

Chapter 4 Tackling climate change: Investment trends and policy challenges EUROPEAN INVESTMENT BANK INVESTMENT REPORT 2020/2021

Building a smart and green Europe in the COVID-19 era

Part II Investing in the transition to a green and smart economy

Chapter 4 Tackling climate change: Investment trends and policy challenges



Investment report 2020/2021: Building a smart and green Europe in the COVID-19 era

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About the Report

The EIB annual report on Investment and Investment Finance is a product of the EIB Economics Department, providing a comprehensive overview of the developments and drivers of investment and its finance in the European Union. It combines an analysis and understanding of key market trends and developments with a more in-depth thematic focus, which this year is devoted to European progress towards a smart and green future in a post-COVID-19 world. The report draws extensively on the results of the annual EIB Investment Survey (EIBIS) and the EIB Municipality Survey. It complements internal EIB analysis with contributions from leading experts in the field.

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The mission of the EIB Economics Department is to provide economic analyses and studies to support the Bank in its operations and in the definition of its positioning, strategy and policy. The Department, a team of 40 economists, is headed by Debora Revoltella, Director of Economics.

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Chapter 4

Tackling climate change: Investment trends and policy challenges

Despite the growing rates of investment in climate change in Europe, a greater share of Gross Domestic Product (GDP) must be spent to achieve carbon neutrality and make the European Union's infrastructure climate-resilient. Investment in climate change mitigation grew 2.7% in 2019, with increases in all areas except energy efficiency. Renewable energy investment increased 7.8% as a result of project commitments made in previous years, but this rise also masked a slowdown in new commitments. Estimates for investment in energy efficiency indicate flat investment over the last five years with a decline in 2019 offsetting increases in preceding years. The European Union's investment in adaptation remains very low compared to mitigation, despite growing from 2015 to 2019.

The pandemic will start to stifle investment soon, unless governments put green-growth stimulus packages in place. Experience of past economic slowdowns indicates that large projects like utilities already in the pipeline tend to be relatively unaffected in the short term. Energy efficiency and renewable energy installations in the construction sector will be hit much harder, however, as material deliveries are delayed, adjustments are made to protect employee health and safety, costs rise and quarantines and travel bans are put in place. In the first half of 2020, investment commitments in clean energy projects, a real-time indicator of the project pipeline, were down by 50% compared with the same period in 2019. This decline is expected to be reflected in the investments that will be made in the coming year.

For Europe to harness the full potential of decarbonised energy systems, investment is needed in more expensive and less mature clean energy technologies, such as hydrogen and carbon capture and storage. This investment suggests that the marginal abatement cost of greenhouse gas emissions will increase in the future. In parallel, given that fighting climate change requires a global collective effort, Europe should use its development and financing arms to boost the green transition in partner countries where great climate opportunities exist.

Staying on track with the Paris Agreement requires a coordinated effort from the European Union. The European Union's new ambitious target for emission reductions by 2030 means it will have to step up climate investments. The National Energy and Climate Plans, part of the Governance of the Energy Union and Climate Action, provide the strategic framework for Member States to align their policies with the European Union. Private and public-sector efforts must be calibrated more closely. Municipalities can contribute to the climate transition by shaping and implementing policy measures locally. At the same time, municipalities are also strengthening the public's awareness and ownership of the climate transition.

Introduction

The opening of this chapter aims to shed more light on clean energy investment flows and the corresponding investment trends in mitigation. Building on the EU taxonomy for sustainable finance, it quantifies investment in climate change, covering the United States, China, the European Union and its Member States. The analysis adopts a common methodology to facilitate the comparison across regions, countries and sectors by dividing investment activities into three categories: those that are already low-carbon, transition activities and those that facilitate low-carbon performance.

The chapter then turns to investment in climate adaptation. At the microeconomic level, these investments are widespread, influencing decisions regarding design and location in the public and private sectors. Estimates on climate adaptation investment are, however, not available at the macroeconomic level. Still, two important flows are tracked, namely public investments in Europe under EU programmes and flows of development finance from Organisation for Economic Co-operation and Development (OECD) to non-OECD countries for climate adaptation.

Finally, the chapter discusses investment challenges and opportunities for the European Union as it aligns itself and stays on track with the Paris Agreement, along with the role played by the private and public sectors in the transition towards a carbon-neutral economy. This discussion requires a clear understanding of the European Union, as well as the different national and local priorities. The data collected from the National Energy and Climate Plans, which outline individual countries' climate and energy goals, are analysed. The role of municipalities, which are the third layer in the policy dimension, is also discussed.

European energy and climate policy framework

Climate policy in the European Union has been undergoing a fundamental transformation since 2000. Europe has implemented a unique climate policy framework, with ambitious greenhouse gas emission targets set for 2020, 2030 and 2050. Its ultimate goal is to become the first climate-neutral continent in the world, and the current decade (2020-2030) is crucial to tackling climate change and ensuring that a heavier burden is not left behind for future generations. This involves many challenges, including the energy transformation of all economic sectors, massive investments for upgrading the European Union's capital stock, as well as the introduction and revision of governance structures and supporting instruments. How governments address these interlinked challenges will have a profound impact on EU members' efforts to reduce greenhouse gases, while also playing a unique role in strengthening the European Union's position as a global climate leader.

The Paris Agreement frames the European Union's current policy response to the climate crisis. The agreement sets an overall goal of mitigating climate risks and limiting global warming to "well below" 2°C vs. pre-industrial levels. Within this framework, and under article four of the agreement in particular, global greenhouse gas emissions should peak as soon as possible and then drop to zero in the second half of this century by balancing emissions with removals by sinks, such as forests, oceans or soil. Signatories of the agreement are obliged to submit National Determined Contribution plans (NDCs) every five years, presenting the progress made in comparison to the previous plan. In line with the agreement's goals and monitoring process, the European Commission issued in 2018 a strategy for achieving a climate-neutral economy by 2050, providing cost-efficient trajectories. In 2019, the European Union set the "energy efficiency first" principle¹ as part of the revision of the Energy Efficiency Directive.

¹ To promote climate objectives, a large number of legislative actions were approved at EU level in the same period, including the Emissions Trading System, renewable energy sources, highly energy-efficient buildings and products, standards for car emissions and emissions from fluorinated gases.

Box A Targets under the 2030 Climate and Energy Framework

According to the existing (2019) framework, the European Union has set the following three headline targets for 2030:

- At least a 40% cut in greenhouse gas emissions (from 1990 levels)
- · At least a 32% share for renewable energy (of final energy consumption)
- At least a 32.5% improvement in energy efficiency (compared to the baseline 2007 scenario)

The 40% greenhouse gas target will be achieved collectively by the EU Emissions Trading System sectors (energy suppliers and energy-intensive industries), the Effort Sharing Regulation sectors (transport, agriculture and buildings) and land use, land use change and forestry regulation.

All three goals are part of the EU climate legislation under review, and the latest proposal in September 2020 focuses on greenhouse gas emissions and suggests increasing the reduction from 40% to at least 55% in 2030. The European Commission will come forward with proposals for the other two goals by June 2021.

The European Climate Law, the Governance of the Energy Union and Climate Action and the roadmap for the European Green Deal provide the guidelines for EU and Member States' efforts to meet the **Paris goals.** Each of the three policies establishes distinct processes:

- The European Climate Law makes the European Union's goal to become climate-neutral by 2050 legally binding and establishes a framework for achieving this objective.
- The governance regulation sets a five-year cycle aligned with the review cycle of the Paris Agreement –
 for assessing progress towards the objectives and the alignment of national and EU policies. Member
 States will be asked to take corrective action when their trajectory strays from the overall EU climate
 commitments.
- The European Green Deal roadmap outlines the key policies and measures needed to transform the European Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy. That economy will reduce its net emissions of greenhouse gases to zero by 2050, and economic growth will be decoupled from limited resources.

An integral part of the European Green Deal is the Green Deal Investment Plan, also known as the Sustainable Europe Investment Plan. This plan aims to finance a sustainable transition while supporting the regions and communities most exposed to its impact. In brief, it combines legislative and non-legislative initiatives and has three main objectives. First, mobilise funding of at least EUR 1 trillion from the EU budget and other public and private sources over the next decade. Second, put sustainability at the heart of investment decisions across all sectors. Third, provide support to public administrations and project promoters for creating a robust pipeline of sustainable projects. Around half of the EUR 1 trillion total is supposed to come directly from the EU budget, while other public (InvestEU, the Just Transition Fund) and private sources are expected to provide the remainder of the funds, mainly through leveraging.

The EIB is a key player in mobilising additional funding for the sustainable transition. In 2019, the EIB launched an ambitious new climate strategy that aims to support EUR 1 trillion of climate action and environmental sustainability investment over the next decade. The EIB plans to achieve that goal by dedicating at least 50% of its lending to climate by 2025, by calling a halt to its financing of fossil fuel projects by 2021 and by aligning all financing activities with the goals of the Paris Agreement from

the end of 2020. The EIB, under the European Green Deal, is expected to trigger investment of around EUR 250 billion (one-quarter of the total investment plan) under EU mandates. In November 2020, the EIB Group published its Climate Bank Roadmap, which sets up the path to achieve those commitments.²

In September 2020, the European Union stressed once again its strong commitment to leading global climate action and to continuing the significant progress made in this area over the last two decades. The European Commission's new assessment proposes increasing the target for reducing greenhouse gas emissions from 40% to 55% by 2030 with the goal of reaching net-zero emissions by 2050, factoring in the post-COVID-19 recovery, Brexit and National Energy and Climate Plans. The European Parliament added further impetus, calling for a 60% reduction in greenhouse gases.³ The new strategy presents cost-effective ways of achieving a carbon-neutral economy by 2050 through a socially fair transition. Specifically, the strategy outlines a framework for the long-term transition and addresses investment and finance, research, innovation and deployment, economic and social impact. It also outlines the European Union's global role and the role of citizens and local authorities.

Against this background, the following sections aim to provide greater clarity on clean energy investment flows, and the corresponding investment trends for both mitigation and adaptation. Building on the action plan and the final report on the EU taxonomy published in March 2020, the investment trends in climate change mitigation technologies are discussed with reference to the United States, China, the European Union and its Member States. The analysis adopts a common methodology to facilitate the comparison across regions, countries and sectors.

The EU taxonomy and climate investments

As part of the European Green Deal roadmap, the European Commission adopted the EU action plan on sustainable finance (Sustainable Finance Action Plan) in 2018. This plan aims to channel private financial flows towards investments that support the Paris Agreement's target of a carbon-neutral economy by 2050, and more broadly the United Nations Sustainable Development Goals.

The Sustainable Finance Action Plan involves three key steps. First, establishing a framework for facilitating sustainable investment based on a unified classification system (or taxonomy). Second, introducing obligations for institutional investors and asset managers to disclose how they integrate Environmental, Social and Governance (ESG) factors in their risk assessment. Third, providing low-carbon and positive-carbon impact benchmarks to give investors a clearer understanding of the carbon consequences of their investments.

The first key action, the EU taxonomy, was adopted in June 2020, after the proposal of the EU technical expert group earlier that year. The adopted taxonomy serves as a guide for investors, companies, issuers, and project promoters for what constitutes environmentally sustainable economic activity. In other words, it sets a common language for sustainable finance through a framework of unified criteria.

The EU taxonomy identifies six environmental objectives and sets out Paris Agreement-aligned performance criteria for a set of economic activities. According to this framework, economic activity will be considered sustainable if contributes to one of these six goals, does not significantly harm any other activity, and satisfies at least some minimum safeguards⁴ including human rights (Figure 1). The six environmental objectives are climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, waste prevention and

² The EIB Group Climate Bank Roadmap focuses on four areas: a) accelerating the transition, b) ensuring a Just Transition for all, c) supporting Paris-aligned operations and d) building strategic coherence and accountability.

³ In December 2020, the European Council endorsed a new target for a 55% reduction of greenhouse gas emissions by 2030, compared to 1990.

⁴ These safeguards are set out in the regulation (including the OECD Guidelines for Multinational Enterprises, the International Labour Organization, etc.), together with the technical screening criteria developed by the Technical Expert Group.

recycling, pollution prevention and control, and protection of healthy ecosystems. So far, the agreed taxonomy covers only the first two environmental objectives, while negotiations are still pending for the definition of the remaining ones.

Figure 1 EU taxonomy at a glance



The EU taxonomy covers 70 NACE⁵-defined economic activities at a granular level across seven broad macro sectors. These macro sectors are: 1) agriculture and forestry, 2) manufacturing, 3) electrcity generation, 4) water, sewerage, waste and remediation, 5) transportation and storage, 6) information and communication technologies (ICT) and 7) buildings. The taxonomy covers activities that are classified as green, transitioning or enabling. It excludes mining and quarrying, fishing, glass manufacturing, paper and pulp manufacturing, aviation and maritime shipping. These activities will be addressed in the future.

Figure 2

Classification of climate change mitigation activities



⁵ NACE stands for "Nomenclature statistique des activités économiques dans la Communauté européenne" and shows the statistical classification of economic activities in the European Community.

The taxonomy defines activities as contributing to climate change mitigation if they comply with specific standards, namely if they fall within specific thresholds⁶ and adhere to the principle of doing no significant harm to other environmental objectives. These standards/thresholds are in line with the objectives of net-zero emissions by 2050 and a 55% reduction by 2030, consistent with the commitments made under the EU green deal.

Whereas the details of the taxonomy are applicable at project level, the climate change investment data reported in this chapter provide a high level of aggregation, with no specific project data included. Moreover, the investments reported in this chapter were made before the taxonomy was issued and it is not possible to judge the extent to which the component projects committed to in previous years would have met today's criteria. The taxonomy nevertheless provides some guiding principles.

The subsequent analysis of climate change investments shares a common structure with the EU taxonomy. For example, renewable energy investments and investments in forestry/sequestration correspond to low-carbon activities (Figure 2). Investments in energy efficiency correspond largely to transition activities. Research and development that will make future low-carbon investment possible corresponds to enabling activities, as does investment in transport infrastructure that provides the potential to switch from the use of fossil fuels to renewable energy.

Climate change investment by taxonomy-aligned sectors in the EU27, the United States and China

Regional comparisons of investment trends

China leads the world in clean energy investment, sustaining high investment rates over the last six years. Its current level of investment in climate change is approximately equal to that of the United States and the European Union combined (Figure 3). In 2019, China invested EUR 346 billion compared with EUR 175 billion in the European Union and EUR 152 billion in the United States. China's investment in climate change accounts for 2.7% of GDP, a much higher share than in the European Union at 1.3% or the United States at 0.8%. Moreover, China's investment is growing rapidly. Recent growth in the European Union and the United States has come from renewable energy generation, which has been subject to much more volatile swings. Investment in energy efficiency and transport have both been flat or declining in the European Union and the United States over the last six years. However, in China, all climate sectors have been ramping up quickly.

The European Union is second only to China for climate investment. In the EU27, investment in climate increased by 2.7% in 2019 to EUR 175 billion, with all segments of climate mitigation growing except energy efficiency. Renewable energy generation led the way with a rise of 7.8%, hitting a level not seen since 2012. The increase came largely from the wind and solar photovoltaic (PV) sectors. Estimates for energy efficiency investment indicate a modest decline in 2019 to EUR 55 billion. However, given the difficulty in estimating this kind of investment, it would be safer to say that no evidence exists of a substantial change in real terms over the last five years. In the transport sector, investment in rail and inland waterways grew by 3.6%, making up for the lower rates witnesses since 2014. Forestry grew by approximately 6%, and R&D by 0.8% with increases in government R&D making up for declines in the corporate sector.

The European Union has already gone much further in climate mitigation than the other two regions. At 0.2 kg CO₂/GDP (2010 US dollars), the European Union has the lowest emissions of the three economies

⁶ Thresholds, defined as minimum standards, are used to distinguish activities that contribute to environmental sustainability from those that do not. Thresholds are set at the levels where improvements to existing assets would make a substantial difference to the performance of an activity or asset relative to environmental objectives. For example, electric power plants are considered a sustainable activity if they emit less than 262 g CO₂/kwh. Similarly, until 2025, road passenger cars should not emit more than 95 g CO₂/km to be considered a sustainable activity in the taxonomy.

by far. Greenhouse gas emissions per unit of GDP has been cut in half across the three economies from 1990 to 2017 (Figure 4), reflecting reductions in energy intensity as well as changes in the energy mix, such as the switch from coal to gas and renewable sources in electricity production. The European Union has been actively promoting these investments for a long period and has successfully decoupled its economic growth from energy-intensive inputs, meaning that it has the lowest carbon intensity across the three regions. China, however, and to a lesser extent the United States, still have many untapped opportunities. Lower income European countries or recent EU members also have room to improve rapidly, as they started their decarbonisation process later than high-income EU members.

Figure 3



Climate change mitigation investment per sector (left axis: EUR billion; right axis: % of GDP)

Source: International Energy Agency (IEA), Bloomberg New Energy Finance (BNEF), Eurostat, and authors' estimates. Note: Data on investment in forestry in China were unavailable.

Figure 4

Greenhouse gas emissions to GDP in the European Union, the United States and China (kg CO_2/GDP , 2010 USD)



Box B

Price indicators for climate mitigation, renewable and energy efficiency investments

Climate investments are of the utmost importance in the decarbonisation of specific sectors and the economy as a whole. To better illustrate the cost benefits of clean energy investment, the EIB Economics Department has developed indicators that estimate the price of greenhouse gas emissions or energy consumption avoided as a result of the clean energy projects in the European Union, the United States and China.

Specifically, the following indicators have been calculated as a measure of comparison among the three regions:

- · Climate investment per tonne of carbon emissions avoided
- Renewable energy investment per tonne of carbon emissions from the power sector
- · Investment in energy efficiency per tonne of avoided energy consumption

The carbon emissions or energy consumption of each region are given by the following factors:

$$E_t = A_t * I_t$$

Where E_t represents the either the total energy consumption or the carbon emissions at time t, A denotes the activity index, e.g. GDP, and I denotes the energy or carbon intensity depending on what is measured each time. In additive decomposition, the effects of the various driving factors from the baseline year 0 to the final year T are expressed as follows:

$$\Delta E_t = E_T - E_0 = \Delta A_t * \Delta I_t + I_0 * \Delta A + A_0 * \Delta I$$

The method used for decomposing the changes in the variables of interest follows the standard logarithmic mean Divisia index, (LMDI) methodology summarised by Ang (2015). According to this method, the avoided energy consumption or carbon emissions are based on the following:

$[(E_{T}-E_{0})/\ln(E_{T}/E_{0})]^{*}\ln(I_{T}/I_{0})$

For energy efficiency, avoided energy is calculated by decomposing the change in final energy consumption into the change due to improvements in energy intensity and the change due to GDP growth. The change due to the improvement in energy efficiency is then used as avoided energy consumption in the denominator. Similar methodology is applied for carbon, using carbon intensity instead of energy intensity.

The calculations were made for the EU27, the United States and China. Climate investment per tonne of carbon avoided and energy efficiency investment per tonne of energy consumption avoided were estimated over the six-year period from 2014 to 2019. Renewable energy investment per tonne of carbon emissions from the power sector was estimated over for 2014 to 2017.

On this basis, over the last six years the European Union has invested EUR 8 400 per additional tonne of avoided energy consumption compared with EUR 760 per tonne for China and EUR 1 600 for the United States.

The corresponding calculation for carbon implies that, over the last six years, the European Union has invested EUR 4 200 per tonne of avoided carbon compared with EUR 560 per tonne for China and EUR 890 for the United States.

Table B.1

Note:

Price indicators for climate change mitigation (CCM), renewable energy (RE) and energy efficiency (EE) investments

	Avoided CO ₂ emissions ²	Investment in CCM	CCM/CO ₂	Avoided energy consumption	Investment in EE	EE/toe	Avoided CO ₂ emissions ²	Investment in RE	RE/CO ₂
	(tonnes)	(bn EUR)	(bn EUR/tn)	(Mtoe)	(bn EUR)	(bn EUR/toe)	(tn)	(bn EUR)	(bn EUR/tCO ₂)
EU27	241	989	4.1	42	370	8.8	39	260	6.7
US	967	846	0.9	150	234	1.6	274	267	1.0
China	3 560	1 837	0.5	497	294	0.6	359	611	1.7

Source: Authors' calculation.

The data in the table show the cumulative totals over the six-year period (2014-2019) for total final energy consumption, energy-related carbon emissions, real GDP and investment in energy efficiency, and climate mitigation (adjusted to 2019 prices using the GDP deflator). Toe stands for tonnes of oil equivalent.

In the power sector, the European Union invested EUR 6 800 per tonne of avoided carbon over for 2014 to 2017, compared with EUR 1 700 per tonne in China and EUR 980 in the United States.

Although there are differences across the three regions in the share of climate change and energyefficiency investment in gross fixed capital formation (GFCF), they are much lower than the differences in the indicators presented above.

These comparisons need to be interpreted with caution, as they are not cost-benefit ratios for the following reasons:

- While investments take a long time to materialise, they result in lower energy consumption and reduced carbon emissions. In buildings, for example, the stock turns over only very slowly and the investments are long-lived.
- The European Union is already less energy-intensive and less carbon-intensive than the United States or China. As such, further reductions in energy intensity are expected to be relatively difficult in the European Union.
- The European Union uses less coal in the power sector so renewable energy displaces less carbonintensive alternatives.
- Faster economic growth in China and the United States means that turnover is faster and the share of old appliances and equipment in the total capital stock is shrinking more rapidly. New equipment is more efficient. Faster growth therefore means faster improvements in energy intensity and carbon intensity.

Despite the caveats, these indicators show how different the approaches are in the various regions. They tell us nothing about the economic viability of the investments, but they do show that the European Union has already gone much further in climate mitigation than the other regions, which means that most of the low-hanging fruit have already been picked. While the European Union has been actively promoting these investments over a long period, untapped opportunities still exist in China and the United States and, more generally, in regions that have started their decarbonisation more recently.

Given that tackling climate change is a global challenge, the European Union should continue to support the green transition in partner countries through its development programmes, while fostering domestic efforts to harness the full potential of decarbonisation of its energy systems.

Investment in low-carbon activities

Low-carbon activities are those that are already compatible with a net-zero carbon economy in 2050. For example, renewable sources, when they replace fossil fuels, directly reduce greenhouse gas emissions. Forestry investments can play a role in sequestering greenhouse gases.

Renewable energy and networks

For renewable energy deployment, the European Union is well ahead of the other two countries. In the European Union, the share of renewable energy in primary energy consumption, the gross amount of energy consumed, has more than doubled since 2000, with the rise especially marked after 2005 (Figure 5). The United States showed a similar trend with an increase of 70%, whereas in China, the share of renewable energy was halved because of an unprecedented increase in the country's primary energy supply. Overall, the three regions succeeded in decarbonising their electricity generation from 2010 to 2018, reducing their carbon intensity at least by one-fifth. Of the three, Europe has been the most successful, recording the lowest carbon intensity at 269 g CO₂/kWh thanks to the rapid deployment of renewable energy and the phasing out of coal power plants (Figure 6).

Figure 5

Share of renewables in the primary energy supply (%)



Source: OECD.

Figure 6

Carbon intensity of electricity generation (g CO₂/kWh)



Nevertheless, the European Union is currently behind China and the United States for new investments. EU investment totalled EUR 74 billion in 2019, an increase of 7.8% from 2018 (Figure 3). That was roughly half China's investment, and 85% of US levels. China remains the world leader in investment in the solar PV and wind segments, but the United States and the European Union invest more in energy-smart technologies such as battery storage.

Figure 7

Investment commitments in wind and solar energy, and total investments made in renewable energy (EUR billion)



Source: BNEF, IEA.

Note: The line presents the IEA's figures for investments in renewable energy that has become operational in a given year. The bars show investment commitments in renewable projects, for which the final investment decision was taken and construction has begun, but which might be completed after more than one year.

The momentum of renewable energy appears to be slowing, as commitments from the European Union and China declined in 2019. By contrast, investment commitments in renewable energy increased in the United States (Figure 7). Both solar PV and onshore wind grew in the United States, while wind power declined in the European Union. In China, investment in solar PV declined as a result of changes to the government's support schemes.

Box C

The role of different financing sources in renewable energy

From 2015 to 2019, the bulk of investments in Europe, the United States and China were financed by four different sources: asset financing, venture capital and private equity, non-recourse project⁷ finance and public markets.

Historically, asset financing – loans guaranteed by the companies' assets – was the main source of financing for renewable investment in all three regions (Figure C.1), especially in China, where it

⁷ Non-recourse finance is a type of commercial lending that entitles the lender to repayment only from the profits of the project the loan is funding and not from any of the borrower's other assets.

accounts for more than 90% of total funding. Non-recourse project finance, which is mainly driven by bank lending, is the second-largest source of financing for renewables, particularly in Europe and the United States. The projects funded by this type of finance mainly concern technologies with smaller market penetration, such as rooftop and other small-scale solar projects of less than 1 MW. Public markets, along with venture capital and private equity, are the least preferred sources of financing for renewable projects. In China, funding via public markets and venture capital is almost negligible.

Figure C.1





In Europe, renewable energy now leads investment in the power sector, with fossil fuel investments much diminished. Investment in renewable energy (EUR 52.9 billion) in 2019 accounted for about 75% of total investment in power generation, with the remaining 25% shared approximately equally between fossil fuels and nuclear energy. The expansion of renewable energy also requires stronger electricity networks. The sporadic supply inherent in renewable energy places greater demands on electricity transmission networks. These demands include efforts to connect new electricity producers to the grid but also the need to transport power over longer distances. Factoring in the associated investments in electricity networks (EUR 20.7 billion), the total investment attributed to renewables in 2019 was EUR 73.6 billion.

EU investment in renewable energy is well below the level reached before the 2011 economic crisis. Despite recovering some ground since 2015, investment in 2019 was only at 56% of its level in 2011. The slower pace of renewable energy investment after the economic crisis can be attributed mainly to falling capital costs in solar and wind globally, and to the revised support schemes that reduced subsidies in many EU countries, resulting in fewer installations. In particular, annual new additions of renewable energy decreased from 32 GW in 2011 to around 16 GW.

While investments made in renewables grew by 7.8% in 2019, investment commitments to new projects declined by 8% (Figure 8). While these new projects do not cover all investments in renewable sources, they have so far been a consistent leading indicator of future trends. For example, project commitments for utility-scale investments are typically over several years and these future flows are locked in at the date of commitment.



Figure 8 Investment commitments per renewable technology in the European Union (EUR billion)

EU investment in renewable generation is dominated by wind and solar PV. While investment in solar PV in the European Union has more than doubled since 2017, reaching EUR 15 billion, current levels are quite low in comparison to the peak of 2011. In 2011, solar PV reached unsustainably high levels of investment on the back of short-lived government incentives. Declines are also observed in onshore and offshore wind. In the onshore sector, countervailing forces are at play. On the one hand, the maturity of the sector means that there are limited opportunities for new investments. The most favourable locations in countries with the most supportive incentive regimes have already been taken. On the other hand, technological progress – larger turbines, more efficient management systems and higher load factors – is continuing to drive down costs and increase productivity.⁸

EU investment rates in biofuels, biomass and geothermal energy are also declining. After peaking around 2010-2011 (Figure 8), investments dropped more than 90% for biofuels and biomass – to EUR 90 million for biofuels and EUR 360 million for biomass in 2019. Investments in geothermal energy also declined around 60%, to EUR 90 million in 2019. The role of biomass and biofuels in climate change mitigation depends on the alternatives and the choices being made. For example, a switch from burning fossil fuels to sustainable biomass constitutes a reduction in greenhouse gas emissions. The greenhouse gases emitted by the combustion of the biomass are offset by those captured in the production of the biomass (for example, the forest recovers greenhouse gases, which are returned to the atmosphere when the woodchips are converted to electricity). By contrast, if the alternative to burning biomass is to allow the material to accumulate in the environment, then the climate change benefits are not so clear-cut. These trade-offs considerably affect investment in biomass.

In contrast, EU investment in energy-smart technologies has grown rapidly in the last five years, reaching EUR 5.8 billion in 2019 (Figure 8). A large part of these investments is related to battery storage. Other energy-smart technologies concern digital control devices that improve the efficiency of power

⁸ The cost of technology is also a significant factor in the offshore sector. However, investments are more concentrated in larger projects, and therefore the overall level of investment is driven by the timing of the new megaprojects.

generation capacity by making it more responsive to the needs of the system. These advances are being applied to existing capacity as well as to new investments in renewable energy. These advances increase a renewable energy power plant's ability to adapt more quickly to changing weather conditions. On the demand side, investment in smart meters is creating greater flexibility and allowing consumers more control over their consumption.

Agriculture, forestry and land use

The land use, land-use change, and forestry sector is considered to be a carbon sink. In the European Union, this sector has been sequestering more than 300 Mt of carbon equivalent on average over the last ten years⁹ – which represents approximately 7.5% of current emissions (Figure 9). Forestry is by far the largest contributor to carbon sequestration while the rest of the activities in this sector, including croplands, settlements, wetlands, and grasslands, are small net emitters overall.



Figure 9 Investment in forestry and carbon reduction (EUR billion, Gtn of carbon)

Emissions from deforestation are decreasing while carbon sequestration from afforested areas is rising as new forests are established and recently established forests reach maturity. Investment in forestry is responding to the increased demand for bioenergy, which is a result of the renewable energy targets and the demand for material. These trends are driving up wood prices, which increases the value of forested areas and supports investment.

The latest Eurostat data indicate that forestry accounts for approximately 0.1% of total gross fixed capital formation (GFCF). This ratio has remained constant in recent years, which implies 2019 investment of slightly over EUR 4 billion, or 2.4% of the estimated total investment in climate change (Figure 9). Sweden and Finland are the largest investors in forestry, accounting for 42% of total EU investment in the sector.¹⁰ In the United States, forestry investment is estimated to be around EUR 10 billion.

Investment in transition activities

Transition activities contribute to achieving a net-zero emissions economy in 2050, but do not yet operate at the expected optimal level. For example, energy efficiency limits energy demand, but the investment lags are long and the required standards are not yet in place.

Source: Eurostat.

⁹ United Nations Framework Convention on Climate Change (UNFCCC) inventory data.

¹⁰ Unfortunately, data on investments in agriculture, forestry and land use for China are not publicly available.

Energy efficiency

The European Union's "energy efficiency first" principle is behind improvements in energy intensity. According to the latest available data (2017), Europe is a champion in decoupling its economy from energy use. The European Union boasts the lowest energy intensity across all three regions (Figure 10). Despite differences in the structure of their economies and investment in energy efficiency measures, the European Union, the United States and China continue to converge for energy intensity. Since 1990, the European Union and the United States have cut their energy intensity by 40%, and China by more than 60%. Energy efficiency efforts, adjustments in the power mix and, to a certain extent, a structural shift towards less energy-intensive industries helped achieve this reduction.

Figure 10



Primary energy supply per GDP (1 000 Btu/2015 USD GDP PPP)

Source:

Note: PPP stands for purchasing power parity.

The European Union surpasses the United States and China in energy efficiency investments. The European Union invested around EUR 60 billion in energy-efficiency improvements, in comparison to EUR 53 billion for China and EUR 37 billion for the United States (Figure 3). US energy efficiency investment accounts for about 1% of GFCF, or 0.2% of GDP, around two-thirds of EU levels. China, on the other hand, is much closer to the EU ratios.

In the European Union, energy efficiency investment has remained relatively flat over the last five years, even taking into account a small decline within the margin of error for the estimation (see Figure 3).¹¹ There are a number of possible explanations. Economic incentives for investing in energy efficiency declined, in line with energy prices: Brent crude prices averaged USD 58 a barrel from 2016 to 2019, significantly below the average of USD 93 for the previous four years. At the same time, the price of better insulation materials and more efficient appliances dropped.

Investment in enabling activities

Enabling activities are necessary for reducing emissions, though they act only indirectly (because, as their name suggests, they enable other activities). For example, investment in transport infrastructure allows fossil fuels to be substituted by electricity, as traffic is switched from oil-based road transport to electric trains. Research and development and demonstration projects (such as hydrogen or carbon capture

¹¹ These data are based on the IEA's bottom-up methodology of calculating energy efficiency investment. The methodology looks at the cost difference between alternative investments that are similar except for their energy consumption. This additional cost is attributed to energy efficiency. The methodology has been refined over recent years (IEA, 2019).

and storage projects) can pull in fresh investment and highlight new ways of reducing emissions. The investment developments are discussed across the European Union, the United States and China, with a particular focus on EU developments.

Transport infrastructure

Investment in transport infrastructure contributes to climate change mitigation by facilitating the switch to less carbon-intensive modes of transport. It dovetails with the investments in electric vehicles and other energy efficiency measures discussed above. Urban mass transit systems and infrastructure that promotes the transfer of road freight to rail are two examples of investments that reduce transport's carbon footprint. These transport modes emit less carbon per passenger kilometre or per tonne kilometre of freight.

However, the net impact of these investments on greenhouse gas emissions must be seen in the context of the transport system as a whole. In Europe, where key areas of the transport system are already congested, adding new capacity increases overall demand while also promoting the shift to less carbon-intensive modes of transport. For example, upgrading mass transit in congested urban areas might have a limited impact on the number of private car journeys, even though the number of journeys in the overall mass transit system has increased.

Nearly all investments in inland waterways and rail infrastructure are classified as climate mitigation investments. The only exception would be transport links for the transportation of fossil fuels. Many investments in waterways and rail infrastructure projects include infrastructure that helps shift transport patterns in addition to increasing capacity.



Figure 11 Carbon intensity of transport (kg CO₂ /GDP 2010 USD PPP)

The transport sector remains almost entirely based on fossil fuels in all three regions. Transport accounts for about one-quarter of global carbon emissions. Consequently, it holds great potential for energy efficiency and emission reductions. Yet, in the European Union, as well as in the United States and China, transport is expected to become the largest source of greenhouse gas emissions after 2030 (European Environment Agency (EEA), 2018). The carbon intensity of the transport sector in the United States is twice as high as in the European Union and China (Figure 11). All three blocs have improved their carbon efficiency over time.

China is particularly focused on decarbonising transport, which is driving its total clean energy investment.¹² In 2019, China invested EUR 124 billion (Figure 3) in this sector. It has a leading position in high-speed rail technology, and has far more capacity than anywhere else in the world. EU investment in rail and inland waterways is estimated at EUR 35 billion (0.3% of GDP) for 2019, while the corresponding investment in the United States stood at EUR 11.8 billion. The US rail-freight system is almost entirely privately owned, unlike road, air and waterways where public ownership is significant. Investment in railway infrastructure and rolling stock in the United States is financed by private freight companies, and investments ultimately depend on earnings from freight charges, which are regulated by the government.¹³

Transport infrastructure accounts for 20% of total EU mitigation investments. However, this figure is probably underestimated because it does not include all transport mitigation projects. Transport integration and city planning, transport management and intermodal terminals would positively affect climate change mitigation efforts.

Research and development

EU investment in R&D in climate mitigation activities has grown slowly over the last five years, whereas the increase in the United States and China has been stronger. The United States remains the world leader in climate-related R&D, but China is catching up rapidly (Figure 12). China overtook the European Union in 2018 and, despite a small nominal contraction in 2019, it now has a significant lead.

The EU performance is mostly driven by the corporate sector, despite continued increases in public sector R&D (which accounts for 40% of total R&D expenditure). Corporate R&D declined by 3.6% in 2019, following growth of 6.1% in 2018. Energy-related automotive R&D is estimated to have stabilised in 2018 and 2019 after growing steadily for several years. Automotive is central to overall R&D spending. The pullback might reflect a weakening outlook for car sales combined with the imperative to invest in new models and upgrade manufacturing supply chains. Automakers' margins on electric vehicles remain very tight.



Figure 12

Government and corporate investment in R&D (EUR billion)

¹² https://www.railjournal.com/in_depth/china-rail-investment-2019

¹³ https://railroads.dot.gov/rail-network-development/freight-rail-overview

The sectoral composition of R&D investment in the European Union is broadly comparable to the United States, but quite different from China. Both the European Union and the United States spend approximately two-thirds of their total R&D speding on energy-smart technology (Figure 13). Most of the remainder goes to R&D in low-carbon services and solar power, with a smaller amount to biofuels and biomass. However, in China, solar, wind and small hydro projects make up a larger proportion of the total, accounting for 46%. This difference in composition reflects China's strong global position in manufacturing equipment and components, particularly for solar PV and wind power.





Source: BNEF.

Climate-related R&D is an important part of EU policy under the European Green Deal and the expanded Horizon Europe R&D programme. The coronavirus pandemic may make it hard for implementing agencies to execute projects in 2020 even though the funding is in place. Some public groups are calling for the pandemic response to focus on climate issues. In this case, climate-related R&D would likely be included in the fiscal stimulus package.

The European Union spends 0.05% of GDP on climate-related R&D. Investment varies widely between EU members, depending on their national priorities. France and Germany each account for approximately 20% of EU government expenditure on climate-related R&D, followed by Italy with 12% and Finland with 9% (Figure 14). As a proportion of GDP, Finland and Sweden are the largest spenders in the European Union, while countires in Southern and Central and Eastern Europe spend the least.

R&D plays a special role in facilitating other climate activities. A strong case exists for boosting R&D to increase overall energy efficiency, along with the efficiency of low-carbon power generation, power networks and transformation technologies. Estimates for the amount of R&D vary widely, with USD 4.5 billion to USD 78 billion needed for 2010-2029 globally and USD 115 billion to USD 126 billion for 2030-2049 (Bloomberg New Energy Finance (BNEF), 2020).



Figure 14 Investment in R&D for selected EU countries (EUR billion, % GDP)

Investment in adaptation

Investment in adaptation is much harder to track than investment in mitigation. Adaptation is more diffuse, and can be included in a wide range of investments across many economic sectors. It is impossible to track this type of investment with any accuracy without a globally accepted reporting method. Investors typically do not identify adaptation investments separately in their accounts.

Two categories of adaptation investment are identified and tracked, namely: i) major projects supported by EU public institutions and ii) flows of adaptation finance from OECD to non-OECD countries. However, these two categories very likely represent only a small part of the total. Adaptation investments by individual firms are not tracked, nor are, for the most part, those undertaken by other government entities and local authorities. The adaptation investments that are not covered by the data could be substantial, including for example costs related to the location of factories and warehouses and the associated engineering works, design and location of housing, plants and machinery, and so on.

Climate change adaptation is integrated in EU policies through the European Structural and Investment Funds (Figure 15). Projects include flood protection, land rehabilitation, forest fire protection, habitat conservation and risk management. The projects are funded with a combination of EU and national budgets. Total spending in 2019 reached EUR 23.8 billion, expanding rapidly from EUR 3.3 billion in 2015.

Adaptation funds provided by development finance and international finance institutions are approximately USD 30 billion a year. Almost one-fifth (19%) of the amount comes from development finance institutions. The fund is predominantly used for water and wastewater management, agriculture and forestry and disaster risk management projects in developing countries that are particularly vulnerable to climate change. However, the activity is small compared to the estimated USD 180 billion a year needed to adapt to disruptions in food production, urban services and infrastructure, as well as disaster risk management (Global Commission on Adaptation, 2019).



Figure 15 EU climate change adaptation and risk prevention programmes, total cost (EUR billion)

The impact of COVID-19 on clean energy investments

The pandemic is significantly affecting climate change investment, but the size of the impact varies greatly by market segment. Depending on the EU policy response, investment in energy efficiency, electric vehicles, and other domestic/commercial sector activities is likely to be hard hit. However, renewable energy investment, and in particular utility-scale projects, will be less affected in the short term. Big projects can be worth hundreds of millions of euros, and they are subject to detailed regulatory and planning approval. Financing such projects, in offshore wind for example, typically depends on long-term legal agreements covering pricing and offtake¹⁴. By contrast, investment in energy efficiency could be easily postponed unless it is dictated by regulations.

In 2020, project announcements appear to be continuing, while financing and contracts are lagging behind compared to 2019. Based on Bloomberg New Energy Finance (BNEF) data, which are available for the first 27 weeks of 2020 (52% of the year), 2020 announcements have already reached 68% of total new additions in 2019, but financing has reached only 33% and contracts 22%. However, these data must be read with caution. They are sensitive to a small number of large projects and financing and contracting schedules are not evenly spread out throughout the year. Commissioning in the offshore wind sector, for example, is particularly sensitive to the seasons.

Similarly, the International Energy Agency (IEA) forecasts a decline of 17% in European energy investment in 2020. According to IEA analysis, electricity grids, wind, and energy efficiency measures are holding up better than solar PV and oil and gas investments (IEA, 2020). Nevertheless, investments in energy efficiency and end-use applications are also expected to decline 10-15% in 2020 as vehicle sales and construction activity weaken as do purchases of more efficient appliances and equipment.

¹⁴ An offtake is a Power Purchase Agreement (PPA) between a power producer and the power buyer (also known as the offtaker).

Investment in utility-size renewable energy projects is less affected by the economic downturn, compared to other types of generation capacity. Some renewable energy projects have experienced construction delays because of labour problems or issues with procurement. By and large, however, these investments are already committed, and the promoters are financially sound companies. At the same time, the revenue from renewable energy production are protected by guaranteed¹⁵ access to the market. New utility-scale projects are nevertheless subject to risk. While the majority of planned renewable energy licenses have been issued, some have been postponed. Longer term, government policies are at risk of supporting schemes when energy demand is depressed and the economy is in a recession. Distributed investments in renewable energy (smaller projects such as commercial and household installations) and energy efficiency are more exposed to downturns in the market.

The role and investment needs of EU members and municipalities in the energy transition

The transition to a carbon-neutral economy represents a major, unprecedented challenge for all EU members. The transition involves all participants in the energy chain – all residents and market players – and a host of competing developments, opportunities, barriers and trade-offs. Above all, it requires massive investment in renewable energy plants, grids and pipelines, storage facilities, carbon-free fuel alternatives, as well as in building renovation, efficient industrial processes and appliances, new transportation technologies and smart energy systems.

The energy, climate and environment policies of the European Union – incorporated in its governance and regulatory framework – are driving the economy towards climate neutrality and sustainable growth. One of this framework's cornerstones is the governance regulation¹⁶ (see Box D), under which the Member States have prepared their National Energy and Climate Plans (NECPs) defining their climate strategy. Second, the European Green Deal will help bring climate action and environmental sustainability into the mainstream, contributing to the overall target of devoting 30% of the EU's long-term budget, the 2021-2027 Multiannual Financial Framework, to climate-related expenditure. While Member States are bound to adopt EU policies such as the upcoming European Climate Law (not yet passed), they are also supplementing this framework with their own approaches and policies.

Box D

The EU framework governing the climate transition

The Governance of the Energy Union and Climate Action bases its framework on the five dimensions of energy policy. These are energy efficiency, renewable energy and a reduction in greenhouse gas emissions (all under the umbrella of decarbonisation), interconnections, and research and innovation. The NECPs are an integral part of the effort to coordinate national and supranational strategies to facilitate and accelerate the transition towards a carbon-neutral economy. The national goals also provide the basis for an ongoing open-dialogue between the European Union and Member States.

In 2018, the European Commission asked EU members to present their long-term plans and strategies for meeting the overall objective of carbon neutrality by 2050, along with intermediate targets for reducing greenhouse gas emissions by 40% for 2030. In September 2020, the European Commission assessed all NECPs, inviting members to take action in various domains to address remaining gaps

¹⁵ Priority in the dispatching schedule.

¹⁶ The 2018 EU regulation on the Governance of the Energy Union and Climate Action aims to support the reliable and transparent governance of the Energy Union to help the European Union meet the energy and climate policy goals set for 2030 and beyond.

and shortcomings. While the Commission will revise its key climate and energy-related legislation by 2021, EU members have until 2023 to fully implement and update their NECPs, reflecting the more ambitious EU energy and climate targets.

The governance process incorporates, and is also supplemented by, other elements aiming to ensure that the necessary resources are devoted to the climate transition. In addition to the 30% of the 2021-2027 Multiannual Financial Framework being allocated to climate-related expenditure (a 10 percentage point increase from the previous budget), 30% of the EUR 750 billion NextGenerationEU financial package will also be dedicated to climate investments. In addition, regional policy sets aside specific sums for the climate transition. In the 2014-2020 Multiannual Financial Framework, EUR 40 billion from the European Regional Development Fund and the Cohesion Fund went to climate-related spending. For research and innovation, Horizon 2020 includes climate action as a major objective. In 2020, a regulation establishing the Just Transition Fund was proposed and an EU hydrogen strategy adopted, with many more initiatives forthcoming in 2021.

In this governance framework, members define their approaches by adopting EU rules and adding their own policy tools. According to the European Environmental Agency (EEA), more than 1 500 policies and measures had already been adopted in the European Union in 2018, the most recent data available. Some 74% of these measures relate to the implementation of EU policies. The other 26% (around 400 measures) were rolled out without a direct link to EU directives or regulations. In addition, 89% were economic, using incentives to reduce greenhouse gas emissions (infrastructure programmes, subsidies, investment programmes, feed-in tariffs, loans/grants and trading schemes) or regulatory (binding standards and regulations).

According to the EEA's assessment, 84% of policies and measures were adopted by central governments while 16% were introduced by regional or local authorities. However, local levels of government, and particularly municipalities, are key players in areas such as waste management, public and private transport as well as residential energy efficiency. Recognising this role, the European Union launched the Covenant of Mayors for Climate & Energy in 2008. The aim was to facilitate networking among municipalities willing to adhere to or exceed EU targets for climate and energy. Another initiative involving municipalities in Europe is the Urban Agenda for the European Union, established in Amsterdam in 2016, which also recognises municipalities as key hubs for innovation and experimentation in the climate field. The principle of networking and replicating the best practices of other Member States' policies has a powerful influence on municipalities as well.

Overview of total EU investment needs

The European Commission's latest impact assessment analysis (2020) indicates that annual energyrelated investment of around EUR 550 billion is needed throughout the current decade. The new proposal to cut greenhouse gas emissions 55% by 2030 increases the annual energy-related investment needed by an average of about EUR 100 billion a year compared to the baseline scenario in 2021-2030 (Figure 16) and close to EUR 200 billion for 2031-2050. To achieve both the new greenhouse gas target by 2030 and carbon neutrality by 2050, spending would have to increase steeply to around 3.1% of GDP a year in the current decade (excluding transport investment needs), then decline over the next five years to 2.5% of GDP before ramping up again to around 3%.

The European Commission estimates that around 2% of the European Union's GDP is currently invested annually in the energy system and related infrastructure. This estimate includes spending on conventional technologies and excludes spending on transport for 2011-2020 (Figure 16). The baseline envisages a broadly similar investment-to-GDP ratio, implying around EUR 340 billion, or 2.3% of GDP a year up to 2030. The new proposed greenhouse gas emission reduction target of 55% increases the annual additional investment needs by about EUR 220 billion (excluding transport) compared to historic trends.



Figure 16 Annual investment expenditure, 2021-2030 vs. 2011-2020 (left axis: EUR billion; right axis: % GDP)

While all economic sectors will need to contribute to the transition, the scale of the challenge is not the same. Some sectors (Figure 16) will have to invest more to reduce their energy and carbon intensity and play their part in the EU climate plans. In the current decade, the largest portion, namely 65-75%, of total additional investments are expected to come from final energy consumers, involving building insulation, the improvement of industrial processes, efficient equipment and new transportation technologies. By contrast, the majority of additional investments in 2031-2050 should come from the energy suppliers, involving the development and strengthening of energy infrastructure, the building of renewable energy power plants and facilities for storing energy, as well as the production of carbon-free hydrogen and synthetic fuels.

Box E

Zoom on global scenarios for future climate investment needs

The IEA (World Energy Investment 2019, p30) compares the current level of investment and the required level in two global scenarios, the New Policies scenario and the Sustainable Development scenario. Under the Sustainable Development scenario, investment in the power sector is one-third less than what is needed for decarbonisation and electrification. The requirements include a two-fold increase in spending on renewable power as well as higher spending on nuclear and electricity networks.

One of the IEA highlights the relative lack of policy attention to energy efficiency and consumers.

The Intergovernmental Panel on Climate Change (IPCC) reviews a number of models looking at global investment needs, broken down between the OECD and non-OECD blocs. When climate policy

Source: European Commission.

constraints are absent, the models show a reliance on fossil fuel energy, particularly in the non-OECD countries. Introducing climate policy objectives results in a reduction in fossil fuel investment and an increase in renewable energy. This implies an increase of approximately 100% in the global annual investment in renewables, nuclear and electricity generation, and carbon capture and storage over from 2010 to 2029.

European Union's experience backs up this idea. Nearly all investment in the European Union has gone towards renewable energy, with very little dedicated to fossil fuels.

However, the same kind of shift has not happened outside the European Union. Some Asian economies, for example, are still making significant investments in fossil fuel generation.

The analyses from different bodies (Box E) all indicate that the current level of climate investment falls short of what is needed to meet environmental objectives. The estimated investment rates in the previous sections indicate that the European Union is struggling to maintain a level of investment that was already insufficient for achieving climate goals.¹⁷ Although climate investment is not calculated on the same basis as other investment trends, climate investment has declined slightly as a share of GDP and of GFCF since 2016, a trend that will likely continue in 2020. The gap between the investments made and climate objectives seems to be increasing.

The gap is small, particularly considering the uncertainties of long-term climate projections. It is still cause for concern, however, because it suggests that the European Union is moving in the wrong direction. Climate investments are slowing whereas all of the climate scenarios indicate that they need to increase. Although falling costs for renewable energy generation mean that more capacity is being installed per euro of investment, the price drop is not likely to be enough to compensate for the lack of investment. European markets are mature and an increasing proportion of investment is going towards replacing existing capacity rather than building new capacity.

Overview of National Energy and Climate Plans

The investment needs¹⁸ set out in Member States climate plans are not sufficient to achieve EU climate objectives. Concretely, EU members have assessed their investment requirements for the climate transition in different degrees of detail, with at least one paragraph devoted to this issue in the last chapter of each NECP. The sum of the Member States' investments is slightly below the EUR 260 billion required annually to meet the 40% emission reduction target, according to the European Commission's calculations. In line with the new target of 55%, investments should be scaled up to around EUR 340 billion a year. Figure 17 summarises the current plans and the estimated increase in investment needed to achieve the new target.

Investment needs are higher for Central and Eastern Europe (as a share of GDP), and for energy efficiency measures. As a share of GDP, the stated investment needs fall into three groups: Eastern European countries, where investment needs are very high; the large countries of Southern and Northern and Western Europe, where investment needs are mid-range; and the countries for which the transition is more advanced (Finland, Sweden and Denmark), where investment needs are lower. Central and Eastern European countries started the decarbonisation process later than Western European countries, and more effort is needed for them to catch up. Once again, the NECPs show that almost half of the investment needs concern energy efficiency investments (45%), with 20% of the total going to renewable energy, 10% to investment in grids and distribution networks, and 15% to transport-related investment. The remaining 10% falls into a variety of other categories.

^{17 (}European Commission, 2020; IEA, 2020; IPCC, 2019)

¹⁸ The collected data refer to total investments, apart from Germany and Luxembourg (additional investments), Malta (public costs), and France, Italy and Portugal whose amounts are for total investments apart from transport (additional). Finland and Sweden reported only on part of the categories.



Figure 17 Climate investment needs¹⁹ by country and category, targets of 40% vs. 55%



Source: NECPs.

Note: The first panel represents annual investment needs by country as a share of GDP (by category), the second panel represents investment needs corresponding to the 40% and the 55% emission reduction targets. The new investment needs are calculated with the contributions of country groups kept at a constant.

Private investment has a more prominent role in Western and Northern Europe and Southern Europe.

The plans refer to the overall investment needs, in many cases providing details on public-sector efforts (national or local authorities or European programmes) and expectations for the private sector. Public-sector investment needs are linked to the creation of required infrastructure in the energy distribution or transport networks, infrastructure built for zero- or low-carbon mobility, or increased energy efficiency in public buildings. In their NECPs, five Central and Eastern European countries explicitly quantify fairly high investment needs in their distribution networks. In addition, a significant share of their electricity production still relies on coal, which, as it is phased out, will require other (mainly public sector) investments.

¹⁹ Note that some of the Member States' expenditure with no explicit climate-related goals was excluded from the table, and it is possible that other amounts that should have been included were not captured. One example of an excluded amount is the EUR 759 billion that the Italian plan shows as investment in vehicles, including "the gradual and natural renewal of the vehicle fleet." The table here includes only the incremental expenditure due to the policies mentioned in the plan (to be adopted) with respect to the baseline (at current policies). This difference amounts to EUR -27 billion (page 321, table 78 of the Italian plan). The same applies to Portugal, Cyprus and France.

At both national and local level, governments provide incentives (directly or in the form of tax expenditure²⁰) for mobilising private investments. Private investments are encouraged through incentives for retrofitting buildings or production processes, energy production feed-in tariffs²¹, auction prices, and offtake agreements²² as envisaged by the NECPs. While it is not easy to determine how much of the overall EUR 2.6 trillion investment needed over the next decade will come directly from public investment, information contained in the NECPs suggests that around 45% on average (unweighted), with a much larger share (due to the EU funds' contribution) in Central and Eastern Europe (at almost 60%) and a more contained role in other countries (37% in Western and Northern Europe and 39% in Southern Europe, Figure 18). This issue is of particular relevance considering the current crisis that could hamper the private sector's propensity to invest.

Figure 18



Public and private sources of needed investments

Source: NECPs.

The targets embedded in Member States' renewable energy projections indicate a huge increase in wind and solar power as sources of energy. The NECPs suggest that from 2021 to 2030, installed capacity for wind (particularly offshore wind) will increase substantially, and solar energy is likely to see triple-digit growth rates in many countries (see Figure 19). In this period, the production of energy from biomass will also grow, but much less than from solar and wind power.

The NECPs indicate that Member States' production capacity based on solar PV (photovoltaic energy) will almost quadruple in Southern Europe and Central and Eastern Europe, while wind power capacity will almost double in the two regions. This heady growth has three consequences. The first is that integration in the grid will require investment in additional infrastructure by the network manager (often a state-owned enterprise), mainly to overcome discontinuities in the energy supply. The second is that this strong growth could generate a larger-than-projected decline in unit costs due to technological advances.

²⁰ Tax expenditures are defined as a transfer of public resources that is achieved by reducing tax obligations with respect to a benchmark tax, rather than by direct expenditure.

²¹ Feed-in tariff is a mechanism designed to accelerate investment in renewable energy technologies by offering long-term contracts to renewable energy producers.

²² Offtake agreements are negotiated in advance, helping the renewable energy producer to sell their product at a locked in price, thereby improving the financial attractiveness of such projects.

The third is the need to provide storage capacity when renewable energy is produced, but not used²³, and the most obvious use of excess renewable energy is to produce hydrogen (through electrolysis²⁴).



Figure 19 Planned growth in renewables²⁵

Source: NECPs. Note: The unit of measurement is TWh.

The NECPs highlight the growing role of hydrogen, mainly in Power-to-X²⁶ technologies, but also in other areas. A majority of national plans rely on hydrogen technologies for the climate transition (19 out of 27 countries, with only one country not mentioning it at all – see Figure 20 and Box F on hydrogen technologies).

Member States do not typically report on carbon capture, utilisation and storage technologies. While installations to capture and store carbon dioxide are recognised as necessary for achieving carbon-neutrality to compensate for unavoidable emissions, explicit reference to this technology is not frequent in NECP plans. In fact, almost half of countries do not mention carbon capture or include only generic references to it (Table 1). The theme is included among the research topics (with explicit financing) in seven plans, four of which allude to international (or EU-sponsored) collaboration. Currently, two pilot projects are operational (and one has been abandoned).

²³ During the summer months, a large share of energy demand in some EU countries is already satisfied by renewable energy. Excess solar or wind energy should be stored by accumulators or transformed into a zero-carbon fuel like hydrogen.

²⁴ Electrolysis is a clean method of producing hydrogen, by splitting water into hydrogen and oxygen using renewable energy.

²⁵ Note that the table presents data harmonised using different sources and partially different concepts. Some EU members present targets referring to installed capacity, others to production and a third group to final demand. The concept of capacity was converted into the concept of consumption using the implicit conversion rate in the tables on the two concepts presented on page 43 of the German NECP.

²⁶ Power-to-X refers to the transformation of surplus renewable electricity into fuel (hydrogen in this case).





Table 1

Implementation of key technologies in the climate transition, by country group

Hydrogen					Carbon capture and storage				
	EU	WNE	CEE	SE		EU	WNE	CEE	SE
Explicit targets for charging station/ vehicles	8	4	3	1					
Research projects with allocated spending	11	5	3	3		7	3	3	1
International collaboration	11	7	3	1		4	1	2	1
Pilot projects	5	1	2	2		2	2	0	0

Source: NECPs.

Box F

Hydrogen

Hydrogen, which can be used to store excess renewable energy and as a fast-recharging fuel for a wide range of vehicles, has significant untapped potential. Hydrogen solutions – such as renewable hydrogen, which is produced by electrolysis using renewable electricity, and combinations of low-

carbon hydrogen generated from steam methane with carbon capture and storage – can help decrease carbon emissions, yet none of these technologies have been scaled up in the European Union. Apart from reducing carbon emissions, hydrogen holds the possibility of creating jobs and adding more value than what is currently outlined under the NECPs. Some pilot projects are focusing on hydrogen infrastructure, by reusing or adapting exisiting methane infrastructure. But for the industry to reach its potential, proper regulation needs to be put in place, and the barriers to hydrogen's development overcome. Some top issues are:

- (1) adequate hydrogen transport and supply infrastructure needs to be developed;
- (2) the best hydrogen technologies need more time to mature and become competitive.

While specific government initiatives can support transport and infrastructure, to reach maturity, global, sector-neutral measures are needed such as ambitious targets set by Member States to reduce greenhouse gas emissions, as well as the application of a sufficiently high carbon tax.

The EU Hydrogen Strategy is the most ambitious energy transition policy internationally to date. While the strategies of countries such as Japan, South Korea and China prioritise the use of natural gas for hydrogen generation, with or without carbon storage, the European Union's EUR 430 billion pledge to the hydrogen strategy focuses more on renewable hydrogen.

The Clean Hydrogen Alliance, which consists of the European Commission, Member States and industry, is the cornerstone of the EU Hydrogen Strategy. Coordinated actions among EU members are needed to roll out hydrogen projects. A number of projects are already ongoing. Denmark and Germany are constructing a 3-5 GW offshore wind energy power plant to fuel trucks, buses, ships and aircrafts through a hydrogen electrolysis facility. Spain plans to construct a power plant with 100 MW of capacity, including a battery storage system and an electrolysis-based hydrogen production system.

What is exciting about hydrogen is that it can transform and store excess renewable energy. Countries that are already endowed with a large natural gas infrastructure have a strong start (Spain, Hungary). Hydrogen can also be used in private and public transport, for instance, it already powers buses, trains (Portugal and Germany, with the latter already operational since 2018), trucks, ships (Malta, Croatia) and planes. In a few countries, a significant number of charging stations are already functional (particularly in France). The number of charging stations is set to increase, while nine countries have targets for either the number of charging stations or the share of hydrogen in transport. A partnership between the Port of Rotterdam and Air Liquide aims to create a hydrogen corridor connecting the Netherlands, Belgium and West Germany by 2025. The project involves setting up the related infrastructure and electrolysis capacity to produce enough hydrogen to power 1 000 hydrogen-powered trucks. Sweden is working on an advanced industrial project for fossil-free steel production based on hydrogen. Luxembourg has also set the goal of making steel production more sustainable using hydrogen based on renewable energy.

Hydrogen is thus seen as an alternative for hard-to-electrify transportation or industry. However, the bulk of investment in hydrogen (and, to a lesser extent, renewable energy in general), is expected to take place at a relatively late stage, with costs falling as the technology matures.

Around 50 hydrogen projects are in the early stages of development worldwide, and annual hydrogen demand is expected to grow to 8.7 million tonnes by 2030. According to the Institute for Energy Economics and Financial Analysis (IEEFA), the projects already in development phase have a combined annual production capacity of 4 million tonnes of hydrogen, total renewable power capacity of 50 GW, and an estimated capital cost of USD 75 billion. Although delays are probable, large-scale hydrogen facilities are expected to start operating by 2022-2023 and 2025-2026.

Member States need to make better use of regional cooperation when setting climate objectives, using that cooperation to build on the NECPs. The European Commission pointed this out in its EUwide assessment of the national plans (2020). Some existing forums already address energy transition priorities such as energy efficiency, transport, smart grids and renewable energy (skill shortages in renewable energy, for instance), but the transition could still be enhanced through regional cooperation. Four existing groups are especially worth mentioning: the Northern Seas initiative, the Baltic countries' plans for joint auctions of offshore wind, the Pentalateral Energy Forum, and Central and South Eastern Europe Energy Connectivity (CESEC). Regional planning for offshore wind would facilitate a steady pipeline of projects in a cost-effective way, provided a harmonised regulatory environment supported those projects. Beyond offshore wind, fast-charging networks for electric vehicles along Europe's main TEN-T transport corridors could also be developed regionally.

Local policies and coordination among municipalities

Municipalities are one of the key players in implementing green policies. In many countries, municipalities are responsible for the implementation of policies for energy efficiency, transport or waste disposal. In addition, municipalities issue regulations and provide a system of incentives and penalties with the potential to heavily influence people's individual choices (particularly in the areas of transport and energy efficiency). For this reason, local governments were active in the NECP consultation phase in all Member States. As Figure 21 shows, their role in shaping policies and implementation is explicitly mentioned in two-thirds of NECPs (eight out of ten NECPs in Western and Northern Europe, four out of six in Southern Europe and five out of 11 in Central and Eastern Europe).



Figure 21 The role of municipalities in the NECPs

Source: NECPs.

The municipalities' role is explicitly mentioned in transport, energy efficiency and waste management policies. While energy efficiency and mobility-related issues such as pollution and the time spent driving have local implications for the quality of life in an urban setting, municipalities are themselves greenhouse gas emitters and can therefore address their own carbon footprints. For transport (see Table 2), many policy measures can be effectively imposed locally, such as incentives encouraging public transport and low-carbon vehicles while limiting private vehicle use, topped up with direct investment in low-carbon public transport and infrastructure for vehicles using alternative fuels.

	EU	Western and Northern	Central and Eastern	Southern
Role in transport policies	10	4	2	4
Role in energy efficiency policies	12	6	3	3
Role in waste management policies	4	2	1	1
Renewables generation	2	2		
Data measurement	2	1		1
Association with Covenant of Mayors	5	1	2	2

Table 2 NECPs highlighting the role of municipalities in climate-related areas

Source: NECPs.

The NECPs also underline the role of the Covenant of Mayors, the largest EU network of municipalities, in the energy transition. There are various initiatives that bring together local governments voluntarily committed to implementing EU climate and energy objectives. The covenant now involves around 10 000 municipalities (10.5% of all municipalities in the European Union), with the majority (more than 80%) of adhering municipalities located in Southern Europe. Other countries also have widespread participation, such as Belgium in Western and Northern Europe or Hungary and Romania in Central and Eastern Europe. Municipalities that are part of the covenant commit to submitting a climate action plan within two years of their signature, describing targets and planned steps in climate mitigation or adaptation. By 2020, more than 6 500 (63%) of covenant signatories submitted an action plan with over 5 000 (50%) assessed and accepted by the European Commission's Joint Research Centre, while more than 3 100 (30%) already have monitoring reports.

Six out of ten climate action plans submitted to the Covenant of Mayors include climate mitigation actions that directly impact municipality operations. These climate actions can include public lighting or energy efficiency in municipal buildings (Figure 22), but a majority, 50% of plans, also involve the private sector (energy efficiency in residential buildings). More than half of the plans involve transport and local energy production. There are geographical differences, however. Southern European municipalities are less active in local heat production, and Central European municipalities are less active in local energy production.

The importance of coordination among municipalities is also highlighted in the EIB Investment Survey (EIBIS), which surveys municipalities' attitude towards networking (see Chapter 9). The related question asks "...how often, if at all, does your municipality/city coordinate its investment projects with networks of cities/municipalities with similar policy priorities, incl. associations such as Covenant of Mayors, or UN compact of mayors."²⁷ In what follows, "networking municipalities" are defined as those that answered "always" or "frequently" to this question, while the others are considered "not networking municipalities."

²⁷ The answer options are "always", "frequently", "occasionally", and "never".

Figure 22





Source: Covenant of Mayors' data.

Municipalities that report being part of a network that shares policy priorities are smaller, more frequently located in Southern Europe and in areas leaning more towards manufacturing. Based on the responses, the group of networking municipalities is composed of smaller municipalities (the average number of inhabitants is 59 500 in networking municipalities vs. 105 500 in the whole sample). This difference is most pronounced in Southern European municipalities (with the average population of networking municipalities being less than half that of the whole sample), but the trend also shows up in Western and Northern Europe.²⁸ Municipalities coordinating with networks are more frequent in Southern Europe, particularly in Cyprus, Greece, Spain and Portugal (but also in Czechia, Slovenia, Slovakia and France). Municipalities that participate in networks seem to be proportionally more active in the manufacturing sector (26.6% of networking municipalities report that manufacturing is the most important employer in their area, vs. 19.8% for the others).

Table 3

Overview of networking municipalities (by country group)

	Networking municipalities Average population		
		Networking	Non networking
Central and Eastern	27.6%	58.1	49
Southern	37.0%	67.9	219.2
Western and Northern	26.0%	50.7	88.5
EU	30.3%	59.5	125.6

Source: EIBIS Municipality Survey, population in thousands.

²⁸ In Central and Eastern Europe the reverse happens, as networking municipalities are bigger than the others.

EIBIS networking municipalities tend to focus more on climate change measures and policies. Figure 23 shows that regarding infrastructure investment, networking municipalities include (or plan to include) green budgeting more often. Similarly, they include projects for smart grids, energy storage, sensors and real-time weather monitoring more frequently than their non-networking counterparts do. The results are consistent whether using alternative definitions of networking, such as coordination with direct neighbour municipalities²⁹ or with municipalities in the same region.³⁰ Municipalities that coordinate locally with their peers are also likelier to embark on climate projects.





Source: EIBIS Municipality Survey.

Networking municipalities tend to measure and analyse their carbon footprint more frequently, but large variations exist across country groups (Figure 24). The gap in measuring the carbon footprint between networking and non-networking municipalities is larger in Southern Europe and Central and Eastern Europe than in Western and Northern Europe. Similarly, the share of networking municipalities that plan to measure their carbon footprint is largest in Southern Europe. However, Western and Northern Europe rank first in the number of municipalities that already carry out carbon footprint exercises.

In recent years, networking municipalities have invested more in climate adaptation than non-networking ones (47.5% vs. 39.1%). The same is true of waste and water treatment (49.1% vs. 38.2%) and transport (48.2% vs. 36.3% for networking vs. non-networking municipalities respectively), while more networking municipalities consider their level of climate investment to be adequate (44.7% vs. 27.0%). In addition, networking municipalities have adapted their investment plans after the coronavirus pandemic more often (Figure 25, left-hand panel). Interestingly, their reaction seems to be in line with the European Union's strengthened climate-related ambitions. Municipalities are ready to step up their efforts (Figure 25, right-hand panel).

²⁹ The related question asks "...how often, if at all, does your municipality/city coordinate its investment projects with neighbouring municipalities." The overlap with networking municipalities is 56%.

³⁰ The related question asks "... how often, if at all, does your municipality/city coordinate its investment projects with other municipalities in your region (excluding your immediate neighbouring municipalities)." The overlap with networking municipalities is 66%.



Figure 24 Carbon footprint inventories of municipalities (by country group, %)

Source: EIBIS Municipality Survey.

Figure 25

The impact of coronavirus on climate change adaptation and mitigation (%)



Source: EIBIS Municipality Survey.

Networking municipalities plan to invest more frequently in climate-transition projects than others (Figure 26). The difference is most pronounced for the circular economy and climate change adaptation.



Figure 26 Climate-related and other investments by municipalities, networking vs. not networking (%)



Figure 27

Climate and other investments and carbon footprint inventory (%)





Climate action is correlated with awareness and the willingness to invest. Municipalities that have measured their carbon footprints³¹ or have green budgeting procedures in place³² are increasing their

32 The same is true for municipalities that have included or plan to include smart grids, chargers, sensors and real time weather monitoring in their investment projects.

³¹ Or which plan to measure their carbon footprint in the future.

investment in climate mitigation more frequently than municipalities without a (planned) carbon footprint exercise. Their plans also tend to include other climate change-related items more frequently.

The EIBIS Municipality Survey shows that municipalities are more sensitive to climate-related themes when they coordinate with a network with similar policy priorities. These municipalities may have more knowledge of available investment alternatives, can share plans and experiences and are exposed to the best practices of network peers. It also shows that a precise framework of measuring phenomena (carbon footprint inventory) or the transparency concerning climate-related expenditure (green budgeting) is associated with more active climate investment behaviour.

Conclusion and policy implications

Additional investments are needed for decarbonisation and to contain the fallout of climate change. Simply put, replacing carbon-emitting production facilities and fuels with cleaner sources as well as maintaining and upgrading existing assets requires continuous capital investments. The level of these needed investments rises with climate ambitions. Europe has been a global frontrunner in decarbonisation and more successful in lowering its carbon footprint than the United States and China. To get there, EU investments in climate change focused on two main areas: renewable energy and energy efficiency.

Yet the rate of investment needs to increase if Europe wants to become the first climate-neutral continent. The analysis of the NECPs and the European Commission's ambitions to reduce greenhouse gas emissions by 55% by 2030 indicate that energy-related investment would have to rise substantially – by around EUR 350 billion a year (including transport) over the current decade, compared to today's investment rates. The scale of the investment challenge is not the same across all economic sectors or EU countries. Some sectors, mostly energy-intensive ones, and certain countries, mainly in Central and Eastern Europe, will have to invest more to reduce their energy and carbon intensity and meet the EU climate plans.

Europe is a decarbonisation leader China and the United States, but China is rapidly catching up. Investment trends reflect climate policy priorities, with China following Europe in its climate ambitions and pledging to be carbon-neutral by 2060. However, the three regions are at different decarbonisation phases, which partly explains why Europe has to spend more to to lower its carbon emissions or improve energy consumption compared to China and the United States. Regions that have made more progress in curbing their emissions will eventually be forced to invest in more costly, less mature technologies, such as hydrogen and carbon capture and storage, to cut emissions further. This challenge will be global, and will become more evident as the world fights climate change. Europe should therefore support the scale-up of investment in these global technologies while using its financial and development arms to continue fostering the green transition in partner countries, where big gains can be made from the existence of much "low-hanging fruit."

In addition to investing in climate change mitigation, Europe should make its infrastructure more climate-resilient. Despite the significant increase (seven-fold) in adaptation investment from 2015 to 2019, resiliency efforts should be stepped up because the amounts spent on it are considerably lower than on mitigation. Resiliency investments are mainly funded by the public sector, as adaptation projects do not attract as much private-sector interest. Nevertheless, the pandemic has underlined the importance of planning for crises and physical risks, either acute or chronic, which will intensify in the future. It is therefore crucial for the European Union to make its infrastructure more resilient to extreme weather events by spending more on water and waste management, agriculture and forestry, and disaster risk management projects, in addition to investing in climate mitigation projects.

The pandemic is expected to stifle investment unless governments put in place stimulus packages focusing on green growth. The various actions proposed to fight the coronavirus pandemic could be crucial in determining Europe's climate success. The European Union's policy response, together with the benefits of the single market and economic and monetary union, could provide the impetus needed for a strong and green European recovery. The European Commission's 2020 recovery plan, NextGenerationEU, is likely to prove an important turning point. The size of the recovery support packages, the policy areas chosen for support, the financial instruments available to support them, and the willingness of the EU members to move towards a greener economy, could provide the crucial support needed for climate investments. Moving towards a carbon-neutral economy is a win-win situation, with more investments in climate and specifically in R&D, innovation, green technologies and digitalisation a potential boost for Europe's recovery and future growth.

Better coordination across Member States and municipalities would help the European Union achieve carbon neutrality by 2050. The European Union sets the targets and provides the EU-wide framework

governing the Energy Union, while the Member States shape and align their policies accordingly. Coordination has started recently and could benefit further from discussions on common plans that could achieve the economies of scale needed for transformative technologies. However, given the coronavirus crisis, the reliance on private investment in Member States' climate plans could be too optimistic. The need to step up efforts to combat climate change and the need to support the economy call for public intervention and a strong role for public investment at all levels of government. Local governments are best placed to provide direct answers to local challenges in climate mitigation and adaptation. As the EIBIS shows, networking municipalities are more aware and responsive when it comes to measuring their carbon footprints and introducing green budgeting, and they are more willing to invest in climate mitigation, adaptation and the circular economy.

References

Ang, B. (2015). "LMDI decomposition approach: a guide for implementation." Energy Policy, pp.233-238.

Association of American Railroads (2020). "Freight Railroad Capacity and Investment." March.

Bloomberg New Energy Finance (2019). "Corporate Energy Market Outlook." Available at: https://about. bnef.com/new-energy-outlook/

Bloomberg New Energy Finance (2019). "Clean Energy Investment Trends."

Bloomberg New Energy Finance (2019). "New Energy Outlook."

Bloomberg New Energy Finance (2020). "Electric Vehicle Outlook."

Centre for Energy Finance (2019). "Clean Energy Investment Trends."

Climate Policy Initiative (2019). "Global Landscape of Climate Finance."

European Commission (2018). "A Clean Planet for all."

European Commission (2020). "Winter 2020 Economic Forecast."

European Commission (2020). "Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people." Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission (2020). "An EU-wide assessment of National Energy and Climate Plans - Driving forward the green transition and promoting economic recovery through integrated energy and climate planning." Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

European Commission (2020). "2020 report on the State of the Energy Union pursuant to Regulation (EU) 2018/1999 on Governance of the Energy Union and Climate Action." https://ec.europa.eu/energy/sites/ ener/files/report_on_the_state_of_the_energy_union_com2020950.pdf

European Environment Agency (2019). "Adaptation challenges and opportunities for the European energy system."

European Environment Agency (2019). "The European environment — state and outlook 2020."

European Environment Agency (2018). "National policies and measures on climate change mitigation in Europe in 2017."

European Investment Bank (2019/2020). "Energy Transition: investment challenges, options and policy priorities." In: European Investment Bank Investment Report, pp.155-191

EU Technical Expert Group (2020). "Financing a Sustainable European Economy."

Federal Railroad Administration (2020). Available at: https://railroads.dot.gov/rail-network-development/ freight-rail-overview

Gilbert, R. and Newbery, D. (1982). "Preemptive patenting and the persistence of monopoly". *The American Economic Review,* June, pp.514-526.

Global Center on Adaptation (2019). "Adapt Now: A Global Call for Leadership on Climate Resilience. Global Commission on Adaptation." Available at: https://cdn.gca.org/assets/2019-09/ GlobalCommission_ Report_FINAL.pdf.

Gupta, S., Harnisch, J., Barua, D.C., Chingambo, L., Frankel, P., Garrido Vázquez, R.J., Gómez-Echeverri, L., Haites, E., Huang, Y., Kopp, R., Lefèvre, B., Machado-Filho, H. and Massetti, E. (2014). "Cross-cutting Investment and Finance Issues." In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IEA (2019). "Energy Efficiency." OECD, Paris.

IEA (2019). "Renewables." OECD, Paris.

IEA (2019). "World Energy Investment." OECD, Paris.

IEA (2020). "World Energy Investment." OECD, Paris.

IMF (2020). "World Economic Outlook."

OECD (2019). "Climate Finance Provided and Mobilized by Developed Countries in 2013-17."

OECD (2020). "Exploring options to measure the climate consistency of real economy investments: the manufacturing industries in Norway."

Port of Rotterdam (2020). https://www.portofrotterdam.com/en/news-and-press-releases/air-liquide-and-port-of-rotterdam-authority-hydrogen-road-transport

Regulation (EU) 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change.

Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action.

Sinclair, O. (2019). "China plans largest-ever rail investment in 2019." *International Railway Journal*. Available at: https://www.railjournal.com/in_depth/china-rail-investment-2019

Trinomics (2020). "Opportunities for Hydrogen Energy Technologies Considering the National Energy and Climate Plans."

UNFCC (n.d.). "Investment and Financial Flows to address Climate Change."

World Bank (2016). "New Report shows How Africa's Electricity Providers Can Be Profitable and Still Make Electricity Affordable".

World Bank (2019). "Doing Business 2020."

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Data annex

Glossary of terms and acronyms