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# How to boost the European Green Deal's scale and ambition

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# Executive Summary

The European Green Deal (EGD) is the European Union's flagship strategy to tackle climate change. This policy study compares the ambition and scale of the EGD with the current relevant scientific literature. The goal is to assess whether the current proposals are capable of fulfilling the EU's commitment to limit global warming to 1.5°C in line with the Paris Agreement. Before embarking on the details of that question it is crucial to emphasize three core messages which emerge from climate science:

1. **Tackling climate change requires that greenhouse gas emissions (GHG) are cut to net zero**. Importantly, this net zero goal allows for positive emissions as long as they are offset by negative emissions. However, the technological and ecological uncertainties involved in large scale deployment of negative emissions technologies, means **the emissions goal should be thought of as being close to an absolute zero goal**.
2. **There is not much time left** to take action globally and in Europe. The latest estimates of global, as well as European carbon budgets, suggest that at current emission rates global warming will increase by more than 1.5°C in less than ten years. In addition, self-reinforcing feedback loops which push earth onto an irreversible warming path (hothouse earth) might set in from global temperature increases as little as 2°C.
3. **The price of inaction will be high** and most likely underestimated by the general public. While Europe will not suffer the worst consequences of climate change, heat waves, floods and droughts will still cause severe human suffering and economic damage. In addition, by 2070 up to 3.5 billion people could live in regions unsuitable for human habitation. This has the potential to trigger an unprecedented global migration wave.

The question which emerges against this background is whether the EGD is ambitious enough to avoid the worst consequences of climate change. First, and most important, is the overall emissions reduction targets. While the EGD proposes to cut emissions by 50% to 55% percent by 2030 compared to 1990 levels, recent research suggests that in order to stay well below 2°C, a reduction of 65% by 2030 would be required, as would be fully decarbonized energy production by 2035-2040.

The EGD currently assumes that reducing GHG emissions by 40% by 2030 requires additional annual investments of € 260 billion. This is likely an underestimation of the volume of required investments for several reasons:

1. Increasing the reduction target towards 55% or even 65% will require faster and broader action.
2. Increasing energy efficiency renovation of buildings alone is likely to require annual investments of € 490 billion.
3. Scaling up Research and Development (R&D) investment to 3% or 4% of GDP in the EU27 requires additional annual investments of between € 75 and € 200 billion.

**Taken together, this suggests that annual investment requirements of up to € 855 billion (excluding transport) in the EU27 would be required for a successful transition.** Setting and delivering on more ambitious GHG emission reduction targets requires the use of all possible policy tools. The EGD is a promising start in this context as it relies on a broad set of instruments from regulations, carbon markets, taxes and public investment. **Given the limited time available however the EGD should go a step further and upgrade the Sustainable Europe Investment Plan into a comprehensive climate master plan which determines clear targets and timelines for renewable energy capacity, building renovations, transport infrastructure, R&D targets etc**. This would not only provide the private sector with clear long-term signals but also allow for timely monitoring of the EU's progress.

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## Policy Recommendations

For a detailed discussion of these recommendations see Section 4.

Boost EGD's scale and ambition along four key dimensions:

1. **Decarbonise the energy system by 2035-2040.**
2. **Refrain from relying on large scale negative emission scenarios.**
3. **Scale up the investment target to match total required expenditures.**
4. **Use individual transfer payments and training grants to address the regressive nature of rising energy costs.**

Take steps and actions to reach these more ambitious goals:

5. **Increase fiscal room via new revenue sources and reformed European fiscal framework.**
6. **Upgrade Sustainable Europe Investment Plan into a comprehensive climate master plan.**
7. **Implement and expand a carbon border adjustment mechanism.**
8. **Align the ETS with general emission targets and establish a price floor and inflation target.**
9. **Focus on providing stable finance for companies and refrain from encouraging further household sector borrowing.**
10. **Work with the European Research Council to establish a group of Europe-specific climate models published in an open source format.**

# 1 Introduction

Climate change refers to the ongoing increase in Earth's mean surface temperature also commonly referred to as global warming[1]. Current estimates are that the planet is about 1°C warmer when compared to the pre-industrial period. Emissions of greenhouse gases[2] (GHG) due to human activities are responsible for these temperature increases. In order to limit the catastrophic consequences of climate change, the global community signed the 2015 Paris Agreement to limit global warming to 1.5°C above pre-industrial levels. The European Union and other countries have started to shape a concrete policy response. In particular the EU announced the European Green Deal (EGD) in December 2019 as the roadmap towards a carbon neutral Europe by 2050.

The EGD represents a necessary and welcome shift of Europe's overall policy agenda. The key question is whether the EGD is capable of delivering the system change which is required to limit global warming to 1.5°C? Is the European Green Deal ambitious enough?

This policy study responds to this question in two steps. The first is to provide a concise summary of climate science's main conclusions and the second, is to compare these with Europe's policy response in general and the EGD in particular.

There are already many reports which explain and summarise the mechanisms that lead to the changing climate, most importantly the work done by the Intergovernmental Panel on Climate Change (IPCC). This policy study therefore seeks to condense the wealth of information and technical reports into a short and easily accessible summary. In so doing, it responds to four key questions (section 2):

I. **What needs to be done to stop climate change?** There is a positive causal relationship between the amount of greenhouse gases in the atmosphere and global temperatures. Therefore, in order to stop further temperature increases, the amount of greenhouse gases in the atmosphere has to stabilise. Achieving this requires cutting human emissions to net zero. Any reductions that fall short of this will not be enough. This is an uncomfortable truth that is often suppressed when business as usual scenarios are discussed under labels like "green growth" or "sustainable growth".
II. **What is the price of inaction?** Without an intervention climate change will lead to more regular and more severe floods and storms in northern European countries and more regular and extreme heatwaves and droughts in Southern Europe.[3] Globally, some areas will become permanently uninhabitable with the potential to trigger large scale migration flows.[4]
III. **How much time is left?** The basic mechanism behind human made climate change is quite simple: the more greenhouse gases there are in the atmosphere, the warmer the planet gets. Scientists can estimate how much carbon dioxide is left to emit (i.e. a carbon budget), if we commit to limit the warming of the planet to 1.5°C. At current global emission rates, the EU's remaining carbon budget will be used up by the end of 2029, at the latest.[5]
IV. **Which policy measures are required to stop climate change?** Limiting global warming to 1.5°C over pre-industrial levels requires a global effort where policy priorities vary by region. For the EU these priorities are to (1) reorganise electricity production from fossil fuels to wind and solar as the primary energy source, (2) renovate the existing building stock and (3)

[1] In the remainder of the study climate change and global warming will be used interchangeably.
[2] The main greenhouse gases (GHG) are carbon dioxide (CO2), methane (CH4), and nitrous oxide (NO2). See IPCC (2018, ch. 2) and Forster, P., et al. (2018).
[3] EEA (2017, pp. 69-89)
[4] EEA (2017, pp. 292-293)
[5] Anderson and Stoddard (2020).

decarbonise its transport sector. In addition, co-operation and cost sharing with global partners is necessary, since meeting the EU's climate targets alone will not be enough to address the global climate problem.

The second contribution of this policy study is to compare the scientific consensus discussed in the first part with Europe's policy response in general and the EGD in particular (section 3). The comparison focuses on six policy areas:

I. The **investment requirements and financing plans**;
II. The **design and effectiveness of the Emission Trading Scheme;**
III. The **transformation of the energy production sector** in the EU;
IV. **Energy efficiency renovations of buildings**;
V. The **decarbonisation of transport**; and
VI. The **decarbonisation of industries**.

This policy study concludes and presents policy recommendations designed to address the identified gaps of the EGD in its current form (section 4). While the report identifies significant challenges - and associated funding gaps - in the EGD, the main conclusion is a cautiously optimistic one: not only do many of the key technologies required to transform Europe already exist, they are viable. For example, producing electricity from renewable resources (wind and solar) is cheaper than using fossil or nuclear sources. Heat pumps require only a fifth of the energy compared to conventional electric resistance heating, and electric or hydrogen powered vehicles can be run on renewable electricity. **Decarbonizing industrial processes can be technically challenging and thus do not only require implementation efforts but also the development of novel technological capabilities.**

**While the task ahead is achievable, the implementation of these policies requires substantial investments**. **A key finding is that the EGD currently underestimates these investment needs**. Furthermore, past and current investment rates fall short of the required scale. Surprisingly, the main barriers for transformation are not technical issues since the technical feasibility has largely been proven. Rather, a lack of funding, rejection of market intervention in general, and the efforts of special interest groups in particular, seem to be the main factors preventing Europe from finding a political consensus for a fast and effective transformation into a carbon neutral society.

During the time of writing of this report, the Covid-19 outbreak has seriously affected Europe's health care systems and economies. The Covid-19 crisis will dominate the policy making process for months to come at the global, European and national level. However, the fundamental problem of ongoing climate change which the world is facing will re-emerge as the main policy challenge. While the Covid-19-induced recession has led to a reduction of emissions, this reduction is tied to the severity of the economic downturn. Fighting this downturn and preventing human suffering in the short-term is the right policy reaction from a macroeconomic perspective, but it must not be mistaken with a long-term plan of how to tackle climate change as emissions will rebound in the course of the economic recovery. A focused and ambitious policy response to change the global economy and transform it into a carbon neutral system is still necessary.

# 2 Climate Change: The Challenge Ahead

This section provides a summary of the scientific consensus on the nature and scale of the climate change threat to the world in general and Europe in particular. This is not an attempt to provide an exhaustive summary but to condense the key takeaways from the scientific literature into answering four questions: *What needs to be done to stop current climate change? What is the price of inaction? How much time is left?* and *Which policy measures are required?*

## 2.1 What needs to be done to stop current climate change?

The answer to this question is simple: Humanity needs to cut global emissions of greenhouse gases to (net) zero. Since negative emissions exist naturally (for example due to growing forests), some (residual) emissions can be netted out via negative emissions reaching net zero emissions in the aggregate. While this possibility exists in principle, the IPCC as well as individual scientists remain highly sceptical about the feasible deployment of large-scale negative emissions technologies. Acknowledging this scepticism requires the adoption of a net zero goal which is very close to an absolute zero goal.

The discussion of policies effective in reaching net zero requires an understanding of the activities and sectors responsible for the current problem. The consumption of goods and services involves, directly and indirectly, the emission of greenhouse gases as an unwanted by-product. Direct emissions result mainly from the consumption of services, such as a domestic air-travel, that require energy produced from fossil fuels. Indirect emissions are embodied in objects we purchase, such as mobile phones, both from the manufacturing process and the materials used to produce them. Even if the manufacturing processes are carbon neutral, the energy used in production as well as transportation might be based on fossil fuels. The consumption-production-emissions link is key to understanding the changes that European society needs to make. Table 1 below provides a sectoral breakdown of greenhouse gas emissions in Europe.

The bulk (79%) of Europe's greenhouse gas emissions stems from energy production.[6] This includes fuel combustion for electricity production, fuel combustion in road transport (12% from cars), fuel combustion by households mainly for heating and fuel combustion in manufacturing industries and construction. Emissions from industrial processes are released during the production of goods. Industrial process emissions exclude emissions produced by electricity providers to the manufacturers. Agricultural emissions may be divided between those produced by the biological processes associated with rearing livestock and those associated with crop farming. In the EU, about 60% of agricultural emissions are due to livestock and about 40% are associated with the crops and soil management.

The energy production sector needs to be carbon neutral between 2035 and 2040, the specifics about the timing are discussed in section 2.3. Most importantly, the production of energy needs to become zero carbon. Transportation will need to become electrified or transformed to rest on alternative zero carbon fuels in cases where electrification is not possible. The European building stock will need to undergo a large-scale renovation to reduce emissions from households. Industrial processes need to be developed and implemented that are both more efficient and zero-carbon. The agricultural sector

[6] Energy production does not refer solely to the production of electricity, it extends to energy production in the broad sense of the word: including energy for direct heating and transportation.

needs to adopt more environmentally harmonious practices. These are the challenges which lie ahead. In section 2.4, we discuss specific policies to bring about the required transformation.

*Table 1: Breakdown of greenhouse gas emissions.*

| ***Sectoral Decomposition of Emissions (Percentage of Total EU 27 GHG emissions)*** | | |
|---|---|---|
| **1** | **Energy production** | **79%** |
| 1.1 | Fuel combustion in energy industries | 26% |
| 1.2 | Fuel combustion in road transport | 19% |
| 1.3 | Fuel combustion by households | 8% |
| 1.4 | Fuel combustion in manufacturing and construction | 11% |
| 1.5 | Other Energy[7] | 15% |
| **2** | **Industrial processes and product use** | **8%** |
| **3** | **Agriculture** | **10%** |
| **4** | **Waste management** | **3%** |
| | | **100%** |

Excluding land use, land use change and forestry and biomass. Source: Eurostat [env_air_gge] and European Environment Agency

## 2.2 What is the price of inaction?

Although it is difficult for human beings to notice a 1°C difference in temperature, from the perspective of climate science this seemingly minimal 1°C difference in the average global temperature is extreme. Climate scientists use global average temperatures[8] as a proxy for the *average energy* contained in the earth's atmosphere. Notably, an even smaller change, from 1.5°C to 2°C of average warming would result in an additional 6°C of warming in the polar regions - and an associated rise in sea-levels.

Europe has been affected by climate change in a number of ways already. The changes will intensify as long as temperatures continue to rise. The European climate is changing: flooding, storms, heatwaves and droughts will continue to increase their severity and frequency. Heat related mortality is projected to increase by between 60,000 and 165,000 deaths per year by the 2080's.[9] Sea-levels will continue to rise, threatening to displace up to 5.5 million Europeans living in low-lying coastal areas.[10] The changing climate will continue to make Europe more favourable towards vector-borne[11] diseases that were more rarely seen in the region. Such vector-borne diseases include: Tick-borne Encephalitis, Dengue, Chikungunya, Zika, West Nile Fever, and Malaria.[12]

Figure 1 shows a projection of how earth's suitability for human habitation is expected to change over the next 50 years in a business as usual scenario. The black regions mainly in the Sahara Desert represent regions with current mean annual temperatures above 29°C. These are regions unsuitable

[7] Other Energy includes all other items under energy including international aviation and shipping.

[8] The technical term is *global mean surface temperature* (GMST). The near surface air temperature across both the surface of the ocean, ice and the earth. Many measurements are taken regularly over a large number of points across the planet and averaged (IPCC 2018a). It is expressed as a change from a reference temperature, for example, the 1850-1900 GMST.

[9] EEA (2017, pp. 208-210).

[10] This figure includes the UK, see EEA (2017, pp. 208). Also see EEA (2017, pp. 12, 80-84, 205).

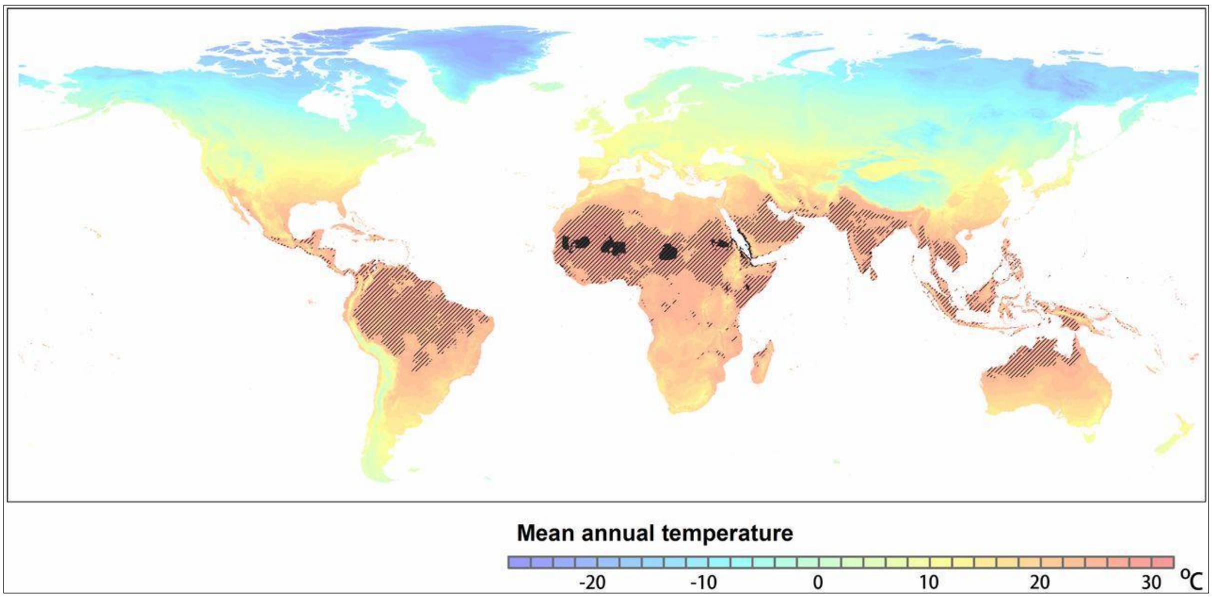
[11] Vectors are blood-sucking organisms such as ticks and mosquitoes that carry and transmit diseases.

[12] EEA (2017, pp. 211-217).

for human habitation. The dark shaded areas are regions unsuitable for human habitation by 2070 in a business as usual scenario. An estimated 3.5 billion people would be directly affected.[13] The result will be unprecedented human suffering and immigration pressures on more temperate regions like Europe.

The cross-border effects of climate change operate through various channels. Agricultural commodities will become subject to greater environmental risks resulting in more volatile food prices.[14] There have already been cases of supply interruptions directly attributable to climate change. The high degree of economic integration between Europe and the rest of the world increases the impact of agricultural as well as non-agricultural supply shocks from the rest of the world. Further climate change will continue to increase the risk of both agricultural and non-agricultural supply interruptions. The European Environmental Agency notes that the risk of being displaced by a weather or climate related disaster has increased by 50% since the 1970's and that over 2008-2015, an average of 22.5 million people had been displaced annually due to weather or climate related hazards.[15] Some of the regions most vulnerable to climate change are in North Africa and the Middle East. The EEA projects that Europe's neighbours, specifically North Africa and the Middle East, will experience increasing environmental, economic and geopolitical instability, which eventually will amount to increased immigration into Europe.[16]

*Figure 1: Impact of climate change on earth's suitability for human habitation.*




Areas currently unsuitable for human habitation (black) and areas unsuitable for human habitation in 2070 (black shaded) in business as usual scenario. Source: Xu et al. (2020)

It is important to appreciate that temperature increases and climate risks do not move at the same pace. The risks need to be understood in terms of the principle of *accelerating risk*: the further away from the optimal temperature that organisms and ecosystems attempt to function the more fragile

[13] Xu, C. Kohler, T. A. Lenton, T. M. Svenning, J. and Scheffer, M. (2020). Future of the human climate niche, PNAS. doi.org/10.1073/pnas.1910114117

[14] EEA (2017, pp. 290).

[15] IDMC and NRC (2015) cited in EEA (2017, pp.293).

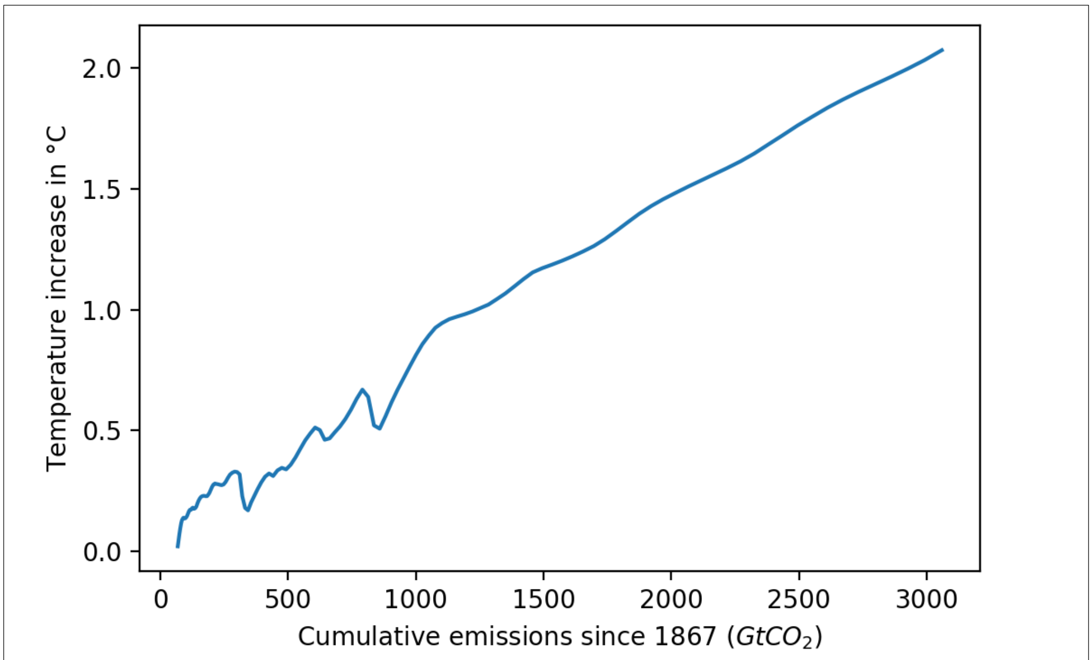
[16] EEA (2017, pp. 12 and pp. 293).

they become at an accelerating rate. As a consequence, individuals and systems can reach a point (a *tipping point*) where, with little warning, they can no longer function leading to a rapid systemic collapse.[17] This entails that half a degree of warming up or down can make a dramatic difference to outcomes. Moreover, emissions pathways that aim to overshoot the target, with the intention of bringing it back down over the subsequent decades through negative emissions and Carbon Capture and Storage technology, arrive much too late to prevent the irreversible damage that is caused by overshooting the climate target. Furthermore, crossing such tipping points might force earth on an irreversible warming path which cannot be stopped due to self-reinforcing feedback loops. While it is inherently difficult to pin down where such irreversible thresholds lie, recent research suggests that they could be as low as 2°C warming above pre-industrial levels.[18]

## 2.3 How much time is left?

Climate change is no longer a problem for 'our children or grandchildren'. The effects are currently being felt and will continue to accelerate. The main cause of global warming is the total quantity of greenhouse gasses emitted since pre-industrial times. Figure 2 illustrates the approximate linear relationship between cumulative emissions of carbon dioxide ($CO_2$) and global average temperature increases since pre-industrial times. Per 1,000 $GtCO_2$ of emissions, global mean temperatures rise between 0.2℃ and 0.7℃.[19]

*Figure 2: Cumulative emissions and average warming.*

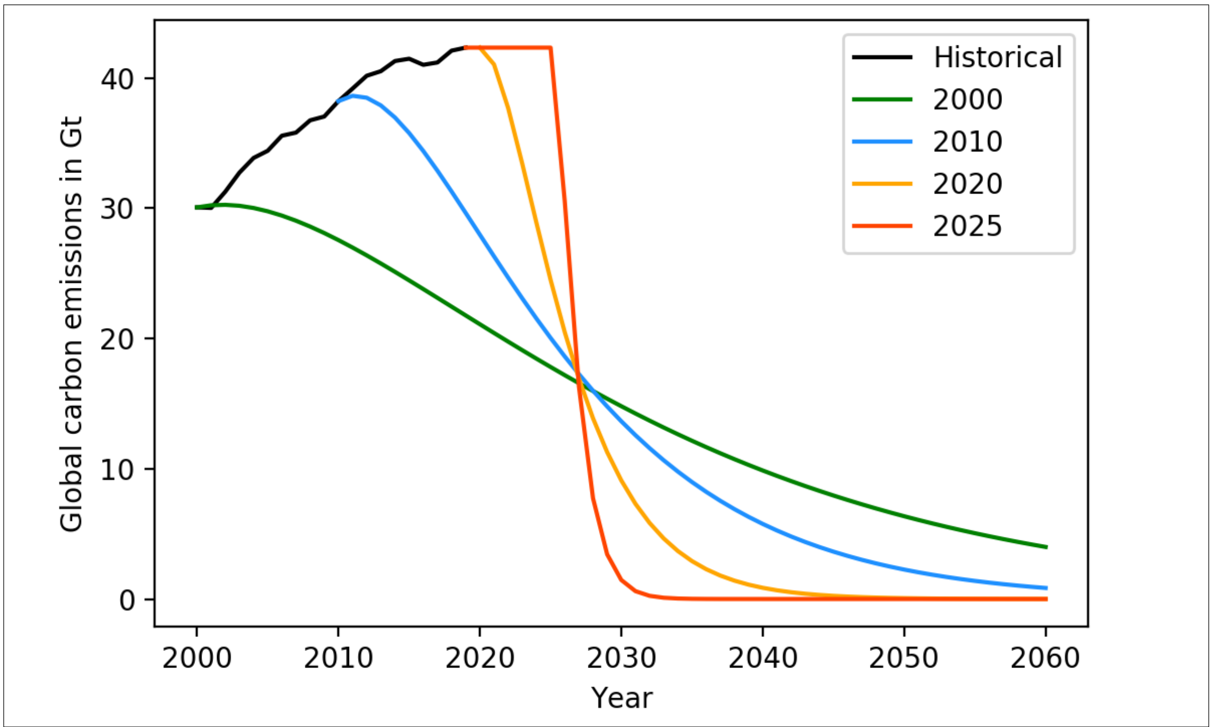



Based on data from IPCC RCP 8.5 scenario (Meinshausen et al, 2011) simulated with FAIR 1.3 model (Smith et al, 2018).

[17] Hoegh-Guldberg et al., (2019).
[18] Steffen et al. (2018)
[19] It is important to note that this is an approximate relationship for illustrative purposes only. The scientific modelling of climate change is far more complex and rigorous than this example suggests. IPCC (2018); Smith et al. (2018); Rogelj, J. et al (2019); Millar, R. J., et al (2017); Forster, P. et al. (2018).

This relationship lends itself to a concept known as the carbon budget. **The carbon budget is the total amount of global emissions remaining until temperatures reach a threshold**. At the beginning of 2020, global average temperatures were approximately 1℃ above pre-industrial levels and the remaining global carbon budget implied by a target of 1.5℃ is estimated to be between 238 and 349 $GtCO_2$. Over the course of the year 2018, global emissions were 42 $GtCO_2$. If global emissions continue at 2018 rates, the budget will be exhausted between 2025 and 2028. This would lead to temperatures increasing 1.5℃ above pre-industrial times between the years 2030 and 2050.[20] If annual emissions are reduced, the budget will last longer while the world economy transforms to a net-zero emissions economy.[21] Accordingly, there is a variety of emissions pathways consistent with a 1.5℃ carbon budget.

*Figure 3: Annual global 1.5°C consistent emissions pathways.*




Data source: Global Carbon Project.

Figure 3 plots four different reduction scenarios together with the historic path of global carbon emissions. All scenarios stay within a fixed carbon budget of 238 $GtCO_2$ from 2018 onwards but are different in that emissions peak at different points in time. The first scenario displays a slow gradual reduction in emissions if they had peaked in the year 2000. Peak emissions occurring in 2010 would have still allowed for a relatively slow gradual reduction in emissions. If emissions were to peak in 2020 a much steeper reduction is required and if the world continues to emit at current rates until 2025 an almost instant switch to a carbon neutral economy would be required in order to limit global warming to 1.5℃. The message which emerges is clear: **The sooner emissions peak, the more time is**

[20] Constrain (2019).

[21] The COVID-19 crisis has forced many countries to shutdown large parts of their economies for prolonged periods of time. This will very likely result in a decline in global greenhouse gas emissions over the course of 2020. However, if the world reverts to a business as usual scenario by the beginning of 2021, the reduced emissions in 2020 will only push the date at which the carbon budget is exhausted by less than a year.

**left to manage the transition. The more of the budget is used up, the more difficult and costly it becomes to stay within this constraint.**

Leading climate scientists have recently estimated the following carbon budget for the EU 27 that is consistent with the Paris Agreement. The EU has a maximum of 27 $GtCO_2$ of energy only carbon budget from 2020 onwards, less than 9 years of current emissions. This requires a cut in total energy $CO_2$ of 75% by 2030 compared with 1990 (70% compared with 2018). Mitigation rates will need to reach 10% each year by 2025 rising to 20% by 2030. Energy will need to be zero-carbon by 2035-40 across all sectors, this includes electricity, heat and transport (international shipping and aviation).[22] **This is equivalent to a 65% reduction in all Greenhouse Gasses on 1990 levels by 2030**.[23]

Many climate models (and the European Commission, see section 3) rely on negative emissions. This means they model global emission pathways in which emissions exceed the available budget for some years or even decades, but carbon is removed from the atmosphere later (negative emissions). Heavily relying on negative emissions is problematic for two reasons. First, the technology for large scale carbon removal does not exist and its prospects are not bright.[24] Therefore, climate strategies which rely on decades of carbon removal in the second half of this century and in some cases even in the next century, represent a big gamble.[25] The second problem with large scale negative emission plans stems from the fact that the global climate system is subject to the principle of accelerating risk: it becomes disproportionately more fragile with each additional 0.1℃ of warming until it collapses with little warning.[26] This implies that relying on negative emissions is a high-risk strategy because the system might reach a point where unanticipated self-reinforcing feedback effects are triggered which will make it impossible to stick to the initial emission target and might even set earth on an irreversible warming path (hothouse earth).[27]

## 2.4 Which policy measures are required to limit warming to 1.5°C?

The previous sections have summarised the scientific consensus on the relationship between GHG emissions and climate change, estimates of remaining carbon budgets and the likely consequences of inaction. This section provides a summary of policies which are regarded most effective and most feasible for tackling climate change.

### 2.4.1 Energy production

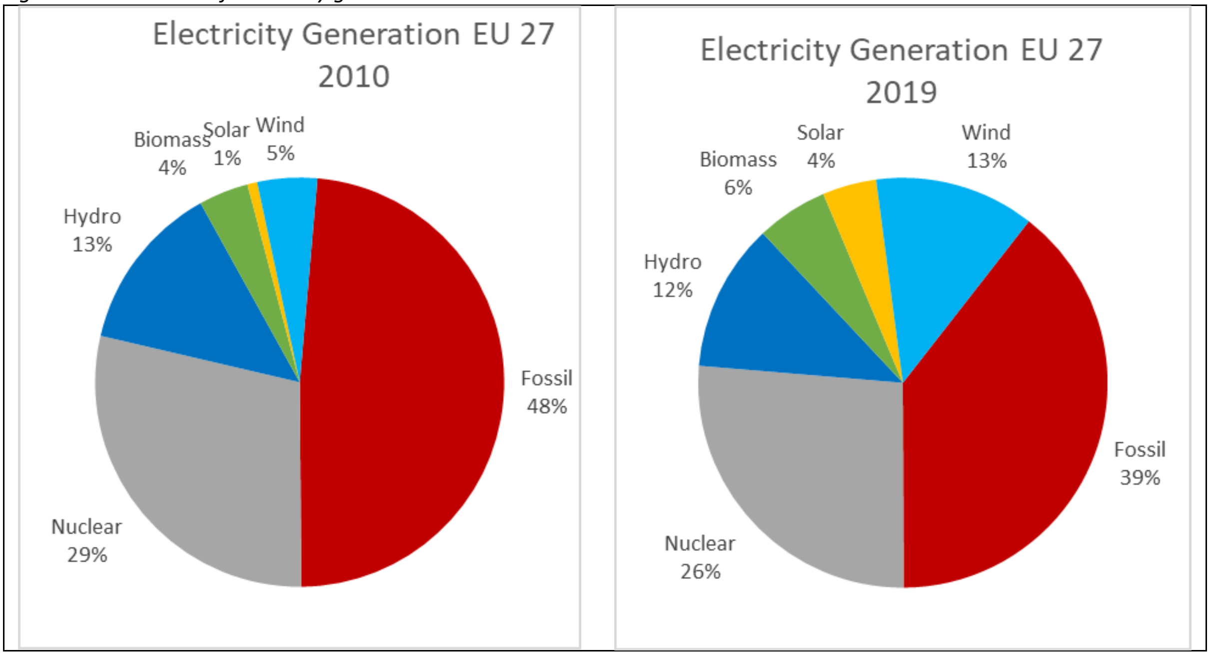
As discussed in section 2.3, the production of energy is the largest source of emissions in Europe. The most important task is to increase the share of renewables in gross energy consumption (currently at around 15%). This will require to 1) primarily source energy from wind and solar, 2) switch to electricity as the dominant energy carrier, and 3) modernise grids to accommodate the needs of a new system.[28]

Total electricity produced has been relatively constant across the EU 27 for the past 15 years. Figure 4 shows that the share of renewables in gross electricity production for the EU 27 has increased from

[22] Anderson, K. and Stoddard, I. (2020)
[23] Authors' calculations.
[24] Anderson, K. and Peters, G. (2016).
[25] Asayama, S. and Hulme, M. (2019).
[26] Hoegh-Guldberg et al., (2019).
[27] Steffen et al. (2018).
[28] IRENA (2019) Electrification of Renewables.

23% in 2010 to 34% for 2019.[29] Renewables such as wind, solar and biomass, are responsible for this shift, replacing fossil sources such as coal. However, electricity production from gas has increased steadily since 2014 and, while it produces fewer emissions than coal, it is still a source of carbon emissions. Output from nuclear energy has slowly declined since 2004.

*Figure 4: Breakdown of electricity generation in the EU 27.*




Data source: Agora Energiewende (2020)

Given existing technologies, electricity production from renewables is both technically feasible and economically viable: Europe has the potential to generate enough power from on-shore wind to satisfy the entire planet's energy needs through to 2050[30]; and new investment in wind and solar is more cost-efficient than investment into fossil fuels.[31] Despite the technical feasibility, the required capacity expansion in order to fully decarbonise energy production is substantial. Recent research points to zero-carbon electricity production by 2030 as a prerequisite for reaching the 1.5°C target.[32] The reliance on wind and solar stems from the fact that additional hydroelectric resources in Europe are limited.[33] Furthermore, biomass is limited by two constraints: the availability of feedstocks that can be sustainably harvested, and competing but non-substitutable uses of bioenergy such as aviation biofuels. Ultimately, European renewables growth needs to come from wind and solar. While these sources haven been rapidly expanding over the past decade, wind and solar power currently contribute only 17% of EU electricity production.

The electrification of energy consumption will lead to an increase in overall electricity demand as energy for transportation, heating and industrial processes are sourced from electricity rather than

[29] Agora Energiewende and Sandbag, (2020). The European Power Sector in 2019: Up-to-Date Analysis on the Electricity Transition and Eurostat nrg_bal_peh.
[30] Enevoldsen et al (2019)
[31] IRENA (2019) Renewable Power Generation Costs in 2018.
[32] Hainsch et al. (2019) and Anderson and Stoddard (2020).
[33] Agora Energiewende (2019).

fossil fuels such as gas and petroleum. Increases in electricity demand will need to be moderated by efficiency gains in consumption usage[34]. However overall, the electrification of energy consumption will require an increase in electricity production even in the light of efficiency gains. This makes fast decarbonization of electricity production (most likely by 2030) a key priority.

The European energy infrastructure and markets will have to be modernised to accommodate a new energy system. The energy grid needs to transport energy to final consumers. Renewables such as wind and solar energy are dependent on local weather conditions for power production and subject to intermittent fluctuations in output.[35] Further integrating the European energy grid will bring stability as fluctuating supply due to varying weather patterns are balanced across multiple weather regimes.[36] In addition, in order to efficiently manage fluctuating energy balances from a larger number of distributed suppliers, power grids need to be upgraded from passive energy delivery systems, to incorporate active informational systems ("smart" grids).[37]

The existing literature provides a wide range of investment expenditures required to meet the target of carbon neutral energy production in Europe. Many models simply assume current expenditures in fossil fuel infrastructure will be re-directed towards renewables. This assumption is extremely optimistic given a recent analysis by the International Energy Agency, which shows that only 1% of capital expenditures of big oil conglomerates is in renewables.[38] In addition, increasing the share of renewables in energy production is likely to lead to falling electricity prices which in turn render investment in renewables unprofitable under current market conditions.[39] **Direct government action in the form of capacity investment might be required in order to meet the short-term climate targets while at the same time securing long term supply security**.

### 2.4.2 Buildings

Buildings in the EU are responsible for 40% of total energy demand and 36% of total $CO_2$ emissions. Reducing emissions in the building sector is essential to becoming carbon neutral by 2050. This requires the elimination of direct emissions from the combustion of fossil fuels on site for heating and cooking and the elimination of indirect emissions. The latter stem from the fact that the energy that is required for the construction of buildings may have been produced from fossil fuels.

Making buildings carbon neutral requires the implementation of strict building standards for new buildings. However, given that about 75% of the current building stock will still be in use in 2050, a large-scale energy efficiency renovations programme over the next 30 years is required.[40]

Energy efficiency renovations need to accomplish three goals. First, they need to increase the *efficiency of actual energy usage* by installing more efficient technologies. Heat pumps for example perform the same task as fossil fuel boilers[41] but consume up to 75% less energy than gas boilers and up to 85% less energy than conventional electric resistance heating systems.[42] Second, renovations need to *reduce the energy needs* of a building by improving the thermal insulation. Third, renovations

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[34] Agora Energiewende (2019).
[35] Redl (2018).
[36] Grams, C. M. et al (2017)
[37] IRENA (2020), Global Renewables Outlook: Energy transformation 2050.
[38] IEA (2020).
[39] Höschle, H. et al (2013) and Söder et al (2019).
[40] Artola et al (2016).
[41] Heat pumps use electricity to heat water which may then be used for bathing and space heating.
[42] Willem et al (2017).

need to ensure that *renewable energy sources* are used for the remaining energy needs.[43] The installation of solar collectors to produce electricity or heat for a building are examples of renewable energy generation on site.

In order to achieve mid-century carbon neutrality, the weighted energy renovation rate needs to increase from currently 1% of the existing building stock per year to 3%. Current expenditure on renovations would need to increase from its annual average of approximately €245 billion per year to €735 billion per year. It is estimated that this would employ an additional 2-4 million people in the European construction industry. [44]

For consumers, the major barriers to undertaking a renovation are the financial costs, the technical complexity, and the lack of skilled installers. Many consumers find it difficult to assess the benefits of a potential renovation against the costs of repaying the financing of the project.[45] Therefore, a Europe wide action and funding plan seems necessary to successfully speed up renovation rates by two means: increased, direct public initiative as well as more clear-cut incentives for private actors.

### 2.4.3 Transport

Most transportation emissions are produced by motor vehicles, international aviation and international maritime transport in order to move goods or people around.[46] Eliminating these emissions by 2050 requires a diverse combination of measures.

Land transport needs to be electrified as widely as possible. This requires large-scale investment in the electrification of public transport commuter systems and inter-regional high-speed rail. In addition, zero-emissions vehicles will form an important component of both personal, commercial and freight transport. In order to facilitate the development and adoption of zero-emissions vehicles, the public sector will need to work with the private sector to finance new technologies and the necessary supporting infrastructure. For example, battery electric vehicles require more public charging infrastructure for wider adoption. Hydrogen production from renewable energy is becoming more cost competitive in comparison to fossil fuel sourced hydrogen.[47] Hydrogen fuel cell vehicles are available on a small scale from a number of motor vehicle manufacturers but there is a lack of refuelling infrastructure and the vehicles are expensive. Working with manufacturers to assess the infrastructure needs would accelerate development.[48]

Air transport, both domestic and international, continues to grow rapidly across the EU. Continual improvements to jet engines have yielded efficiency gains and emissions reductions per kilometre travelled. Unfortunately, the growth in air travel has outpaced these efficiency gains leading to overall increases in aviation emissions (both domestic and international) which are projected to continue.[49] Until the industry develops and adopts zero-emissions technologies, the available near-term solutions are biofuels combined with reduced demand.

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[43] SETIS (2015).

[44] European Commission, (2019). Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU

[45] European Commission, (2019). Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU

[46] European Environment Agency (2017).

[47] Glenk, G. et al (2019)

[48] IRENA (2019) Electrification of Renewables.

[49] IRENA (2020), Global Renewables Outlook: Energy transformation 2050.

A short to medium term mitigation solution is the blending of biofuels with aviation fuel. Currently, the industry does blend negligibly small amounts of biofuels with jet fuel which are recognised under the EU Emissions Trading Scheme. However, biofuels are expensive in comparison to the price of carbon emissions certificates. The use of biofuels to cut emissions cost €390 per tonne of $CO_2$ saved, emissions certificates cost approximately €25 per tonne of carbon emitted.[50] Ultimately, it is much cheaper for an airline to pay the emissions fee than the price of a low emissions fuel.[51]

One of the reasons that biofuels are expensive for airlines is that European biofuel industry is focused on biofuel production for the road transport market. This results in the majority of biomass feedstocks being consumed in the production of road transport fuels with a limited possibility for expansion given existing land and food production. The current refinery capacity is profitably configured to produce biofuels for road transport, not for aviation. Considering the fact that biomass for aviation fuel production needs to compete with other uses of biomass which have other viable non-biomass zero-carbon substitutes, it may be advisable to reserve biomass for sectors that have no other viable alternatives. Specifically, biomass should be directed away from heat, electricity and road transport towards aviation. Moreover, biofuels do not represent a long-term solution for aviation given that they produce other pollutants such as particulate matter and are of questionable sustainability.[52]

### 2.4.4 Industry and Manufacturing

The industry and manufacturing sector contributes directly and indirectly to global GHG emissions. The IPCC provides an overview on direction emissions due to industrial processes.[53] The most important ones are mineral production such as cement and lime, the chemical industry and metal production such as iron and aluminium. Further emissions occur from using fossil fuels and electricity produced from fossil fuels. In general, the bulk of energy in manufacturing is required for process heating and steam generation and most electricity is used for mechanical work.[54] In the EU fuel combustion in manufacturing and construction accounts for 11% of total emissions and industrial processes account for another 8%.

Reducing industry emissions in line with a 1.5° C scenario poses a challenge: global final energy consumption in the sector is expected to increase by 40% compared to 2010 levels in baseline scenarios and still by 30% in 1.5° C scenarios. Reducing emissions while satisfying the energy needs of the sector requires measures along five dimensions:

1. The **increasing electrification of energy demand** is a powerful tool to decarbonise the industrial sector, given that electricity is produced from zero emission sources. Implementation requires fundamental technological change and large-scale investments.
2. **Increasing the energy efficiency** of industrial processes is crucial in order to limit global warming. It requires targeted policies and regulations to ensure that best practices and technologies are implemented widely. Establishing efficiency targets only for energy hungry industries such as cement, iron or steel is not enough. Instead cross sector standards should be established and SMEs included into these efforts. Across the board efficiency improvements can be achieved by focussing on motor systems, steam generation and waste heat recovery.

[50] Prussi et al (2019)
[51] Lu, C. (2018)
[52] Prussi et al (2019)
[53] IPCC (1996)
[54] IPCC (2018), p. 138

3. **Reducing the carbon content of non-electric fuels** means a rapid phase out of coal and using natural gas where feasible instead of more polluting fuels. While switching fuels can provide substantial emission reductions quickly, it also raises the prospect of path-dependency and technology lock-ins. Relying on clean hydrogen can represent a sustainable alternative.
4. **Reducing the use of industrial materials** by moving towards a circular economy has the potential to reduce emissions while providing broader ecological benefits. In a circular economy, products are used longer, repaired instead of discarded and finally recycled.
5. The implementation of **new industrial processes** is required to reach the global 1.5°C target. This implies significant changes to industrial production which require substantial investment in research and development.

It is important to point out that path dependencies have the potential to make countries stick with undesirable strategies. For example, opting for large scale deployment of CCS instead of electrification might make a switch towards electrification later on more difficult or expensive. The use of these technologies on a material scale would require substantial shares of future energy systems being committed to them into the 22nd century.[55] While reliance on biofuels and CCS require less fundamental change, opting for these technologies might not be effective in the long run. In addition, CCS is still costly (up to € 168 per mitigated ton of CO2)[56] and requires substantial investments. Bio-based feedstocks on the other hand can be associated with substantial life-cycle emissions and have negative side effects on biodiversity due to increased land demand.

# 3 The European Green Deal in Perspective

The EU Commission presented the initial legislative roadmap of policies and measures for the European Green Deal in December 2019[57]. The EGD proposes to mitigate the problem of climate change:

> "The European Green Deal is a response to these challenges. It is a new growth strategy that aims to **transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy** where there are **no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use.**"[58]

This section puts the EGD in the context of the existing scientific literature and asks whether it is likely to achieve the objective of limiting global warming to 1.5°C. Table 2 compares the main climate goals in the EGD to the previous targets as well as the recent scientific evidence. The first column contains the goals based on the Commission's "old" long-term strategy for addressing climate change, called A Clean Planet for All.[59] This strategy, devised in 2018, aimed at cutting GHG emissions by at least 40% compared to 1990 levels by 2030 and to achieve at least a share of 32% of renewable energy and at least a 32.5% improvement in energy efficiency. The EGD increases these targets by cutting emissions by 50-55% instead of 40% in 2030, while leaving the targets for renewable energy and energy

[55] Creutzig et al (2019). The mutual dependence of negative emission technologies and energy systems. Energy Environ. Sci. 12, 1805-1817. DOI: 10.1039/C8EE03682A

[56] See IPCC (2018) pdf 154 which cite Irlam (2017)

[57] COM (2019) 640 final.

[58] Excerpt from The European Green Deal (2019), emphasis as in original document.

[59] COM (2018) 773 final - A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy.

efficiency unchanged.[60] The third column contains recent estimates based on a Paris-compliant energy-only carbon budget for the European Union of 27 $GtCO_2$, at most. Staying within this budget requires a cut in total energy $CO_2$ emissions of 75% by 2030 compared to 1990 (70% compared to 2018). This is roughly equivalent to a 65% reduction in all GHG on 1990 levels by 2030. Energy production is required to be zero-carbon between 2035 and 2040 across all sectors, this includes electricity, heat and transport (international shipping and aviation).[61]

*Table 2: The EU's main climate targets in perspective*

| Targets for 2030 | Clean Planet for All (2018) | European Green Deal (2020) | Scientific Literature |
|---|---|---|---|
| Cut in greenhouse gas emissions (1990 levels) | -40% | -50% to -55% | -65%[A] |
| Share of renewables in energy production | 32% | 32% | 72%[B] |
| Improvements in energy efficiency | 32.5% | 32.5% | |

A: Anderson and Stoddard (2020) argue that a 75% reduction is necessary for energy CO2 emissions only. The underlying carbon budget of at most 27 $GtCO_2$ is also consistent with Constrain (2019). Greenpeace[62] argues that at least 65% percent reduction is required to achieve net zero emissions by 2040. B: Anderson and Stoddard (2020) argue for zero carbon energy production between 2035 and 2040. The EU27's share of renewables in energy production was 19% in 2017. Simply assuming a linear increase of 4 percentage points annually leads to a renewable share of 72% in 2030.

This comparison shows that while the EGD's increased ambition is necessary and welcome, further action is needed still. Two factors are driving the more ambitious targets of Anderson and Stoddard (2020). The first is that they take the equity commitments of the Paris Agreement towards less industrialised countries into account and secondly, they do not rely on large scale negative emissions in their underlying climate budget model. The last point is of special importance since the 1.5°C scenarios the European Commission is using, rely heavily on negative emissions over the period 2050 to 2100. In the 1.5TECH scenario for example the EU emits a cumulative of 49 $GtCO_2$ up to 2050[63], which is almost twice as much as the carbon budget estimated by Anderson and Stoddard (2020) or implied by the updated estimates from Constrain (2019). The Commission further assumes in that scenario that the EU will subsequently remove 21 $GtCO_2$ between 2050 and 2100. Thus, it relies heavily on negative emissions over that period. The 1.5LIFE scenario is very similar but relies on natural carbon sinks instead of technical solutions.

The remainder of the section discusses the EGD's proposals in more detail and points out policy options to meet the more ambitious 2030 targets presented in Table 2.

## 3.1 Investment requirements

The European Commission and the EGD acknowledge that limiting global warming to 1.5°C above pre-industrial levels requires upgrading Europe's existing capital stock along several dimensions. It estimates that the required additional annual investment expenditures in order to meet the previous goal of GHG reduction of 40% relative to 1990 levels by 2030 requires additional annual investments

[60] Although these are likely to change as well in light with the increased overall ambition.

[61] Anderson, K. and Stoddard, I. (2020)

[62] Greenpeace (2019).

[63] See Cumulative $CO_2$ emissions from Table 9 in EC (2018b).

of € 260 billion[64] and acknowledges that the increased ambition to reduce GHG by 55% by 2030 will require further investments.[65] In order to meet the 1.5°C goal by 2050 it estimates that between 2031 and 2050 annual investments of between € 175 and 290 billion[66] in addition to current policies are required. All numbers are based on the EU28.[67]

Putting these estimates into context unveils two problems. First, they stem from a set of mainly proprietary models (most importantly the PRIMES core).[68] Modelling not only the European economy but integrating economic and ecological systems is a hugely complex task with substantial model uncertainties. **The only way to reduce these uncertainties is to develop and draw information from several modelling approaches**. In addition, the proprietary nature of the core models hinders transparency and scientific debate. **The Commission should work with the European Research Council to set up complementary research groups in order to have access to a broader modelling perspective[69]. In addition, the current level of ambition in the Commission's models is muted. For example, only two model scenarios achieve net-zero emissions by 2050, both rely on highly disputed carbon capture and storage technology[70] and neither looks at the requirements to phase out nuclear energy.**

Second, as the example of energy efficiency renovations of buildings has already indicated, detailed sector specific assessments of investment needs typically find that reaching the 1.5°C target requires much higher expenditures. In addition, the Commission estimates cited above neither take the increased ambition of reducing emissions by 55% by 2030 into account nor do they consider the commitment to support poorer countries and regions as part of the global effort. Altogether, there is a real possibility that these estimates substantially understate the scale of the required green investment initiative Europe needs.

*Table 3: EU27 investment expenditures and investment gap estimate.*

| source | business as usual scenario | 1.5°C scenario estimate | investment gap |
|---|---|---|---|
| | | billion € | |
| European Commission - total investment[A] | 1,190 | 1,480 | 290 |
| European Commission - excl. transport investment[A] | 377 | 576 | 199 |
| Authors' calculations - excl. transport investment[B] | 824 | 1,679 | 855 |

The European Commission investment figures are based on the PRIMES model suit (EC 2018b, Table 10) which are referred to in the EGD documents. The business as usual column refers to the baseline scenario used in EC (2018b) and consists mainly of pre-2015 policies and initiatives. The authors' business as usual scenario is based on recent historical investment expenditures. The 1.5°C scenario column contains the estimated investment expenditures, necessary to limit global warming to 1.5°C (1.5TECH scenario in the case of EC/PRIMES). The investment gap is the difference between business as usual and 1.5°C scenario. For a detailed breakdown see Table 8 the Appendix and the following sections. A: Expenditures for the 2031-2050 horizon in 2013 prices. B: Expenditures in current prices.

[64] See EC (2019b) p. 17
[65] See EC(2020a) p. 1
[66] See EC(2018) p. 16 and EC(2018b) Table 11.
[67] E3MLAB (2019).
[68] See https://ec.europa.eu/clima/policies/strategies/analysis/models_en
[69] See for example Dafermos et al. (2017) and the DEFINE model as an alternative direction.
[70] Implicitly through the underlying carbon budget estimations and explicitly by modelling its use.

Table 3 compares the investment estimates on which the EGD relies on (rows 1 and 2) with sector specific calculations from the authors (row 3). If the transport sector is excluded, the Commission estimates an investment gap of € 199 billion annually. This contrasts with our own estimate of € 855 billion which is more than four times higher than the Commission's figure. The latter figure should be regarded as the answer to a series of "What if…" questions and thus provides valuable context to the Commission's estimates. For example, the € 855 bn estimate includes the estimated cost of tripling current energy renovation rates of buildings. The fact that buildings are a major source of emissions, and that this measure alone accounts for an investment gap of € 490 bn and thus more than twice the Commission's total, shows that more research is required with respect to Europe's investment requirements. Given the severity of the situation, a cautious approach would be to substantially revise the Commission estimates upwards.

The remaining sections provide a detailed breakdown of the investment requirements by sector. By estimating and putting the investment requirements on the political agenda the EGD represents an important step in the right direction. The key challenge lies in setting out the appropriate level of ambition. On the positive side, the Commission explicitly acknowledges the need for a detailed assessment of the investment needs across all sectors and is currently working on such an assessment.

## 3.2 The Sustainable Europe Investment Plan

The Sustainable Europe Investment Plan is the EGD's investment pillar. It is the tool to fill the investment gap outlined in the previous section. The Sustainable Europe Investment Plan aims to **mobilise investment projects with a volume of € 1 trillion** over the decade 2021-2030. This signals two things; first and foremost, the political difficulty to find consensus on a far-reaching public sector-led investment initiative that can meet the scale of the problem. Particularly after years in which the EU economic growth strategy has been based on fiscal consolidation, a shift towards investment-led growth is not achieved. Second, it implies that member states will have to play a major role in filling this investment gap with national resources. In other words, the shortfall reveals that the EGD is not a European master plan including national as well as EU-level efforts. Such a master plan would be required to set appropriate investment and climate targets and monitor them across the EU.

In May 2020 the European Commission announced its plans for how to recover from the COVID-19 crisis under the label "Next Generation EU". According to these proposals the Commission plans to borrow € 750 billion on financial markets and use these funds to help member states through the recovery phase. A proportion of these additional funds is earmarked for green projects such as energy efficiency renovations of buildings, increasing the Just Transition Fund by € 40 billion and the InvestEU scheme by another € 15 billion. At the time of writing however it is neither clear how much of these € 750 billion would be used for green projects nor what the finally agreed volume will be. In principle, if these proposals went ahead, they would have the potential to provide fresh resources for the fight against climate change in Europe. This would be a fundamental improvement over the pre-COVID proposals of the Sustainable Europe Investment Plan since the funding for the latter consisted mostly of existing funds for existing programmes. A key problem remains the limited size of the European Budget in general. The € 750 billion amount to 5.4% of EU 27 GDP. Fighting off the most severe recession in a century while becoming a carbon neutral society will require more. This highlights the crucial role member states will have to play in both efforts.

The second aim of the Sustainable Europe Investment Plan is to **enable green investments** by the private as well as the public sector. This includes the development of a green finance taxonomy to determine whether a given economic activity is environmentally sustainable. The idea is that such a taxonomy would make it easier for investors to deliberately invest in green projects and thus it could bring down the financing costs of such projects. In addition, the green finance taxonomy could be used by financial regulators to lower capital requirements for sustainable investments. Furthermore, public funds can be used to de-risk green investments via guarantees (InvestEU scheme) in order to enable projects which would not be viable otherwise. However, the assumption that the green transition is not happening because investors lack information on what constitutes a sustainable economic activity seems optimistic. In contrast, past examples of attempts to establish new industries and technologies, suggest that private finance is fundamentally risk averse.[71] Thus, providing finance at attractive rates to green businesses is an important part of a long-term green transition strategy. However, guaranteeing financial instruments which are deemed to be green, might be less effective. For example, using public funds to guarantee equity tranches of a securitised green bond consisting of green car or home improvement loans has the potential to further increase household sector debt levels and increase financial fragilities.

Overall, the Sustainable Europe Investment Plan hardly provides fresh resources for the fight against climate change. Positive aspects include the commitment to a detailed assessment of the actual investment needs in Europe, acknowledging the importance of long-term signals for firms to plan and the commitment to revisit state aid rules and the Just Transition Mechanism.[72] The Next Generation EU proposal for a COVID stimulus package announced in May 2020[73], might provide an opportunity to not only support the economic recovery but also to fund some of the crucial infrastructure which will be needed for a green transition. In addition**, to increase the actual financial firepower of the Sustainable Europe Investment Plan, it should be developed into an investment master plan with clearly specified targets for strategic sectors (wind and solar electricity generation, (public) transport, building renovations etc) with corresponding public funding support. That would provide the long-term signals the private sector needs to get active and expand capacities where needed**. In addition, such a master plan should comprise initiatives at the national level such that the targets can be monitored, compared and adjusted given the actual emission path the EU is on.

## 3.3 EU Emissions Trading System

The EU Emissions Trading System (ETS) is a mechanism for determining the price of emissions and allocating the cost of emitting to polluters. This takes place through an EU wide emissions trading market in what is known as a "cap and trade system". Participating firms are obliged to surrender a tradable permit, an EU emissions allowance (EUA), to the regulator for every tonne of GHG they emit or be fined in addition to surrendering an EUA. EUA's may be purchased through European commodity exchanges or, in some cases, are allocated to firms for free by the Regulator. The EU Regulator is the only entity able to create or destroy EUA's which are maintained in a central registry. The Regulator supplies a fixed number of EUA's to the market thereby allocating a collective emissions budget to participating firms at a market determined price.[74]

The ETS system operates in the EU 27, Iceland, Liechtenstein and Norway.[75] The system covers approximately 45% of EU emissions. The cap-and-trade system has several benefits. If it is strictly

[71] Mazzucatto (2011).

[72] Although Storm (2020) argues that the € 100 bn Just Transition Fund is insufficient to fulfill its primary goal which is to compensate the coal mining communities within the EU.

[73] See https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response/recovery-plan-europe_en

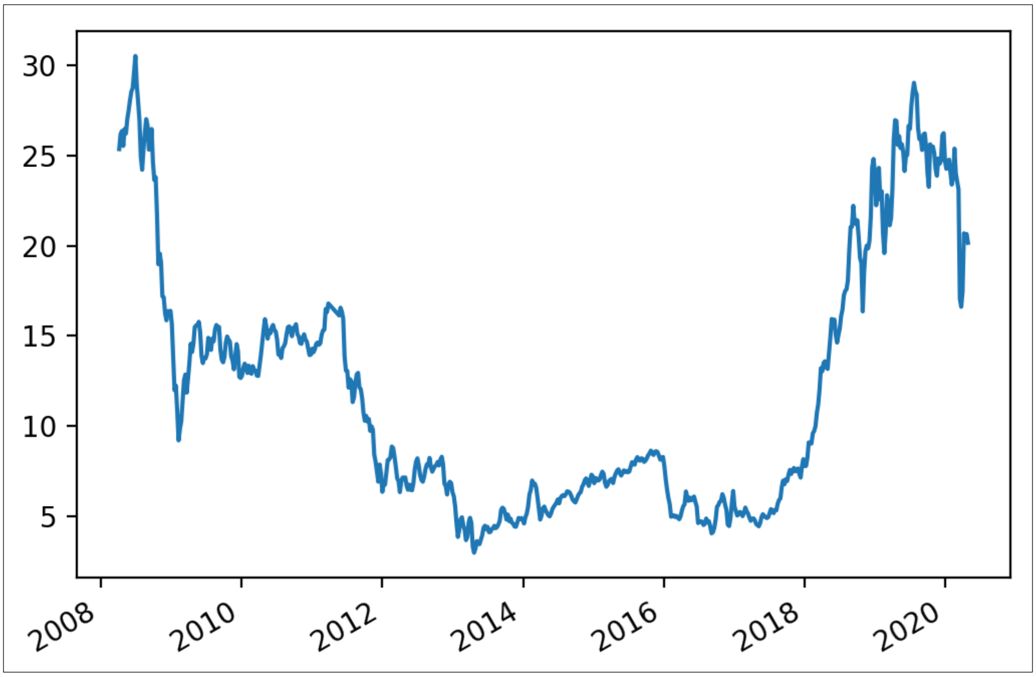
[74] Bernd, H. Chapter 1: introduction. In: (2005)

[75] The UK continues to participate until 1 January 2021.

applied, then it is possible for the system to deliver reductions that are consistent with a given emissions target. In addition, the system is relatively easy and cheap to administer. Finally, the system is flexible to the extent that it does not need to function in isolation to other environmental policies in order to achieve the necessary emissions reductions. [76]

The ETS' main problem has been the low price of emission certificates (see Figure 5), even since the system became more mature with the third phase, which began in 2013. At a basic level, this was caused by an oversupply of emissions certificates. Different causes for the low price are discussed in the literature: the collapse in industrial output because of the financial crisis, falling coal usage over the same period and the falling prices of renewable energy sources. Low carbon prices represent a strong incentive for households and businesses to delay climate action in the form of behaviour change or investment in zero carbon technology. Recent research argues that introducing a price floor in the ETS is both technically and legally viable.[77] Periodic increases of this price floor or the introduction of a carbon price inflation target could provide stable price signals for firms and households while constantly increasing the incentive to take action.

*Figure 5: Price of EU Emissions Allowances in € per tonne of carbon.*




A drawback of carbon pricing/taxation over such a broad number of regions and sectors is that it is socially regressive.[78] To this end, additional policies will need to be implemented to mitigate these effects or future rises in carbon prices may lose public support as evidenced by the recent *Mouvement des Gilets Jaunes*. **Evidence from Latin America[79] and the Caribbean[80] shows that it is both cheaper, more efficient and beneficial to the climate, to abolish fossil fuel subsidies and transfer the money**

[76] DG Climate Action. (2015).

[77] Fischer et al. (2019).

[78] Feng et al (2010).

[79] Schaffitzel et al (2020).

[80] Feng et al (2018).

**to the affected consumers as cash. Carbon pricing has similar distributional consequences and can be mitigated with cash transfers to lower and middle-income consumers.[81]**

The EGD proposes to abolish fossil fuel subsidies. The EU spent approximately € 260 billion in 2015 on fossil fuel subsidies[82] the abolition is estimated to be worth € 100 billion in fiscal savings.[83] **It is recommended that member states abolish these subsidies and use them for cash transfers to lower and middle-income consumers instead, in order to mitigate the effects of carbon pricing.**

Further, the ETS quantity targets will need to be updated to reflect higher levels of emissions reductions consistent with a -65% goal by 2030.

## 3.4 Energy

The current set of energy policies were presented by the Commission in its vision for an *Energy Union*[84] (2015) with a substantial amount of legislation passed in the *Clean Energy for All Europeans*[85](2019) package. Together with the EGD, Europe's energy policy rests on three key strategies: 1) an integrated energy market, 2) the ETS which internalises the cost of carbon and thus incentivises investment in renewable energy and 3) the national energy and climate plans (NECP) which are 10 year policy plans member states are required to submit and are focussed on the sectors not covered by the ETS.

The core idea in the EU's energy strategy and the EGD is that a competitive market for energy, will eventually lead to cheap and carbon free energy for European consumers. The efforts to integrate the grid and energy markets across member states should ensure competition and the ETS will ensure that the costs of GHG emissions from fossil-based energy sources are fully internalised.

Linking up national grids, which is the physical requirement for market integration, is necessary for a carbon neutral electricity system. It improves the stability of the network and reduces the need for grid storage, and associated costs, as weather conditions influencing renewable energy supplies are aggregated across a wider geographical area.[86] However, relying on the market mechanism to balance energy supply and demand while ensuring sufficient investment in renewable energy increases the risk of price volatility and long-term under-capacity. Boom and bust investment cycles might emerge as price fluctuations induce firms to invest and subsequently exit the market.[87] Furthermore, there is no internal mechanism ensuring targets such as future energy supply or renewable energy shares are met. The latter can be addressed by setting explicit goals for renewable energy production capacities as part of the Sustainable Europe Investment Plan and monitor the progress of reaching them. Many EU member states currently employ different policy instruments, capacity markets for example, to ensure the security of their energy supply and investments necessary to ensure this.[88]

[81] Vogt-Schilb, A. and Hallegatte, S. (2017).
[82] Coady et al. (2019).
[83] Storm, S. (2020).
[84] COM (2015) 080 final.
[85] European Commission (2019) Clean Energy for All Europeans.
[86] Grams et al (2017); Child et al (2018)
[87] Fabra, N. (2018); Bublitz et al (2019); Höschle et al (2013)
[88] Söder et al. (2020).

*Table 4: Non-R&D capital formation in the electricity sector.*

| | 2015 | 2016 | 2017 | average |
|---|---|---|---|---|
| gross value of non-R&D capital stock | 1,649 | 1,671 | 1,725 | 1,682 |
| gross non-R&D capital formation | 67 | 67 | 66 | 67 |
| gross non-R&D capital formation relative to stock | 4.1% | 4.0% | 3.8% | 4.0% |
| additional 5% stock replacement | 82 | 84 | 86 | 84 |
| additional 10% stock replacement | 165 | 167 | 173 | 168 |

Electricity sector defined as section D of NACE Rev. 2. All figures in billion Euros, current prices. Data: Eurostat (nama_10_nfa_st and nama_10_nfa_fl). Based on data for 18 EU member countries. EU 27 excluding Bulgaria, Croatia, Cyprus, Denmark, Ireland, Latvia, Malta, Spain and Sweden due to data availability.

This section provides estimates of the investment requirements in the energy sector. Table 4 displays the non-R&D capital stock and annual gross investment in the electricity sector (NACE Rev. 2 section D, i.e. operation of utilities that generate and distribute power and gas). Currently the existing capital stock is replaced and expanded at a rate of 4% a year, which amounts to € 67 billion. Replacing an additional 5% would amount to € 84 billion annually and an additional 10% to € 168 billion. This compares with the Commission's estimate of an investment gap of € 112 billion annually for power plants and grids. This comparison shows that for the power sector the investment rates implied by the Commission estimates are in line with a significant increase in current capital stock replacement rates.

## 3.5 Buildings

EU policy has adopted a principle of "efficiency first" towards the buildings sector in order to reduce final energy consumption by buildings.[89] Major legislative proposals were passed in 2009 and 2010 with the Energy performance for buildings Directive and the framework for the setting of eco-design requirements for energy-related products.[90] The legislation has since been amended under the *Clean Energy for All Europeans*[91](2019) package.

The purpose of the earlier legislation required member states to adopt long term renovation strategies for the national building stock and establish minimum energy performance requirements from renovations and new builds.[92] Provisions were passed to 'mobilise' investment towards the renovation of national building stocks in the energy efficiency directive.[93]

Unfortunately, an EU report[94] assessing renovation rates of the EU over the period 2012-2016 concludes that the current weighted energy renovation rate of 1% is far too low to achieve a

[89] Commission Recommendation(EU) 2019/786.

[90] Directive 2010/31/EU

[91] European Commission (2019) Clean Energy for All Europeans.

[92] Directive 2010/31/EU

[93] Directive 2012/27/EU

[94] European Commission, (2019). Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. European Commission: Brussels. doi: 10.2833/14675

decarbonised building stock by 2050. The report concludes that the rate of renovations would need to triple in order to achieve this target:

> "If this [weighted energy renovation] rate of 1% persists, the building sector will clearly and significantly fail to deliver its share in the overall need for primary energy reduction and consequently a reduction in greenhouse gas emissions. […] A tripling to 3% primary energy savings per year would need to be achieved […]." EC (2019, p. 79)

Furthermore:

> "If for example the current weighted energy renovation rate would triple from 1% to 3%, a corresponding tripling of needed investments in energy renovation to about [735][95] billion Euros could be expected. Evidently, this needs new and different funding schemes and financing instruments."

This assessment is in stark contrast with the EGD's estimate of required additional investments of €260 billion per year across all sectors and only € 27 billion for residential buildings (which represents ¾ of the building stock). The fact that the EGD is likely to substantially underestimate the investment needs in order to bring Europe's building stock in line with the necessary climate targets is supported by the calculations in Table 5. When comparing the actual building investment flows into residential and commercial buildings with the target of replacing 3%[96] of the existing stock annually, an average annual buildings investment gap of € 380 billion emerges. While this is not a precise estimate because it does not distinguish between renovations and outright replacement, the magnitudes involved are much more in line with sector specific studies such as EC (2010) rather than the Commission's model-based estimates which form the basis of the EGD.

*Table 5: EU investment gap estimate for buildings based on gross fixed capital investment data.*

| | 2015 | 2016 | 2017 | average |
|---|---|---|---|---|
| gross value of stock of buildings and structures | 48,915 | 50,109 | 52,021 | 50,349 |
| gross capital formation of buildings and structures | 1,084 | 1,116 | 1,191 | 1,130 |
| cost of replacing 3% of total gross stock | 1,467 | 1,503 | 1,561 | 1,510 |
| buildings investment gap estimate | 384 | 388 | 369 | 380 |

All figures in billion Euros, current prices. Investment and capital stock figures at current replacement costs. Buildings are defined as residential buildings plus commercial buildings. All sectors of the economy except energy (NACE D). Data source: Eurostat (nama_10_nfa_st and nama_10_nfa_fl) for 23 EU countries. EU 27 minus Bulgaria, Croatia, Malta and Sweden due to data availability.

Overall, the EGD proposal is not ambitious enough in regard to renovations.[97] The estimated investment gap for energy efficiency renovations is a magnitude lower than those from sector-specific

[95] The figure in the report is €800 billion for the EU 28. Using the figures in the report, we have adjusted it for the EU 27 and estimated it to be €735 billion per year.

[96] This is a rough comparison since EC (2019) uses energy weighted renovation rates.

[97] A recent positive development is that as part of the Next Generation EU plan, the Commission announced a 3% renovation rate target, although at cost of just € 350 billion annually.

calculations. Further, the Green Deal proposes to regulate buildings under the ETS mechanism. This could have potentially disastrous consequences for energy poverty and affordability of housing. Finally, implementation of renovation strategies depends largely on the member states themselves. A great deal depends on the Integrated National Energy and Climate Plans which not all member states have submitted.

## 3.6 Transport

The EGD aims to reduce transport emissions by 90% by 2050[98]. The remaining emissions comprise those activities which are difficult to fully decarbonise, most importantly aviation. While the EGD claims this goal to be in line with the 2050 objective of carbon neutrality, the remaining emissions need to be offset by negative emissions. As pointed out above, the feasibility of large-scale negative emissions is highly uncertain.[99]

The EGD seeks to achieve its emission reduction target by moving freight transport from the road to rail and waterways. For that purpose, the European Commission is going to consider whether the ETS should be extended to road transport. In a similar vein the EGD hints towards tighter emission standards for trucks and to reconsider new efforts towards the introduction of effective road pricing.

With respect to private transport the EGD encourages the development of shared mobility services in order to increase the efficiency of (urban) transport. In addition, the EGD states the intention to "revise by June 2021 the legislation on CO2 emission performance standards for cars and vans"[100] with the goal of potentially tightening them from 2025 onwards.

The EGD also pledges to support alternative fuels and their infrastructure and to review the alternative fuels directive.[101] Alternative fuels include electricity, liquified and compressed natural gas and hydrogen. The limited size of the European budget prevents effective direct planning and provision at the European level. The latter problem emphasizes the need to transfer the decision mechanism for these policy areas to the European level together with a substantial increase in the European budget and planning of strategically important cross-country transport infrastructure.

While these measures about land transport emissions represent steps in the right direction and most importantly steps towards fully internalising the costs of carbon emissions, it remains questionable whether they are enough. Especially the non-committal language poses a cause for concern, since road transport emissions grew by 23% between 1990 and 2017 while overall EU emissions fell by 25% over the same time period.[102]

With respect to the aviation sector the EGD relies on the Single European Sky initiative to reduce emissions together with a reduction of free ETS certifications for the aviation industry and ending fossil fuel subsidies like the VAT exemption of aviation fuels. Ultimately the EGD does not include an ambitious strategy to substantially reduce aviation emissions and passenger numbers.

[98] European Commission (2019a)
[99] See Larkin et al. (2018) and Anderson and Peters (2016).
[100] European Commission (2019a)
[101] Directive 2014/94/EU on the deployment of alternative fuels infrastructure.
[102] Calculated based on Eurostat emission data (env_air_gge) on GHG emissions in CO2 equivalents.

## 3.7 Industry

The Commission communicated its *New Industrial Strategy for Europe* in March 2020. The industrial strategy has a number of proposals with specific relevance to carbon neutrality. A priority is the development of new industrial processes in sectors that are currently carbon and energy intensive. This includes support and subsidies for the research and development required. The EGD does not provide estimates of the research and development investments required to decarbonise industrial processes. A comparison with given EU targets for R&D spending can provide a valuable yardstick. The Europe 2020 strategy[103], announced in 2010, included a goal to spend 3% of GDP on research and development as part of the EU's long-term economic strategy. Table 6 compares actual R&D spending with that 3% target as well as a 4% target. The latter can be interpreted as a rough way of taking the R&D requirements of a more ambitious climate transition into account. Compared to 2010 when the 3% target was announced, less time is left and therefore most likely more effort is needed to deliver the required results. Reaching the 4% target would require additional annual investments of € 201 billion. This compares to the Commission estimates which are purely based on known technologies and thus excludes R&D expenditures.[104]

*Table 6: Research & Development (R&D) investment in the EU.*

| | 2015 | 2016 | 2017 | average |
|---|---|---|---|---|
| EU gross R&D investment in % of GDP | 2.4% | 2.4% | 2.3% | 2.4% |
| EU gross R&D investment | 294 | 306 | 305 | 302 |
| 3% R&D investment gap | 71 | 69 | 85 | 75 |
| 4% R&D investment gap | 193 | 194 | 215 | 201 |

Data: Eurostat (nama_10_nfa_fl and nama_10_gdp). Based on EU 27 excluding Croatia due to data availability. All figures in billion Euros, current prices.

In addition to developing carbon neutral industrial processes, industries must also implement these technologies. It is impossible to estimate the costs of implementing technologies which are not yet in existence. A rough idea can be obtained from data on the core capital stock and investment flows in the manufacturing and mining sector. In order to be consistent with the remaining calculations core capital stock and investment represents all capital expenditures minus those on buildings (dwellings and structures) and minus R&D expenditures. This adjustment avoids double counting. Table 7 shows that the EU manufacturing sector has invested on average € 210 billion annually in its core capital stock (excluding buildings and R&D expenditures). Implementing new technologies and processes at a rate of 3% of the current capital stock would cost € 80 billion annually. This compares with Commission estimates of an investment gap of € 17 billion annually. The latter figure would amount to the replacement of less than 1% of the existing capital stock. Given that many industrial processes need to change fundamentally, € 17 billion seems insufficient.

[103] EC (2010).

[104] Capros et al. (2019)

*Table 7: Core capital formation in manufacturing and mining sector (NACE B and C).*

| | 2015 | 2016 | 2017 | average |
|---|---|---|---|---|
| gross value of core capital stock | 2,613 | 2,641 | 2,713 | 2,656 |
| gross core capital formation | 202 | 208 | 221 | 210 |
| gross core capital formation relative to stock | 7.7% | 7.9% | 8.2% | 7.9% |
| additional 3% stock replacement | 78 | 79 | 81 | 80 |

Values in billion Euros, current prices. Core capital formation is defined as all capital expenditures minus those on buildings (dwellings and structures) and minus R&D expenditures. Data source: Eurostat (nama_10_nfa_st and nama_10_nfa_fl). Based on data for 18 EU member countries. EU 27 excluding Bulgaria, Croatia, Cyprus, Denmark, Ireland, Latvia, Malta, Spain and Sweden due to data availability.

The transition towards carbon neutrality will affect the competitiveness of the involved industries and so the plan includes a 'Carbon Border Adjustment Mechanism' to protect domestic EU industries that have higher environmental standards from being undercut by goods producers in regions where environmental and climate standards are less ambitious or poorly enforced.

In March 2020, The Commission announced the **Circular Economy** action plan, as a pillar of the Green Deal. A combination of measures aimed at reducing product material use across the entire product lifecycle are proposed: sustainable product design, changes to consumer habits, and industrial system process change. The plan comprises a number of measures for individual economic sub-sectors. The sectoral plans are not yet available, but the Circular Economy action plan does provide some detail. Some examples of the initiatives are:

- The development of common data-sharing frameworks for goods of varying degrees of durability and the use of digital log-books to record the data and disseminate the information. These strategies aim to improve transparency and incentivise the repair and reuse of durable goods.
- Measures that are aimed at improving the durability of the goods themselves focus on the goods producers themselves.
- Other measures are designed to promote or ban behaviours using regulations and standards. The measures targeting consumption patterns aim to improve the product related information available to consumers such as: the availability of repair services or spare parts and repair manuals. It is assumed that the availability of more accurate product information will induce consumers to make more sustainable product choices.

The industrial policy and circular economy action plan aim to reduce the overall materials consumption in the product life cycle. The introduction of a carbon border tax is a positive proposal and is necessary to develop and market green technologies in the presence of differing international standards. Increasing subsidies for research and development into new technologies designed to displace less efficient, carbon intense processes is a welcome proposal from the Commission. However, it is difficult to assess the climate ambition of these measures. The extent to which consumer behaviour will be influenced by improved informational access is difficult to predict. Moreover, the Commission's proposals suggest influencing the incentives of firms or consumers through an informational framework. While it is possible for this to work, it is particularly difficult to predict the likelihood of it succeeding. Sector-specific strategies are not announced yet. **Achieving fast and effective decarbonisation of the industrial sector will require sector specific energy efficiency**

**and industrial process regulation, a carbon border adjustment mechanism and a detailed circular economy package.**

# 4 Conclusions and Policy Recommendations

Overall, the EGD embodies the EU's response to the climate crisis and as such represents a necessary and welcome step in the right direction. It includes a net zero target for the year 2050 and represents an increase in the block's ambition towards 2030: The EGD sets out a GHG reduction target of -50% to -55% by 2030 compared to 1990 levels. Moreover, it is a policy framework that encompasses a broad range of sectors and policy initiatives: biodiversity, farm to fork, sustainable agriculture, clean energy, sustainable industry, building and renovating and sustainable mobility. The EGD recognises the scale of the problem and embraces it as a challenge that requires major action. It is positive to see too that emphasis is given to cohesion policies which means the regions have the possibility to become significant actors in designing the transformation most suitable for them. In view of the far-reaching impacts of the proposed policies, it also recognises the necessity for an inclusive and just transition since not all member states will be affected equally.

Despite the broad reach and the priority attached to the EDG, this study outlines some aspects for which the current proposal might be unable to drive Europe towards attaining the objectives of the Paris agreement in time. For the EU to contribute its fair share in the global effort to limit global warming to 1.5°C, we recommend to boost the EGD's scale and ambition along four dimensions: **i) the overall GHG reduction target, ii) refraining from large-scale negative emission planning**[105]**, iii) an expanded investment plan and iv) a focus on between and within country inequalities.**

The following policy recommendations set out a framework which would allow the EU to press forward with a bold and ambitious plan to reach the Paris goals. In doing so it would intensify the pressure on other countries and regions to act themselves, while securing first mover advantages in the development and deployment of new technologies. The first four recommendations provide a general sketch of that framework. The remaining six recommendations are specific proposals how these ambitious targets can be met. All ten policy recommendations rest on two general principles. The first is that climate change requires a broad policy approach which makes use of all tools available. The second is that the EGD is an evolving initiative which is updated based on target achievement and new scientific evidence, both of which need to be monitored.

## #1: Decarbonise the energy system by 2035-2040.

While the EGD has made substantial improvements on the EU's GHG targets, recent scientific evidence concludes that in order to stay well below 2°C the following reductions are necessary: a 65% reduction of GHG emissions by 2030, requiring all EU electricity production to be carbon-free by 2030 (note that electricity production is not equal to energy production). The EU's Paris-compliant energy only carbon budget is estimated to lie between 21 and 27 GtCO2 (from 2020 onwards), allowing 9 years at most, at current emissions.[106] Staying within this budget would equate to annual emission reduction rates

[105] Implicitly via the underlying carbon budgets and explicitly when modelling and planning the zero-carbon transition.

[106] Anderson, K. and Stoddard, I. (2020). A Paris-compliant energy-only carbon budget for the EU27. http://kevinanderson.info and Greenpeace (2019). A European Climate Law.

of 10% by 2025 and they would need to increase to 20% by 2030. Energy production (across all sectors, see Table 1) would need to be zero-carbon by 2035-2040. Thus, while the EGD represents an increase in the EU's climate ambitions, taking the Paris Agreement seriously requires further action.

## #2: Refrain from relying on large scale negative emission scenarios.

In their current 1.5°C scenarios the European Commission relies heavily on large-scale removal of $CO_2$ from 2050 onwards (see section 3). The feasibility of the required technologies is unclear while in addition a negative emission focussed approach to climate change risks crossing of irreversible tipping points (hot house earth, see section 2.3). It thus represents a high-risk strategy.[107] Therefore, the EU should reduce its reliance on their deployment as a working assumption in integrated assessment modelling and carbon budget calculations. In addition, the practice of offsetting emissions at an individual level should not be relied on as a feasible means of reducing carbon footprints. The reason being that the negative impact of an individual emission is certain and lasts for centuries, if not longer, while the offsetting activity (e.g. a tree being planted) has a much less certain outcome that depends on a lifecycle of possibly decades.[108]

## #3: Scale up the investment target to match total required expenditures.

The cornerstone of the EGD is the Sustainable Europe Investment Plan which aims at mobilising investments of € 1 trillion over the next decade to achieve the outlined targets. Setting up such an investment plan is crucial and an important first step.

The EGD estimates total investment requirements to be € 1.5 trillion annually and thus € 15 trillion over the next decade.[109] Furthermore around € 1.2 trillion of annual expenditures or € 12 trillion over the next decade would occur under current policies which leaves an investment gap of € 290 billion annually or close to € 3 trillion over the next decade.

Given that energy efficiency renovations of buildings alone are estimated to require about € 7.5 trillion over the next decade, with current policies only supporting € 2.5 trillion, leaving an investment gap of € 5 trillion in the buildings sector alone, the scale of the investment plan should be substantially expanded. While a substantial part of these investments will be required to come from the private sector as well as member states, a strategic long-term plan should encompass all sectors and levels of government in order to facilitate adequate monitoring (also see policy recommendation #6). Our calculations suggest that the total required volume of investment expenditures in the EU27 economy over the next decade is likely to be in the range of € 16 trillion with an associated investment gap of close to € 9 trillion, excluding the transport sector. A European investment plan should enable the monitoring of these investments.

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https://storage.googleapis.com/planet4-eu-unit-stateless/2019/11/20191008-GP-WWF-EU-climate-law-demands.pdf

107 Anderson, K. and Peters, G. (2016) The trouble with negative emissions. Science 354 (6309), 182-183. doi: 10.1126/science.aah4567

108 Anderson, K. (2012) The inconvenient truth of carbon offsets. Nature 484 (7). doi:10.1038/484007a

109 EC (2018b, page 202 Table 10) and see row (9) in Table A1 in the Appendix.

## #4: Use individual transfer payments and training grants to address the regressive nature of rising energy costs.

The EGD pays special attention to regional inequalities when it comes to the burden of the transition. Given that the EGD is an initiative at the European level, the focus on inequalities between countries is expected. However, in order to maintain political support for an ambitious climate action plan, within country equity considerations need to be at the top of the policy agenda at the national as well as the European level. The explicit attention to within country inequalities is required due to the highly regressive nature of increasing carbon prices. As such, the transition will have adverse distributional consequences for members of the society with lower incomes.

Therefore, we believe that the EGD just transition policies will be more successful if they are based on a combination of retraining, reskilling and lump-sum transfers for households that are most susceptible to carbon price increases. These measures can be funded through a combination of carbon taxation, former fossil fuel subsidies and progressive income and wealth taxation (see policy recommendation #5). Furthermore, a bold transition will create new jobs but will also remove jobs in high carbon industries (e.g. coal mining), while this is a necessary part of the transition, monetary compensation should be paired with re-training and local and regional development plans as well as incentives to develop new jobs in depressed or less well-off regions.

## #5: Increase fiscal room via new revenue sources and a reformed European fiscal framework

A more ambitious investment plan (see policy recommendations #3 and #6) and the focus on a just and fair transition between and within member states, requires more fiscal flexibility compared to the EU's current framework. This involves firstly using the full space available in the current framework in order to buy time for a more comprehensive overhaul of the fiscal rulebook. The investment clause which is part of the Stability and Growth Pact allows member states to incur budget deficits (i.e. deviate from the medium-term objective) in special circumstances such as severe recessions, when structural reforms are implemented or other "relevant factors" emerge. **Given the structural character of climate change and the unprecedented importance of the task ahead it would be reasonable to call on these exemptions in order to fund public green investments.[110]** In addition, using more realistic investment multipliers in the calculation and forecast of structural balances would provide further fiscal space within the current framework.[111] Over the longer term "a golden rule for public investment" should be incorporated into the block's fiscal framework. Such a rule would exempt public investment from the current deficit calculations and adjustment protocols. The experience of the aftermath of the Euro crisis has shown that the current fiscal framework works procyclicality and forces countries to slash public investment expenditures. Cutting or underfunding public investment would seriously reduce the chances of meeting the Paris goals.

The recession due to the Covid-19 outbreak is putting unprecedented strain on public finances and thus may risk deprioritising climate change related expenditures. While green public investment can support the recovery, the short-term expenses of income support programmes will not deliver a green dividend. **A European wealth tax should be used to help fund the climate transition and balance its negative distributional consequences.** Such a tax can consist of national taxes in a harmonised

[110] Claeys (2019).
[111] Truger (2015).

structure to fit into the EU's current framework. Such new revenue sources can help to keep public finances sustainable and address the fact that GHG emissions are highly concentrated at the top of the income and wealth distribution[112] and that effective carbon pricing is regressive. Furthermore, harmonization at the European level is attractive because it would maximize compliance. Choosing high exemption thresholds combined with no exemptions of specific assets would simplify tax administration while still generating substantial revenues.[113]

Other ways of raising public funds for the climate transition include increasing income tax progressivity and a tax on air plane tickets which represent the true cost of zero carbon fuels. Both measures can be justified given the concentration of emissions at the top of the income distribution.[114] In addition, revising the ETS has the potential to generate substantial revenues at least in the transition towards a zero-carbon economy (see policy recommendation #8). Phasing out fossil fuel subsidies and introducing other taxes which yield co-benefits in the attempt to make the European economy more sustainable in general, such as a plastic tax, could be used as well. The regressive nature of these latter two measures needs to be taken into account by complementing it with other forms of progressive taxation.

## #6: Upgrade Sustainable Europe Investment Plan into a comprehensive climate master plan.

Delivering on the more ambitious GHG emission reduction targets outlined in policy recommendation #1 requires the use of all available policy tools. The EGD is a promising start in this context as it relies on a broad set of instruments. Given the limited time available, the EGD should go a step further and upgrade the Sustainable Europe Investment Plan into a comprehensive climate master plan. Such a master plan should encompass the EU's investment needs across sectors and match it with existing proposals to deliver these investments based on member states' and European level initiatives. The national climate action plans can provide the basis for such a master plan which covers the European as well as member state level. It would lay out not only investment requirements and targets but also timelines for when to reach these targets. Such a comprehensive plan would have two key benefits: Firstly, it would enable real-time monitoring of the progress made and timely interventions if climate targets are not met. Secondly, it would provide the private sector with clear long-term signals it needs in order to plan investments and expand capacity. The sectors and activities covered by such a plan should include renewable energy capacity, building renovations, transport infrastructure, research and development of key technologies, a timeline for banning combustion engines, a timeline for phasing out coal usage and restrictions of investment in fossil fuel infrastructure to the bare minimum required for the transition period.

## #7: Implement and expand a carbon border adjustment mechanism.

The EGD's increased climate ambition might leave European firms ill placed to compete with international rivals which do not have to adhere to the same standards. The current proposals include

[112] Chancel and Piketty (2015).

[113] A tax simulation for Austria yielded revenues of close to 2% of GDP based on a progressive model with an exemption threshold of € 2 million and a maximum tax rate of 4% above net wealth holdings of € 100 million.

[114] Chancel and Piketty (2015).

a carbon border adjustment tax in order to level the playing field. This is a crucial instrument which should be expanded to also include social standards[115].

## #8: Align the ETS with general emission targets and establish a price floor and inflation target.

The ETS is an essential tool to establish prices of goods and services which reflect the true cost of their embodied emissions. Currently the ETS does not provide strong incentives for firms and consumers to change behaviour because carbon prices are low. This problem should be addressed by reducing free permit and by aligning the annual permit reduction rate with the increased level of ambition (see policy recommendation #1). In addition, the Commission should implement a price floor in the ETS in order to provide crucial long-term signals for businesses and consumers. In addition, the Commission should apply a carbon price inflation target by periodically increasing this price floor in order to ensure increasing incentives to shift out of carbon activities and technologies.

## #9: Focus on providing stable finance for companies and refrain from encouraging further household sector borrowing.

The EGD puts great emphasis on private sector investment and focuses on mobilising private finance in order to bring financing costs down and thus stimulate investment in green projects. However, if private households strongly respond to lower financing costs and take on debt in order to carry out energy efficiency renovations of their residence or purchase electric vehicles, an inherent financial fragility risk remains. Household sector liabilities in the Eurozone stood at 93% in 2018. Encouraging further household financing by creating structured financial instruments under a “green” label against this background is ill advised and has the potential to negatively impact financial stability. Similar concerns remain for lowering capital requirements for green bonds. The focus should be instead on providing patient long-term financing for companies in key sectors[116].

## #10: Work with the European Research Council to establish a group of Europe-specific climate models published in an open source format.

Designing an effective policy response to the climate challenge is an inherently complex and challenging task. The main reason is that in order to understand climate change it is necessary to understand the interactions of two systems which are highly complex on their own: the ecological system and the global and European economies. Stylised models are a necessary tool for studying the dynamics as well as the links between different elements of these two systems. Currently the EGD relies heavily on a single set of models (PRIMES). In order to reduce model uncertainty and enable greater transparency, the EU should follow the example of climate science and aim to develop several Europe specific integrated assessment models, based on different economic paradigms. These should be published in an open source format giving access to the scientific community and the public alike. The European Research Council which is funded through the EU budget would be the ideal tool.

[115] See for example Kapeller et al. (2016)

[116] See Mazzucato (2011) for a discussion of patient finance.

# 5 Appendix: Sectoral investment cost breakdown

*Table 8: Investment requirements and investment gap estimates in billion Euros.*

| Source | Sector | | current policies | 1.5°C scenario estimate | investment gap |
|---|---|---|---|---|---|
| **Official EGD Estimates** | | | | | |
| EC (2018b) Table 10 | power grid | (1) | 71 | 103 | 32 |
| | power plants | (2) | 40 | 120 | 80 |
| | boilers | (3) | 1.3 | 0.8 | -0.5 |
| | new carries | (4) | 0.3 | 22 | 22 |
| | industry | (5) | 11 | 28 | 17 |
| | residential buildings | (6) | 199 | 226 | 27 |
| | tertiary | (7) | 54 | 76 | 22 |
| | transport | (8) | 813 | 904 | 91 |
| | **total (sum of 1-8)** | **(9)** | **1,190** | **1,480** | **290** |
| | **total ex transport (sum of 1-7)** | **(10)** | **377** | **576** | **199** |
| **Author's calculations based on existing literature and national accounts data** | | | | | |
| EC (2019) | residential and commercial build. | (11) | 245 | 735 | 490 |
| National Accounts | residential and commercial build. | (12) | 1,130 | 1,510 | 380 |
| National Accounts | electricity | (13) | 67 | 151 | 84 |
| National Accounts | industry | (14) | 210 | 290 | 80 |
| National Accounts | R&D | (15) | 302 | 503 | 201 |
| | **total (12+13+14+15)** | **(16)** | **1,709** | **2,454** | **745** |
| | **total (11+13+14+15)** | **(17)** | **824** | **1,679** | **855** |

The national account estimates are introduced in section 3.3 for energy, in section 3.4 for residential and commercial buildings and in section 3.5 for R&D and industry. For EC (2018b) the 1.5TECH scenario is used.

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