year of 1990. Therefore, the Norwegian GDP has relatively decoupled from energy consumption (Figure 5). Since total energy consumption is still rising, there is no absolute decoupling happening.

Figure 5. Norwegian GDP and energy consumption in Norway

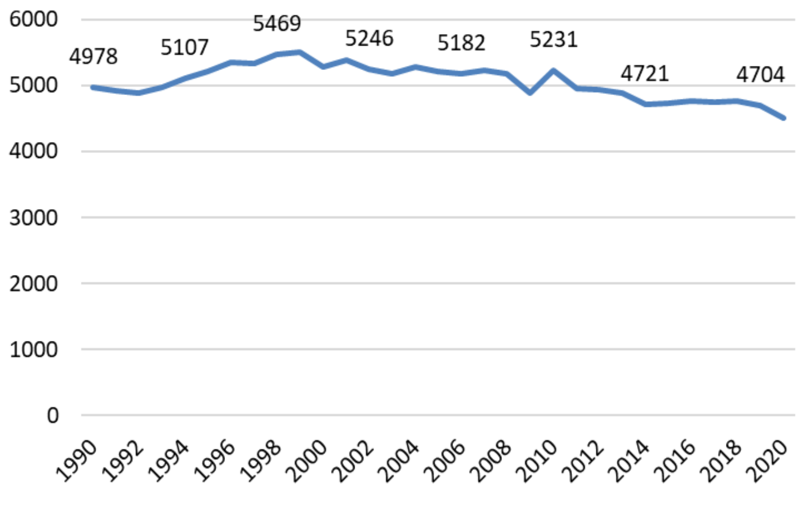


This table shows Norway's GDP and final energy consumption from 1990 to 2020.

Source: Statistics Norway, 2021a and World Bank, 2021.

Since 1990, the Norwegian population has increased 26%, while total energy consumption has increased 15%. Per capita energy consumption has gone down from 4978 to 4704 watts (Figure 6) because the population grew faster than total energy consumption.

Figure 6. Final energy consumption per capita, in Watts



This figure shows the per capita energy consumption (in watts) in Norway from 1990 to 2019.

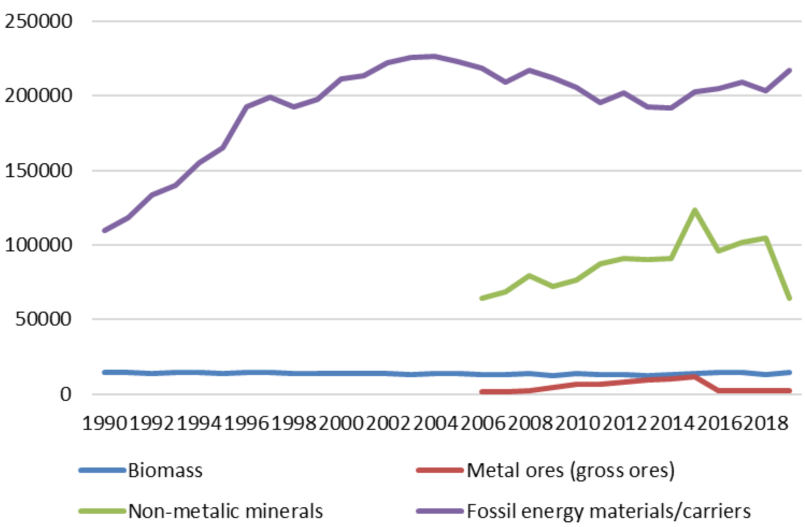
Source: Statistics Norway, 2021a and 2021d.

5.2. Domestic Material Consumption (DMC)

Figures for metal ores and non-metallic materials for domestic extraction are not available from 1990 to 2005 (Norway Statistics, 2020b). Despite this limitation, it is still possible to observe that DMC has increased over the study period: It grew 30% from 1990 to 2005 and 31,6% from 2006 to 2019. Figures for 2020 had not been published by the time this study was conducted.

From 1990 to 2019, biomass extraction has remained stable. The extraction of metal ores increased from 2006 to 2015 but dropped 80% in 2016 and have stayed on the same levels since. Extraction of non-metallic minerals also increased from 2006 to 2015 but dropped 22% in 2016 and 40% in 2019 compared to 2018. Fossil energy materials account for 77% of all raw material extraction in Norway since 1990. Domestic extraction of fossil energy materials doubled in 2000 compared to the base year of 1990, a period of only ten years. Figure 7 shows total material extraction per type of material throughout the study period.

Figure 7. Domestic extraction of materials, by type of material, in 1000 tonnes

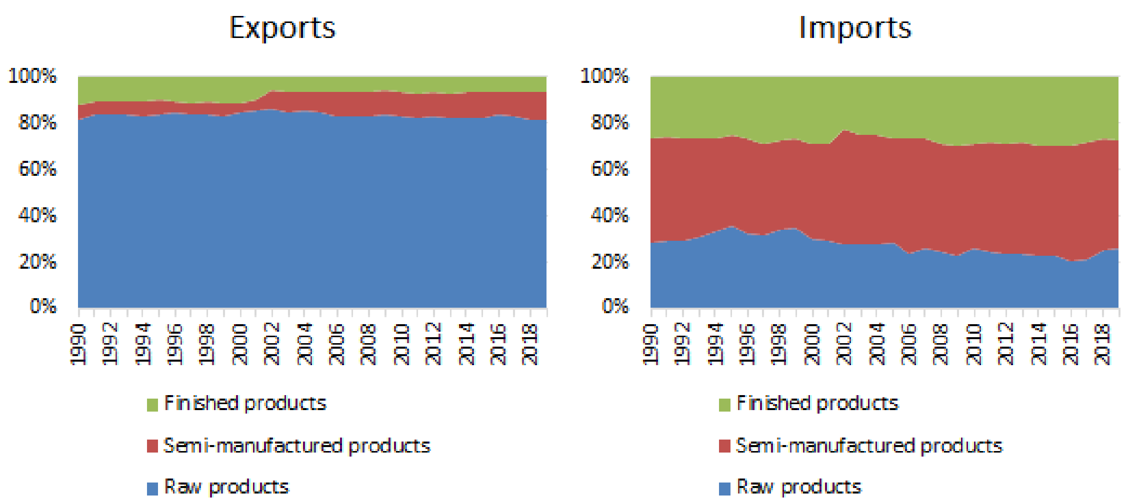


This figure shows the domestic extraction of materials in Norway from 1990 to 2019. Type of materials includes biomass, metal ores, non-metallic materials, and fossil energy materials/carries. Figures for metal ores and non-metallic materials are not available from 1990 to 2005.

Source: Statistics Norway, 2020b.

Throughout the period analysed, Norway has been, essentially, an exporter of raw materials and an importer of semi-manufactured and finished products. Although slowly, the percentage of imported products that are semi-manufactured or finished is increasing – from 71% in 1990 to 74% in 2019 (Figure 8).

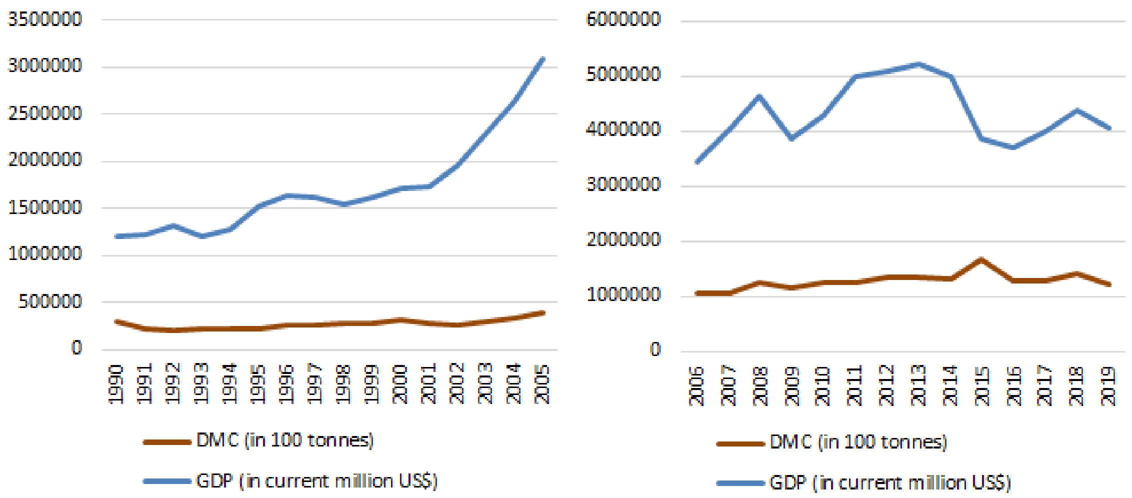
Figure 8. Imports and exports of raw materials, semi-manufactured products, and finished products



These graphs show the share of raw materials, semi-manufactured products, and finished products in imports and exports from 1990 to 2019.
Source: Statistics Norway, 2020b.

Because there is data missing for metal ores and non-metallic materials for domestic extraction in 1990-2005, we did two different analyses for decoupling (Figure 9), one from 1990 to 2005 and another from 2006 to 2019. In 1990, GDP per unit of DMC was 3,9, while in 2005, it was 7,7. In 2006, GDP per unit of DMC was 3,2, while in 2019, it was 3,4.

Figure 9. Norwegian GDP and Domestic Material consumption

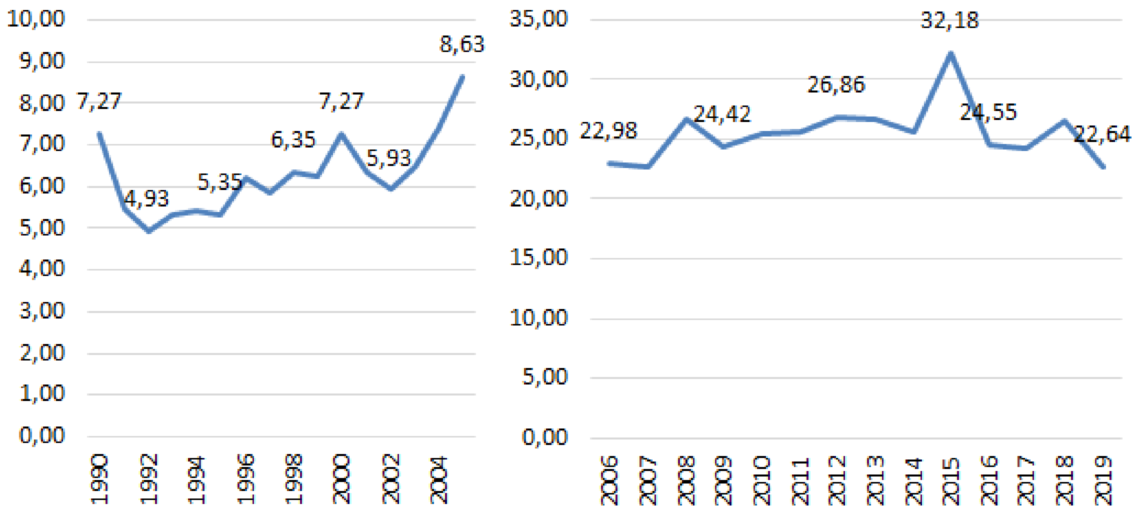


This table shows Norway’s GDP (in current million US$) and final material domestic (in 100 tonnes) from 1990 to 2005 and from 2006 to 2019.
Source: Statistics Norway, 2020b, World Bank, 2021.

However, frequent fluctuations in efficiency from 2006 to 2019 (period that includes all figures for material extraction) indicate no clear or solid track towards relative decoupling. GDP grew considerably in the early 2000s' when petroleum production doubled. During this period, a significant relative decoupling can be observed. However, this trend was later stabilized, and a much weaker decoupling process has happened in the last years, followed by periods of recoupling (Figure 10). The decrease in efficiency, especially from 2007 to 2009 and from 2013 to 2016, is due mainly to a decline in GDP. Total DMC has been rising during both periods analysed (1990-2005 and 2006-2019), which indicates that there is no absolute decoupling happening either.

Since 2006, DMC per capita has fluctuated but remained generally on the same levels. It reached its highest peak in 2015, with over 32 tonnes (Figure 10). Since 2006, the average DMC in Norway has been 25,51 tonnes per capita per year.

Figure 10. Norwegian DMC per capita, in tonnes



These graphs show Norway's GDP and per capita DMC (in tonnes) from 1990 to 2005 and from 2006 to 2019. Figures for the period 1990-2005 do not include metal ores and non-metallic materials. These data are accounted for from 2006 and onwards.

Source: Statistics Norway, 2020b and 2021d.

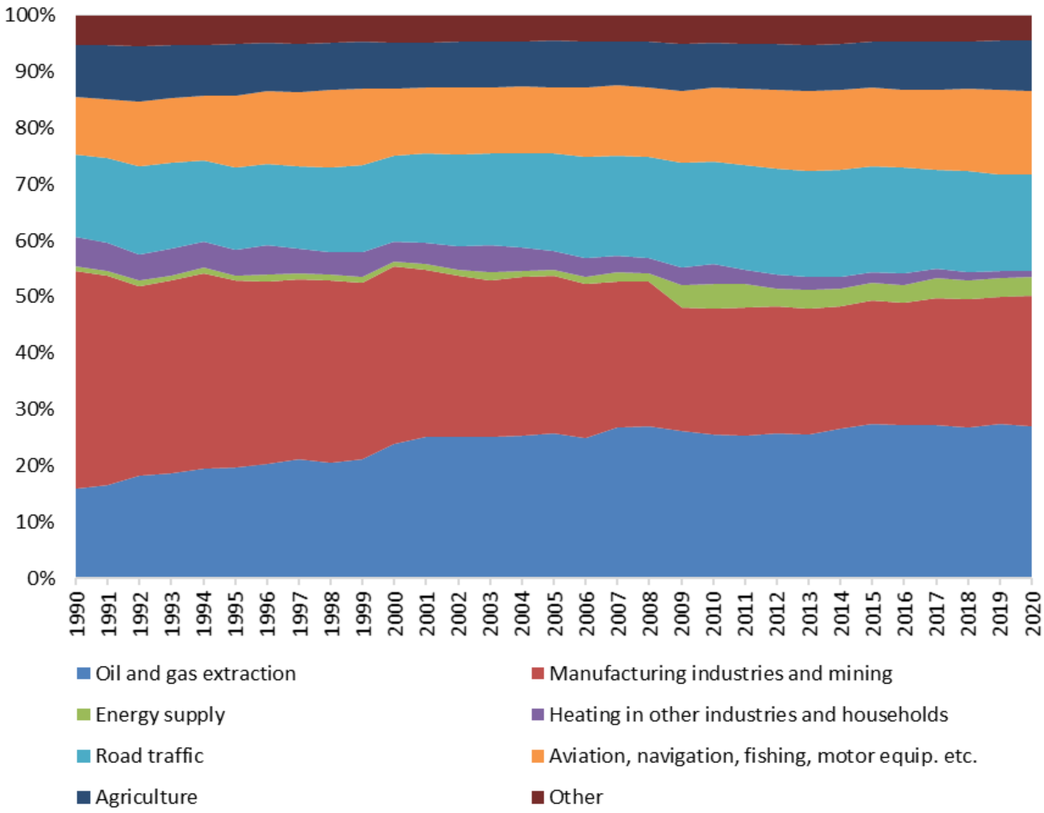
The increase in the Norwegian population has been accompanied by a general increase in material consumption, resulting in the stabilization of DMC per capita at high levels, currently about 3-5 times higher than the defined boundary of 5-8 tonnes.

5.3. GHG emissions

From 1990 to 2020, GHG emissions decreased 37% from coal, 45% from wood, 60% from kerosene, and 77% from heavy fuel oil, while increased 77% from gas, 53% from diesel, and 415% from waste. GHG emissions from Norwegian industries have oscillated (general increasing), while emissions from Norwegian households have been declining steadily since 2010 – a reduction of 33% by 2020 compared to the base year 1990.

GHG emissions from heating decreased nearly 80% from 1990 to 2020, primarily due to the substitution of inefficient fuels for more efficient ones. GHG emissions from road traffic have declined since 2014, following Norway's recent and intense transportation electrification. GHG emissions from energy supply have increased 188% since 1990, with a significant increase of 153% only in 2009 compared to 2008. After the economic crisis of 2008, the use of gas intensified and continued high in the following years. Figure 11 shows GHG emissions from each sector in the Norwegian economy from 1990 to 2020.

Figure 11. GHG emissions in Norwegian territory



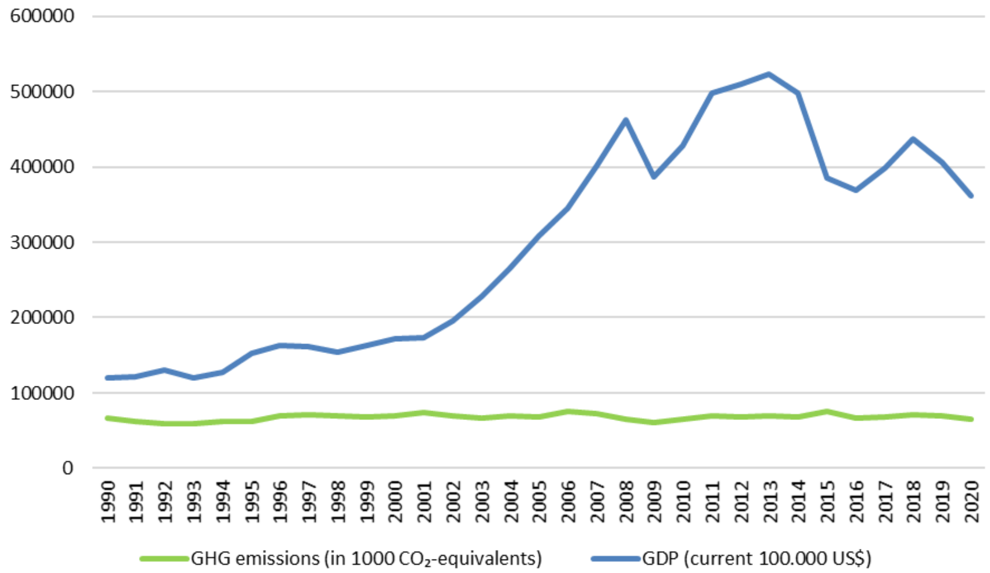
These figures show the share GHG emissions of each industry in Norway between 1990 and 2020, in 1.000 CO_2-equivalents. Figures do not include ocean transport and international air transport. Figures for 2020 are provisional.

Source: Statistics Norway, 2021c.

The increase in GHG emissions from oil and gas extraction follows the significant increase in exploration of fossil energy materials in Norway that doubled from 1990 to 2000 (see figure 7 for DMC). Oil production has declined since 2004, and natural gas production has been rapidly increasing since 1994. Gas production exceeded oil production in 2012, which offset cuts in oil exploration and resulted in higher GHG emissions in the sector.

Norway has become increasingly efficient in terms of GHG emissions. In 1990, GDP per unit of GHG emission was 1,8, while in 2020, GDP per unit of GHG emission was 5,5 (Figure 12). Total emissions from the Norwegian economy have been oscillating (increased: 1992-2001, 2006, 2015, decreased: 2007-2009, 2016, 2020) – but generally have remained on the same level. Therefore, only relative decoupling can be observed between GDP and GHG emissions.

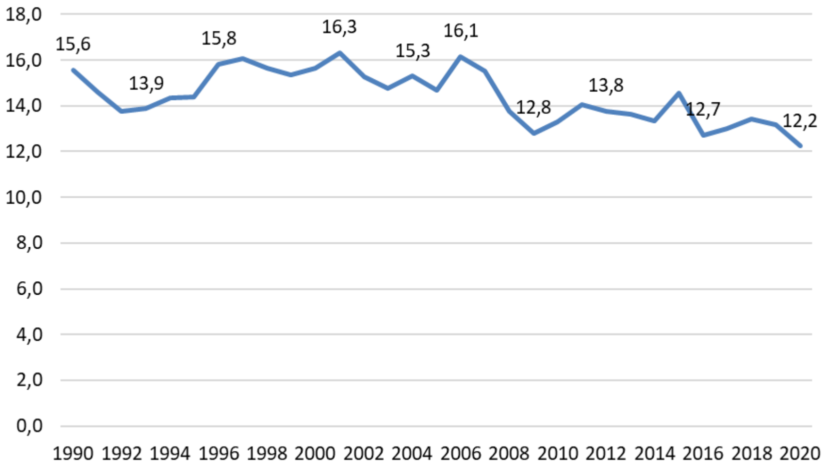
Figure 12. Norwegian GDP and GHG emissions from the Norwegian economy



This figure shows the Norwegian GDP (in current 100.000 US$) and the GHG emissions in the Norwegian territory in 1.000 CO_2-equivalents from 1990 to 2019.
Source: Statistics Norway, 2021c and World Bank, 2021.

Between 1990 and 2020 per capita GHG emissions in Norway declined from 15,6 to 12,2 tonnes per year, experiencing a 12% reduction (Figure 13). However, since total GHG emission levels have not changed significantly, the decrease in per capita emissions is mainly due to an increase in the population.

Figure 13. GHG emissions per capita in Norway, in tonnes of CO_2-equivalents



This graph shows the Norwegian per capita GHG emissions from 1990 to 2020, in tonnes of CO_2-equivalents.
Source: Statistics Norway, 2021c and 2021d.

Despite the decline, Norwegians emitted around ten times more than the per capita quota stipulated, as of last year measured (2020). Hence, trends are far from reflecting a sufficient absolute decoupling.

A summary of decoupling trends between GDP and selected indicators is provided in table 2:

Table 2. Decoupling analysis of the Norwegian economy

	ENERGY	**DMC**	**GHG EMISSIONS**
Relative decoupling	Yes, the Norwegian economy is becoming more efficient	No clear trend. Periods of decoupling followed by recoupling.	Yes, the Norwegian economy is becoming more efficient
Absolute decoupling	No, the total energy consumption is increasing	No, the total raw material consumption is increasing	No, total GHG emissions remain on the same level
Planetary boundary	Between 40 and 9375 W per capita	Between 5 and 8 tonnes per capita	1,25 tonnes per capita
Norway, as of last year measured	4500W per capita	22,64 tonnes per capita	12,2 tonnes per capita
Sufficient Absolute decoupling	No. Although levels are still within the boundary, estimates claim that the population will increase, which will reduce the per capita quota. Moreover, the data suggest that absolute energy consumption will continue to grow.	No. Despite fluctuations, there have been no significant changes in per capita DMC throughout the period analysed, which shows that an increase has followed population growth in overall DMC.	No. The decrease in GHG emissions per capita is due to population growth while total emission levels remained stable. The data suggest that it is implausible that Norway will reach 50% reduction of emissions by 2030.

6. Discussion

The Green Growth framework presumes a substantial policy shift towards greening the economy, including increasing support to renewables and other green technologies while cutting subsidies to fossil fuels. However, the current political scenario is divergent. Policies such as electrification of the transport system and the prohibition of oil for heating have not been enough to reduce total emissions. An outstanding share of energy consumed is through electricity from hydropower – Norway has the second higher per capita electricity consumption in the world, only after Iceland (IEA, 2019b) - but production and consumption of oil products and natural gas are still high. Our data agree with authors who argued that the transition to renewable energy represents a challenge that most likely will not happen with the necessary speed and intensity (Hoffman, 2016).

Our analysis also points out that the Norwegian economy is highly coupled with DMC. From 1990 to 2005, relative decoupling could be observed when GDP increased significantly in a short time. However, since 2006, this correlation had remained unstable, with decoupling periods followed by recoupling – when the economic recessions caused GDP to fall. From 2006 to 2020, no clear tendency in relative decoupling was observed. Total DMC has been rising steadily, so no absolute decoupling is taking place either.

DMC is a problematic indicator as it does not include the material impact involved in the production and transport of imported goods (Wiedmann et al., 2015; Gutowski et al., 2017 cited in Hickel and Kallis, 2019). Many European and OECD countries have improved their resource efficiency measured as GDP divided by DMC in the past decades. However, the scope of DMC is limited as it does not account for upstream raw materials related to imports and exports. Globalisation and the intensification of world trade have allowed for the outsourcing of production and the phenomenon of carbon leakage. Research using material footprint shows that relative decoupling was smaller or nonexistent compared to using DMC (Wiedmann et al., 2015).

The economic growth generated by the oil industry has contributed significantly to the Norwegian welfare state's financing and raising household income, which has been translated into increased consumption of imported goods and services (as shown by figure 8). This study did not calculate footprint, which constitutes the main limitation of our methodology. However, based on the data showing that Norway is an exporter of raw materials and an importer of semi-manufactured and finished products, it is reasonable to assume that the Norwegian environmental footprint is higher than production-based data shows. This assumption goes along with previous research on the Norwegian carbon footprint (Steen-Olsen, 2021). In that case, the relative decoupling observed in some periods might constitute a more optimistic scenario than the actual impact. Unless Norwegians reduce their consumption, decoupling will only happen at the expense of more intensive production elsewhere.

Our data shows that the Norwegian GDP is relatively decoupling from GHG emissions. The electrification of transportation resulted in decreased emissions from road traffic in the last years, but there has been little progress overall towards shifting to cleaner energy sources. Increases in a sector compensate for reductions in others. For instance, emissions from electricity, gas, steam and air conditioning supply, air travel, accommodation, and food services have risen significantly from 1990 to 2020. As an outcome of the global recession during the Covid-19 pandemic, GHG emissions in 2020 were 0,34% lower than in 1990, a non-significant reduction considering this study timeframe.

Achieving the objectives of the Paris Agreement requires the world to quit burning fossil fuels and countries to move away from petroleum exploration. Norway benefits from oil and gas export revenues but is not held accountable for the emissions taking place in other territories. Studies on decoupling at the global level are a valuable tool to assess if economies are becoming genuinely green.

Fluctuations in DMC and GHG emissions corroborate previous observations on the challenges of realizing Green Growth in the face of economic crisis. In times of recession, some countries seem to attach themselves even harder to the idea of pursuing economic growth as a solution (Thiry et al., 2013). Previous crises have shown that the decline in GDP and CO_2 emissions during a recession is more than compensated by stronger growth in the following years (OECD, 2020).

When it comes to sufficient absolute decoupling, the Norwegian economy is far from it. Despite fluctuations, per capita DMC continued roughly the same throughout 2006-2019, which indicates the increase in total DMC accompanied population growth. Norwegian per capita DMC stabilized on levels 3-5 times higher than what we considered sustainable for planetary boundaries.

Per capita energy consumption decreased from 4978 to 4704 watts, but solely due to a greater increase of the Norwegian population than total energy consumption. Although Norwegian energy consumption levels are still within the boundaries, it is essential to highlight that both population and total energy demand are expected to increase in the following decades, potentially placing these numbers beyond the boundaries. As population increases, per capita quotas to keep within planetary boundaries are reduced, and fewer resources are available per person.

A similar trend can be observed with GHG emissions. The per capita emissions have decreased from 15,6 to 12,2 tonnes, but due mainly to population growth, which does not contribute to reducing overall environmental pressure. The population size should remain stable (or decrease) while total emissions fall for sufficient absolute decoupling to happen. Assuming a scenario where population size was stable and per capita emissions were dropping at the same rate observed in 1990-2000, it would still take 175 years for Norwegians to return to pollution levels compatible with planetary boundaries.

Despite efficiency improvements, no absolute decoupling from GHG emissions was observed. Norway has committed to 50% reductions in emissions by 2030 compared to 1990 levels but considering that yearly total GHG emissions have remained roughly the same for the past 30 years, this study suggests that it is unlikely that this target will be reached.

7. Conclusions

This study showed that Norway still has a long way to go towards a green economy when defined as operating within safe planetary boundaries. Relative decoupling was found for energy consumption and GHG emissions only. There is no absolute decoupling or sufficient absolute decoupling for any of the three major indicators analysed. Besides, the Norwegian per capita environmental pressure is significantly higher than what is considered sustainable: 3-5 times higher for material consumption and nearly ten times higher for GHG emissions.

This study used production-based indicators, implying that efficiency achievements for energy and GHG emissions could be less significant if consumption patterns were considered. The use of production-based instead of consumption-based indicators represents the main limitation of this research, but calculating carbon and material footprints was out of the scope of the study.

In summary, Norway is not on the pathway to a green economy. Our analysis showed that despite achieving significant economic growth and high levels of development and human wellbeing, Norway's overall environmental impact has grown over the study period. A few policies have been implemented aiming to reduce that impact, but those were not sufficient. Moreover, the Norwegian economy remains firmly based on petroleum exploration, and the shift towards a green economy is unlikely to happen in this context.

As stated by other scientists and argued here, it does not seem reasonable to design policies around *Green Growth* when the data shows that this remains a theoretical possibility with no substantial evidence that it is achievable. Alternatively, a more concrete and logical goal should be decoupling wellbeing and development from growth.

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