
Matching money with green ideas

A guide to the 2021–2027 EU budget

BACKGROUND

Agora
Energiewende



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PUBLICATION DETAILS

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Preface

Dear reader,

The European Union's revised 2030 climate targets imply that greenhouse gas emissions will have to decrease more sharply over the coming decade than they did over the past 30 years. That means that Europe's economic recovery from the COVID-19 pandemic can only be a green one. Now is the time to accelerate renewables investments, energy efficiency renovations and launch the clean industry transition.

The 2021-2027 EU budget and the additional recovery funds provide a record amount of public financial support across all 27 EU Member States within the next few years. But the clean transition investment needs in the power, transport, buildings and industrial sectors are much bigger. For spending programmes to be successful, they need to be combined with efforts to improve the regulatory environment for investors to achieve lasting effects and pull in private funding.

We prepared this explanatory guide on the EU funding landscape, together with Climate & Company, to assist clean transition stakeholders in identifying suitable EU funding opportunities and putting forward investment ideas, but also to inform national green financing and structural reform debates. Combining EU and other funds and the active participation of stakeholders in all Member States could maximize the impact of the EU budget and put the European economy on a credible and inclusive path towards climate neutrality.

I hope you find this report informative and stimulating.

Patrick Graichen,
Executive Director, Agora Energiewende

Key findings at a glance:

1

The historic EU budget of €1.824 trillion offers plenty of opportunities for green investments through its various instruments, increased climate mainstreaming and introduction of the do no significant harm principle. This guide explains how the various programmes work, how investments into the green transition are triggered and it identifies investment opportunities in four key sectors (industry, buildings, transport and energy).

2

EU funds, national stimulus programmes and policy reforms have to go hand in hand. Despite its historic size, EU funds alone are not sufficient to meet the overall investment needs of the newly raised 2030 climate and energy targets. The instruments under the Next Generation EU and the Multiannual Financial Framework need to be smartly combined with national funding and effectively designed to crowd in private funding in order to deliver a green recovery.

3

The Recovery and Resilience Facility complements other more specific EU funding programmes in that it allows investments into all technologies from innovative to mature as well as in all locations. It can be used to scale up mature clean transition solutions, which in many instances can be deployed quickly. Its specific feature of dealing with investments in conjunction with policy reforms is what will make the difference for sustained green growth. It will be crucial that the Commission applies the necessary scrutiny on the use of funds, enforcing the tracking methodology for the climate target and payment conditionalities.

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Acronyms

BAU	Business as Usual	R&D	Research and development
CEF	Connecting Europe Facility	RRF	Recovery and Resilience Facility
CF	Cohesion Fund	RRP	Recovery and Resilience Plan
COM	European Commission	SMEs	Small and medium-sized enterprises
CCfD	Carbon Contract for Difference	TA	Technical Assistance
DNSH	Do no significant harm principle	TEN-E	Trans-European Networks for Energy
EIB	European Investment Bank	TEN-T	Trans-European Transport Network
ESF+	European Social Fund	TJTP	Territorial Just Transition Plan
ESIF	European Structural and Investment Funds		
ERDF	European Regional Development Fund		
EU ETS	EU Emissions Trading System		
IEA	International Energy Agency		
JTF	Just Transition Fund		
MTF	Multiannual Financial Framework		
NECP	National Energy and Climate Plans		
NGEU	Next Generation EU		

How to read this guide

Chapter 1: Provides a general introduction to the role of different public financing instruments and their respective strength in advancing climate action and the green transition.

Chapter 2: Describes the landscape of EU-level funding instruments for the green transition as of 2021.

Chapter 3: This chapter sheds light on the investments and reforms needed in the buildings, transport, industrial and energy sectors to start the transition towards climate neutrality.

Terms and concepts are highlighted **in black** and explained in the glossary in Annex I. We welcome feedback at: EUBudget@climcom.de

Introduction

In addition to the public health and economic crisis caused by the COVID-19 pandemic, Europe faces a looming climate crisis. With regard to the pandemic, the growing availability of vaccines and quick tests will hopefully enable a rapid return to normal life. As the pandemic subsides, the political spotlight is sure to return to medium- and longer-term challenges, including the economic stimulus programmes needed to address them. To avoid potentially catastrophic levels of global warming, countries in Europe and around the globe must rapidly reduce greenhouse gas emissions in the 2020–2030 decade and achieve climate neutrality by 2050 at the latest. It is essential that economic recovery programmes and spending rebuild the economy with the green and digital transitions in mind. A universal lesson learned from the 2008–09 financial crisis is that the recovery has to be green to avoid returning to the previous path of increasing emissions. The recovery programmes that emerge will also largely shape the global clean technology race.

European heads of state and government agreed in December 2020 on the largest ever EU budget of €1.824 trillion, consisting of the new seven-year **Multiannual Financial Framework** (MFF) of €1.074 trillion and the additional **Next Generation EU** programme (NGEU) of €750 billion. At least €547 billion (30 per cent) of the EU budget *must* be spent on activities that reduce greenhouse gas emissions. The entirety of the NGEU recovery instrument and parts of the MFF must respect the do no significant harm principle (DNSH) enshrined in the EU Taxonomy Regulation. A significant share of the other €1.277 trillion could contribute to advancing climate action if national governments decide to do so. The injection of new funding coincides with the revision of the EU's increased 2030 ambition as well as the transposition of the Clean Energy Package of 2019, thus creating a major opportunity to ramp up climate ambition.

These rather positive headline developments require some qualification: first, the additional funding (Next Generation EU, REACT-EU) needs to be absorbed rapidly. Second, governments have significant flexibility when designing national spending programmes, so there is great need for examining and discussing which climate-related projects are the most important, as there is a serious risk that funding will otherwise not be spent on the most effective projects. Third, even under the most optimistic assumptions, EU funds alone will not be sufficient to meet overall investment needs attached to the new EU climate targets – but they might deliver most of the desired emission cuts if smartly combined with national funding, funding from public banks, and private investment.

Whether this opportunity will be seized depends on the development of “green” recovery initiatives and projects by progressive politicians at the national, regional, and local levels, business associations, investors, civil society groups and experts throughout Europe. This guide intends to support actors who are part of the energy transition in all EU Member States and at all governance levels in identifying suitable EU funding opportunities, informing national debates about funding and policy priorities and, ultimately, ensuring the available money can be absorbed within short timeframes and spent wisely. Ideally, the additional available resources will support the higher ambition of the EU Climate Law for 2030 and hence go beyond the investments planned in the 27 National Energy and Climate Plans (NECPs).

The publication of this guide occurs at a crucial moment, with EU Member States having submitted to the European Commission their recovery plans to access the Recovery and Resilience Facility (the biggest instrument under NGEU). Member State attention is thus turning toward finalizing the plans and programmes that will underpin 2021–2027

regional and cohesion spending; the 2021-2022 absorption of the "fresh" money from REACT-EU; and the establishment of Just Transition Plans while implementing the provisions of the Clean Energy Package.

1 The basics: The role of public financing in upscaling the green transition

Public funding instruments are designed to meet different transition challenges, depending on the requirements of the technology, strategy or projects that are to be supported.¹ Public financing both directly supports investments and/or offers guarantees, while policy and fiscal measures determine the associated investment conditions. Choosing the right public spending approach requires in-depth, context-specific analyses of investment needs, barriers, best-practice examples as well as relevant macro-economic factors. The investment landscape and the interplay of public and private financing for the low-carbon transition has been researched for several countries and sectors in recent years.²

Many clean and green technologies are already highly developed, widely available and often able to compete in terms of cost (e.g. solar PV and onshore wind) in markets with good policy and financing conditions. This is good news for the large-scale deployment of low-carbon technologies, and it reduces their need for public co-financing. In such cases, public resources are more effectively spent on raising awareness and preparing markets and societies for innovations, improving planning and permitting, and eliminating regulatory barriers and/or disproportionately high levies and taxes for clean energy and other low-carbon technologies. Reaching emission targets will, however, require the deployment of novel technologies, such as renewable (green) hydrogen, that are still in the pre-upscaling stage prior to full commercialization. The costs of these technologies still need to fall and their performance needs to improve in order for them to be economically viable. Public financing plays a crucial role when it comes to the development and marketization of innovative technologies (see Figure 1).

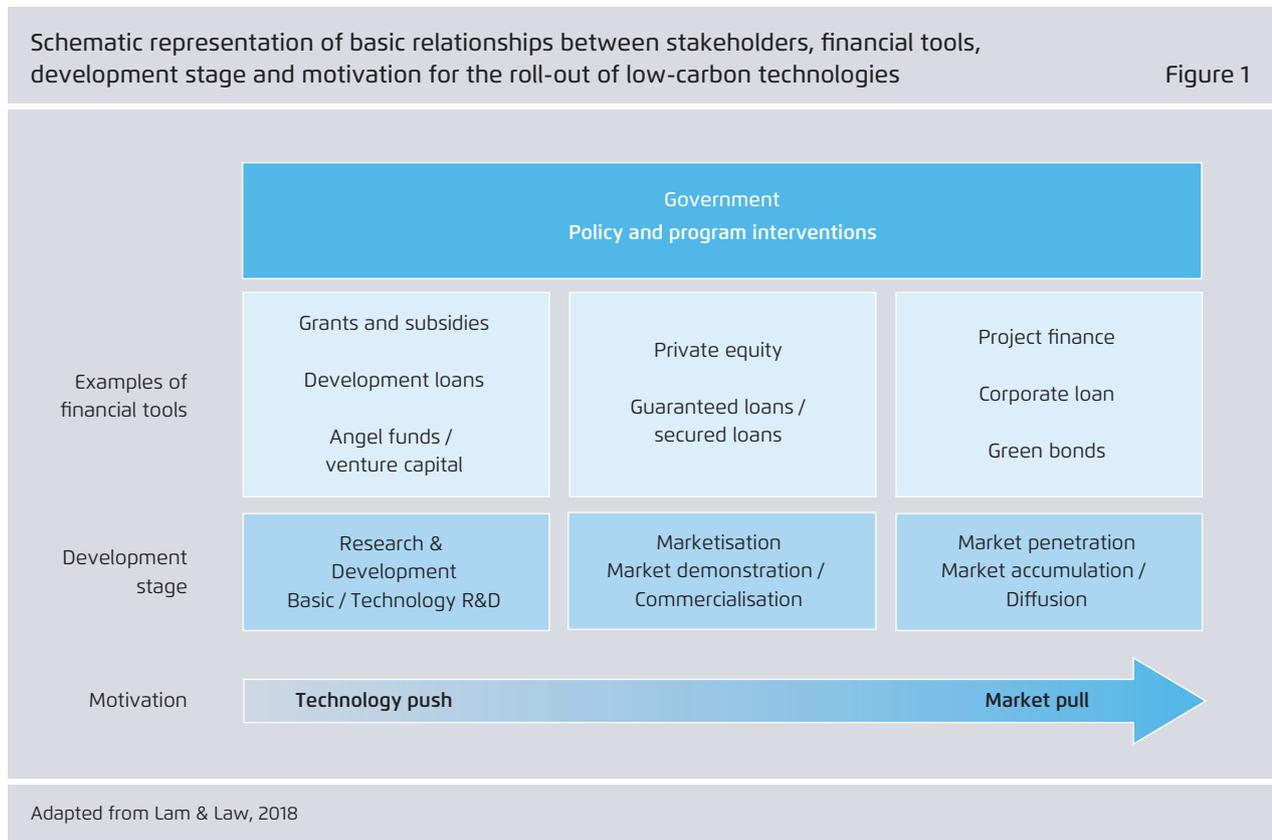
The role of financing instruments varies greatly between sectors and technologies, depending, among other things, on:³

- The level of privatization in different sectors and Member States (in the transport sector, for instance, infrastructure is mostly public, resulting in a crucial role for public direct investment)
- The role of the private and public sector (e.g. many markets, especially the energy market, are regulated and private companies have a duty to deliver and comply with regulated prices)
- The **technology readiness level** (with novel technologies typically requiring substantial public support)
- The abatement cost or cost difference between conventional and low-carbon technologies
- The payback time
- Certainty on how the new technologies influence operational costs (e.g. the rate of decline in the cost of lithium-ion batteries is expected to continue)

Public funding is effective in mobilizing private capital when it targets firms and households facing barriers to credit access and when it mitigates investment risks for investments that have uncertain returns or particularly high initial capital requirements (such as most renewable technologies, deep renovations, clean industry and large infrastructure projects). De-risking is particularly important and there are several instruments to influence the risk/return ratio of investments, such as market-based revenue stabilization for renewables, **carbon contracts for difference** (CCfDs), auctions for **power purchase agreements** (PPAs) and tax credits.

Financing instruments supported by public sources have the crucial role of leveraging private finance (e.g. via grants, **concessional loans**, subsidies and

guarantees), but the instruments do not function in a vacuum. There is a lack of clear, long-term policies on decarbonization and incentives (e.g. high electricity charges compared to fossil-based fuels). Long-term and transparent political planning (with corresponding public investments) can help to assure reliable conditions for investment and investor buy-in. Therefore, financing instruments need to be accompanied and strengthened by appropriate regulative frameworks (e.g. carbon pricing mechanisms, regulations to support market transparency and planning of upscaling of technologies) to be successful in the long term.



2 Why green investments provide a double dividend in terms of growth and jobs and preparing for the green transition

Investing in green projects will not only reduce environmental footprints and pave the way for climate neutrality, but also make the European economy more resilient while supporting recovery from the COVID-19 crisis. Building retrofits will stimulate the construction and industrial sectors, and renewable power generation has the potential to create many jobs in manufacturing and installation, especially solar PV. Cutting fossil fuel consumption will bring health benefits and reduce Europe's energy dependence and its large energy import bill (€275 billion in 2019).

The International Energy Agency (IEA) has estimated that a global Sustainable Recovery Plan can support the recovery and create nearly 9 million additional jobs worldwide per year in the short term, a third of which would be in the construction sector. In the European Union, implementing policies that target climate neutrality would raise employment by 2 million by 2030, [according to McKinsey](#). In both studies, investment in the power sector and buildings would drive most of the net job gains. McKinsey stresses the importance of frontloading infrastructure investment, estimating that 39 per cent of additional capital expenditures up to 2030 should be directed to building infrastructure for electricity grids, transportation, district heating, hydrogen, and carbon capture, usage and storage.

Given the large amounts of money that need to be absorbed within relatively short timeframes, it is important to ensure that green investment is distributed widely across regions and communities while also being directed to projects can be implemented quickly. Indeed, a number of clean technologies in the area of renewable energy, energy effi-

ciency and transportation are already commercially available and rapidly deployable (see e.g. [EY's list of 1000 shovel-ready projects](#)). To some extent, these technologies are not technically challenging and installation times range from few months to less than a year.

EU climate funding seeks to strike a balance between investing in mature and newer low-carbon technologies. Carbon abatement costs and options in the next decades depend on the investments we make today. In the IEA's Sustainable Development Scenario, often used as a reference for meeting the Paris Agreement goals, more than a third of emission reduction by 2050 comes from technologies that are currently in the demonstration or prototype stage, like hydrogen-based steel, ammonia and large batteries for long-distance sea shipping. Rapid innovation and diffusion require not only the upscaling of research infrastructure, but also investing in a skilled workforce. Enhancing human capital will boost economic growth and make the European economy more competitive and resilient.

Green finance will support a new wave of innovation in several areas, not only in energy but also in digitalization, automation, advanced materials and other manufacturing and farming technologies. The pursuit of high energy efficiency will spur research to raise the overall productivity (through product, process and organizational innovation). Cutting carbon emissions in transportation will require a deep rethinking of urban development, freight logistics and our travel habits.

3 Overview of the available EU climate funding opportunities and their tracking

The 2021–2027 Multiannual Financial Framework (MFF) was agreed upon in 2020 and the legal proposals underpinning the different EU budget programmes either have been politically resolved or will soon be, so that programming can start in mid-2021, with a slight delay. In addition to the €1.074 trillion MFF budget, Next Generation EU is a recovery instrument specifically designed to address the challenges of the Covid-19 crisis. It consists of €750 billion that will be committed by Member States up to the end of 2023 and spent by 2026 (see section 3.1.2).

If it manages to leverage private investment, the EU budget and the Next Generation EU in conjunction with national stimulus packages will be a very important catalyser for green investment in the coming years, as Member State's public budgets are seriously constrained due to the Covid-19 pandemic. Moreover, the total EU budget represents around 2 per cent of the national budgets of all EU countries, but in many Member States it is nonetheless of major importance (see Annex IV). Unlike national budgets, the EU budget is planned for a 7-year period and primarily used for investment rather than public services or social security systems. This makes the EU budget, especially in lower-income Member States, a key contributor to long-term investment such as infrastructure.⁴ Cohesion policy funding as a share of public investment is particularly high in some Member States; in 2015–17, it represented 84 per cent of such investment in Portugal, 80 per cent in Croatia, and >40 per cent in Eastern European Member States (aside from Slovenia).

Across the EU budget, 30 per cent of expenditures must be directed to climate action (the so-called "climate mainstreaming" obligation), and various programmes also earmark and/or specifically focus on green transition activities. In addition, the recov-

ery fund and several other EU programmes have to respect the **do no significant harm principle** that was established in the EU Taxonomy.

The EU climate funding landscape

In response to the economic fallout of the Covid-19 crisis, the Recovery and Resilience Facility (RRF) entered into force in February 2021 as the largest instrument of the Next Generation EU Fund (with €312.5 billion in grants and €360 billion in loans). The temporary instrument is designed to help Member States repair the immediate economic and social harm brought about by the coronavirus pandemic. Member States need to submit **Recovery and Resilience Plans** (RRPs) to access the funding by 30 April 2021 and reforms and investments have to be implemented by 2026. The RRF has a climate earmarking of 37 per cent and a digital target of 20 per cent.

Cohesion and structural funds already applied low-carbon spending earmarking in the last MFF, which has been further strengthened and is now applicable to all regions, including high GDP ones. Cohesion spending received a top up for 2021–2022 with REACT-EU, which does not have the same low carbon conditions, but can still use the short-term growth triggering investments, e.g. in building retrofits that are needed for the clean energy transition.

Horizon Europe and the **EU ETS Innovation Fund** (the latter of which is fed from ETS allowances) are funding instruments geared to early development stages, whilst the recovery funds are targeted more at market ready technologies that need to be upscaled for the revised 2030 ambition. One possible vehicle for renewables upscaling with recovery funds is the

Renewable Energy Financing Mechanism, which has been operational since January 2021.

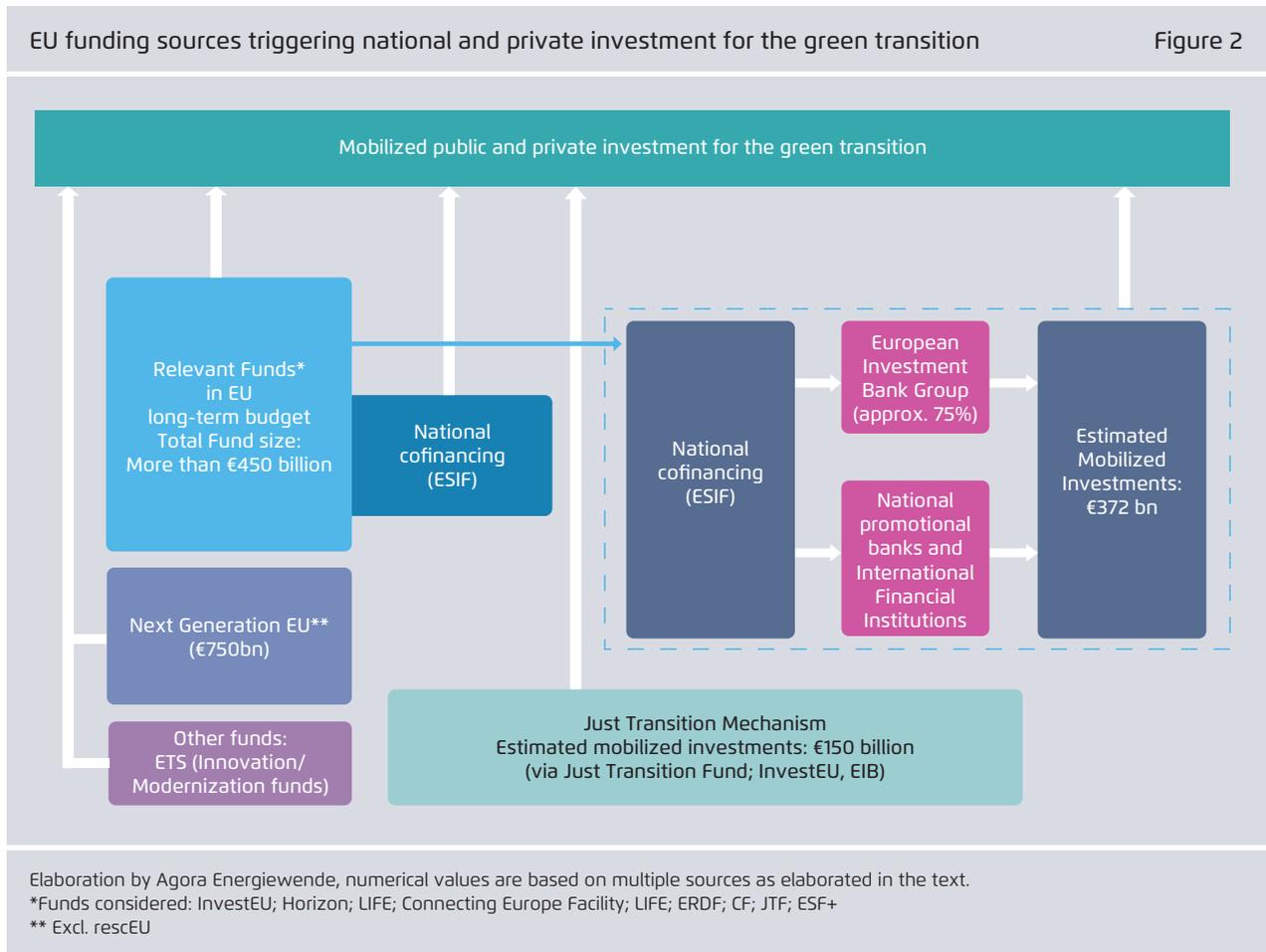
The new MFF is designed to allow funds to be more easily moved from one budget to the other, and for the allocation of grants in combination with **Invest EU** (so-called blending). **Invest EU** itself has a climate mainstreaming target of 35 per cent, has a 60 per cent climate mainstreaming target in its 'sustainable infrastructure window', and also aims to address strategic value chains.

The **Connecting Europe Facility (CEF)**, the EU's main infrastructure programme, focusses in particular on cross-border networks, while local investments (e.g. microgrids) are more often supported through cohesion spending. With the new window on

cross-border renewables and the ongoing revisions of the Trans-European Networks for Energy (TEN-E) and Transport (TEN-T) regulations (which determine the funding priorities for the transport and energy parts of CEF), the 2021–2027 CEF will be further aligned with the Green Deal objectives.

The **Modernisation Fund** and now in particular the **Just Transition Mechanism** are designed to support the countries and sectors/regions that are most affected by the transition towards a climate-neutral economy.

Finally, the new **LIFE** budget features a new Clean Energy Transition subprogramme of approx. €1 billion that comes in addition to another €1 billion of climate mitigation and adaption funding. The LIFE



programme picks up on activities that were once funded through the Intelligent Energy Europe programme – namely, enabling actions to prepare societies and markets for the green transition. Figure 2 provides an overview.

Two types of programme governance – Based on Member state allocations vs. call based

While some programmes are based on Member States receiving a national envelope and being framed by programs and plans (JTF, cohesion spending, RRF), other spending programmes disperse funding via calls for [tender and calls for project proposals](#) or partner institutions such as the European Investment Bank Group or other financial partners (for InvestEU, see implementation chain). The funding instruments have different eligibility criteria and follow different application procedures. For example, LIFE, Horizon Europe, CEF, and the Innovation Fund regularly [publish calls](#) for project proposals with different objectives where eligible entities can directly apply. New for this budget period is the [European Climate, Environment and Infrastructure Executive Agency](#) (CINEA), which is managing the implementation of Green Deal-related parts of certain EU programmes (CEF Transport, CEF Energy, Horizon Europe, LIFE). Additionally, the agency will manage the EU ETS Innovation Fund and the cluster on Climate, Energy and Mobility (from the [Horizon Europe Programme](#)).

To get EU funds where they are needed, funding is channelled through different types of intermediaries. For example, funding through InvestEU is channelled through the European Investment Bank Group (see Figure 2) and national promotional banks, which then use concessional loans to provide support for small and medium-sized enterprises (SMEs). A prerequisite for the disbursement of EU funding is compliance with state aid rules.

The different funding instruments are furthermore designed to complement each other and promote as many synergies as possible, e.g. to increase the amount of EU budget support that is provided through

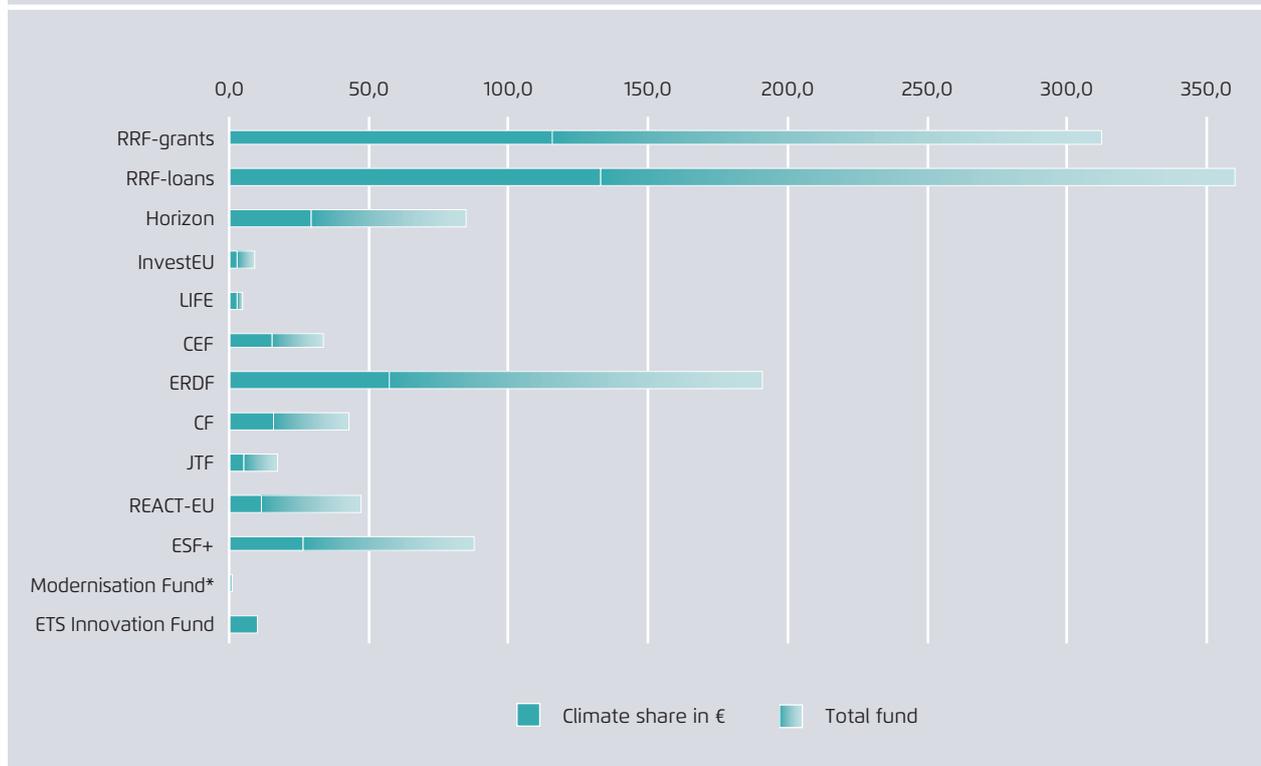
market-like instruments (e.g. loans, guarantees, equity investments) to increase the crowding in of private investment, instead of using traditional grants only. For example, cohesion policy funds could be blended with InvestEU. Combining various sources of funding is allowed provided they do not cover the same cost element.

In the following section, we explain the largest and most relevant funds for green financing (see Figure 2 and Annex II), including their focus, beneficiaries, main mechanisms, relevance to the Green Deal, underlying governance frameworks, and monitoring and technical support instruments. For more in-depth information and an overview of fund allocations to Member States, see Annex II-IV.

This report only highlights the most relevant and biggest funds for selected green transition sectors (industry, buildings, transport and energy), meaning that other very important funds such as the Common Agriculture Policy, which has a budget of €365 billion, are not considered.

Total fund sized and minimum climate shares of selected funds from the 2021-2027 EU budget in € billion (see also Annex 2)

Figure 3



European Commission, 2021 and fund specific documents, see section 3.1

*Current estimate, 2021-2030 period, depending on carbon price, could be as high as €14 billion

Climate target tracking

In the EU budget, the tracking methodology for the climate target is mainly based on the **OECD Rio Marker System** (0 per cent - not relevant to climate action, 40 per cent - significant contribution to climate action but objective not fundamental driver, 100 per cent - principal contribution explicitly designed for climate action); a method that has been repeatedly criticised (not least by the European Court of Auditors) for being misleading, not objective, and not rigorous enough, among other points.⁵ It is a method where climate spending is determined ex-post, in contrast to upfront earmarking.

For the climate and environmental target in the Recovery and Resilience Facility and Regional Funds (incl. the ERDF, the ESF+, the Cohesion Fund and the JTF), those Rio Markers have been improved by

lowering coefficients for selected intervention fields from 100 per cent to 40 per cent or by adding more technical details to the 100 per cent coefficients. One specific example is the budget line “025 - Energy efficiency renovation of existing housing stock [...]”. Table 1 of the Common Provision Regulation assigns a 100 per cent coefficient, which implies that €1 million spent on building renovation fully counts as a “climate spending” – regardless the amount of energy saved. This tracking method has been improved by taking 40 per cent as the “default option” and only awarding spending with the 100 per cent coefficient if at least a medium-depth level renovation is achieved, as defined in Commission Recommendation on Building Renovation (EU) 2019/786, which translates into primary energy savings of at least 30 per cent. This technical criterion was inspired by the EU Sustainable Finance Taxonomy.

However, the method is not fully aligned with the EU Taxonomy and does not include a separate target for biodiversity. No explicit exclusion list has been defined (i.e. a list of activities not eligible for funding, which is used by most financial institutions these days, including EIB). The RRFs do, however, need to specify how they comply with the do no significant harm principle.

Do no significant harm principle (DNSH)

As part of the 2020 EU Taxonomy Regulation for sustainable economic activities, the DNSH principle states that an activity is considered environmentally sustainable only if it does not significantly harm any of the six environmental objectives defined in Article 9 of the Regulation:

1. climate change mitigation,
2. climate change adaptation,
3. sustainable use and protection of water and marine resources,
4. transition to a circular economy,
5. pollution prevention and control, and
6. protection and restoration of biodiversity and ecosystems.

The DNSH principle aims to highlight the interrelationships between different environmental goals and to avoid progress in one dimension of the environment being achieved at the expense of another. DNSH assessment criteria will be further defined in secondary legislation.

For recovery spending, the COM issued a [technical guidance document](#) for Member States where key principles and a two-step methodology for assessing RRF components for their compliance with the DNSH criteria are outlined. While the guidance lays important groundwork for greening recovery efforts, it has been criticized for deeming natural gas power- and-heat generation eligible for RRF funding if certain conditions are met.

3.1 The features of the most relevant climate financing programmes

3.1.1 Funding instruments under the Multiannual Financial Framework

3.1.1.1 Regional and Cohesion Policy Funds (ERDF, CF, ESF+ and JTF)

Regional and cohesion policy funds are part of so-called **European Structural and Investment Funds (ESIF)**, which are managed by Member States through partnership agreements that outline the country's strategy and propose a list of programmes (so-called operational programmes). Partnership agreements and operational programmes for 2021–2027 are expected to be agreed by the second half of 2021 (Member States are currently engaged in informal dialogues with Commission Services) and will then be managed and implemented by national and regional bodies in partnership with the European Commission. Programmes are managed through regional managing authorities, but a range of organizations can benefit from regional funding, including public bodies, some private sector organizations (especially small businesses), universities, associations and NGOs. Funding requires different levels of co-financing by Member States, depending on the development status of the region.⁶ For the 2021–2027 period, operational programmes are in the process of being drafted. Monitoring and evaluation of the programmes are performed jointly by Member States and the Commission.

European Regional Development Fund (€191 bn)

The European Regional Development Fund (ERDF) is focussed on strengthening cohesion in Europe by reducing regional disparities in economic development. The thematic concentrations of the fund are: innovation and research, the digital agenda, support for SMEs, the environment and the net-zero-carbon economy. At least 30 per cent of all funds, which mostly take the form of grants but also financial instruments like loans and **guarantees** from the ERDF, are reserved for a "greener Europe", that is, projects

that contribute to the larger objective of climate neutrality. The funds will also respect the do no significant harm principle. In addition, 8 per cent of funds are specifically reserved for sustainable urban development, where many green transition investments occur, e.g. in heating microgrids or mobility.

Cohesion Funding (€43 bn)

Cohesion Funding (CF) provides financing for Member States whose Gross National Income per inhabitant is less than 90 per cent of the EU average. CF does not fund *individual projects*, but it funds multi-annual national programmes aligned to EU objectives. In line with Green Deal objectives, the Cohesion Fund has a climate earmarking of 37 per cent. The CF provides financing in the shape of loans, guarantees and equity for the TEN-T and for environmental efficiency, renewable energy and sustainable urban mobility projects.

European Social Fund (€88 bn)

European Social Fund (ESF+) is the main fund for developing the human capital needed as the labour market transitions to a digital and green economy. The fund is also designed to fight poverty and promote social inclusion. The largest share of the fund (€87.3 billion) is for the shared management strand implemented by EU Member States (including **ESF+ Technical Assistance**) and €676 million for the **Employment and Social Innovation (EaSI)** strand. The EaSI fund under ESF+ is meant to support social projects and new types of employment, with allocation based on calls for proposals. ESF+ TA and EaSI tenders are published on a **dedicated portal**. There is no specific amount in the ESF+ earmarked for activities related to decarbonization, but upskilling in sectors related to the environment, climate, circular economy and bio-economy is encouraged.

React-EU (under NGEU) (€47.5 bn)

Recovery Assistance for Cohesion and the Territories of Europe (REACT-EU) provides fresh money for cohesion spending to be used quickly in 2021–2022 to help the real economy. This spending comes on top

of the cohesion spending allocation for 2021–2027. It will be broken down per MS based on economic needs due to the impact of COVID-19, as measured through GDP drops, unemployment rates and relative wealth. The €47.5 bn will be channelled through the ERDF, ESF+ and the Youth Employment Initiative. No national co-funding is required for this funding. Operations as of February 2020 can be covered and technical assistance can also be supported. Member States are flexible in terms of how they direct REACT-EU resources to their needs but are “expected” to contribute 25 per cent of its financial envelope to climate objectives, and action supporting the green and digital transitions is explicitly mentioned.

Just Transition Fund (JTF) (€17.5 bn)

The **Just Transition Fund (JTF)**, which is part of the broader **Just Transition Mechanism (JTM)**, is allocated through both the NGEU (€10 bn) and the MFF (€7.5 bn). This fund is meant to help Member States in regions that are heavily reliant on fossil fuels and other carbon-intensive industries to transition to a green economy. The fund is focussed on creating a fair job market for workers who are forced to leave the fossil fuel industry through reskilling & upskilling programs, R&D, the regeneration of sites, job seeking assistance, digitalization, the circular economy and technical assistance. The fund excludes fossil fuels and nuclear power. Moreover, the JTF includes climate policy incentives by a green rewarding system (up to 18 per cent of JTF allocation under MFF) and conditional access to 50 per cent of **national funding allocations** for Member States based on the adoption of national objectives for climate neutrality by 2050. The JTF will be co-financed by MS and complemented with other MFF funds.

National government decide on how they distribute their **national allocations of JTF funds** across regions⁷ through **Territorial Just Transition Plans (TJTP)** that identify regions that need to transition from carbon intensive industries, which need Commission approval. The TJTPs need to be a single country-wide

plan or multiple region-specific plans. The TJTPs propose how member states want these regions to look in 2030, with specific objectives regarding reskilling, development and environmental rehabilitation. Furthermore, Member States seeking to access JTF funding have to provide for each region detailed descriptions of economic challenges, needs, operation types, result indicators, governance mechanisms, monitoring & evaluation schemes and partnerships. Templates for TJTPs are available in Annex II of the JTF Regulation. Regions should be identified in consultation with DG REFORM, need to draw on analysis provided on priority regions in the [Annex D of the 2020 European Semester Country Reports](#) and need to be consistent with National Energy and Climate Plans (NECPs). Technical support and advice on writing the Territorial Just Transition Plans can be accessed through the Just Transition Platform, building on both the Initiative for Coal Regions in Transition and Technical Support Instrument (which helped, for example, the transition of Slovakia's Horna Nitra Region). Some TJTP drafts, like the one for the Polish Wielkopolska region, have received praise, while others have drawn criticism.

In order to unlock funding from the JTF, member states need to match every euro received from the JTF with €1.5 to €3 from the ERDF and ESF+ funds, and JTF financing also needs to be co-financed with national funds, according to Cohesion Policy.

3.1.1.2 Other relevant funds under the MFF Horizon Europe (€84.9 bn)

[Horizon Europe](#) is the EU's main research and innovation framework that sets out funding opportunities through thematically focused calls for proposals. One of its four strategic orientations in 2021–2024 is "making Europe the first digitally enabled circular, climate-neutral and sustainable economy". The fund has a climate target of 35 per cent and a dedicated cluster on "Climate, Energy and Mobility", but innovation relevant to the sectors featured in this guide could also be relevant under other clusters (e.g. digital industry). It also features €10 bn for the

European Innovation Council (EIC), a **one-stop shop** that helps start-ups and SMEs develop and scale up innovation to the stage where it can attract private investment.

Connecting Europe Facility (CEF) (€33.7 bn)

The [Connecting Europe Facility \(CEF\)](#), which covers the transport, energy and digital sectors, aims to support investment with a cross-border dimension, to make Europe more connected and to implement the Trans-European Networks for Energy (TEN-E) and Transport (TEN-T). In 2021–2027 it has a budget of EUR 33.7 billion: EUR 25.8 billion for transport (including EUR 11.29 billion for cohesion countries); EUR 5.84 billion for energy, of which at least 15 per cent is earmarked for cross-border renewable energy projects; and EUR 2.06 billion euros for the digital sector. The programmes focus on targeted infrastructure investments and "missing links" to make Europe more connected. The regulation for CEF stipulates that at least 60 per cent of CEF funds need to contribute to EU climate objectives, with the separate requirement that 100 per cent of investments in certain areas need to contribute to EU climate objectives (namely, related to rail infrastructure, charging infrastructure, alternative and sustainable fuels, clean urban transport, smart grids, electricity transmission and storage, CO₂ transportation and renewable energy). Waterways, multimodal transport and gas infrastructure have a 40 per cent earmark, but only if they enable the use of renewable hydrogen or bio-methane. The green objectives of CEF are expected to be further strengthened in the reviews of the TEN-E and TEN-T Regulations, which detail eligible actions for CEF.

CEF mainly uses grants, with different co-financing rates depending on the project type, but also offers financial support to projects through other financial instruments such as guarantees, performance-based grants, co-financing structures and project bonds. The 2021–2027 CEF provides more room for so-called synergy actions, when an investment delivers in two sectors. To be eligible for support under CEF Energy,

projects must be contained in the “projects of common interest list” (for the infrastructure component).

LIFE – Programme for Environment and Climate Action (€4.8 bn)

The **LIFE** programme is the only EU budget fully devoted to environmental objectives. The 2021–27 programme period is currently being defined; the European Commission has proposed raising the budget to €5.45 billion. The new LIFE programme is anticipated to have four sub-programmes: nature and biodiversity; the circular economy and quality of life; climate change mitigation and adaptation; and the clean energy transition. The programme fills the niche between research funding and infrastructure funding and e.g. with regard to clean energy transition (€1 bn), the objective is capacity building and making markets and societies ready for the energy transition and supporting implementation of EU provisions for energy efficiency and renewables. The programme allows any private or public entity in Europe (e.g. SMEs, public authorities, start-ups) to apply; projects are generally small scale. Projects receive co-funding of up to 60 per cent. Technical assistance projects can receive a contribution of up to 55 per cent, which cannot exceed €100,000.

There are yearly rounds of calls for proposals with different timelines, requirements and budgets for both classic and ‘integrated’ projects, focussed on climate mitigation, adaptation, technical assistance and governance & information related projects. These proposal calls can be accessed through the EU’s [funding & tender portal](#).

InvestEU (guarantee of €26.2 billion)

The **InvestEU** programme builds on the **European Fund for Strategic Investment** (EFSI) and it specifically targets higher risk innovations, SMEs, and projects hindered by market failures. It provides a framework for debt financing, risk sharing, and equity and **quasi-equity** instruments backed up by a guarantee from the EU budget and other implementing partners. It is demand driven, meaning that

private actors such as SMEs can directly apply for funding via local intermediaries.

The majority of the **InvestEU** budget (75 per cent) is implemented through the **European Investment Bank** (EIB), and the remainder by national promotional banks. The €9.4 bn earmarked in the MFF and RRF for InvestEU allows the EU budget to provide a guarantee of €26.2bn, which is designed to ultimately trigger an estimated €372bn in additional investment in 2021–27 (a multiplier effect of 11.4). In addition to the funding instrument itself, InvestEU consists of an advisory hub that provides technical support as well as its own portal, which aims to connect investors and project developers. In the new EU budget, all other EU programmes have a clause that allows for blending with InvestEU.

InvestEU funding has an overall climate spending target of 35 per cent. However, the sustainable infrastructure window (which supports projects in sustainable energy, digital connectivity, transport, the circular economy, water, waste, other environment infrastructure) has a 60 per cent target. Furthermore, the Strategic Investment Facility is meant to support critical infrastructure, including energy (e.g. renewables, storage, batteries, hydrogen, CCS). The other windows under InvestEU (Research, Innovation and Digitalization; SMEs; Social Investment and Skills), are also highly relevant to the green transition. In InvestEU, the “do no significant harm” principle of the EU taxonomy regulation applies horizontally (see [Technical guidance on sustainability proofing for InvestEU](#)). InvestEU furthermore includes a Just Transition Scheme that is linked to the Just Transition Mechanism, which provides loans for investments in energy efficiency, renewables, and green technologies.

Link to the Climate Roadmap of the European Investment Bank (EIB)

The EIB is at the heart of EU programmes directed at co-financing specific projects (e.g. under InvestEU). The EIB is currently redesigning its [investment](#)

strategy to incorporate sustainable finance objectives by committing to:

- increasing “its level of support to climate action and environmental sustainability to exceed 50 per cent of its overall lending activity by 2025 and beyond, and thus help to leverage €1 trillion of investment by the EIB Group over the next decade”.
- Ensuring that “all financing activities are aligned to the goals and principles of the Paris Agreement by the end of 2020. As the EU climate bank, the EIB Group cannot support the Agreement with 50 per cent of green finance if, at the same time, it undermines the goals with the remaining 50 per cent. In line with the principles of sustainable finance, the EIB Group needs to ensure that all its activities do no significant harm to the low-carbon and climate-resilient goals of the Agreement”.
- Using the EU Taxonomy as a starting point, “with the expected adoption shortly of technical screening criteria to establish whether an activity ‘does no significant harm’ to climate change mitigation or adaptation objectives”.

As the EIB is, next to InvestEU, central to a number of other funding mechanisms under the new budget, this commitment could have a huge influence on the decarbonization of specific investment programmes.

3.1.2 Recovery and Resilience Facility

Comprising €672.5 billion, the Recovery and Resilience Facility (RRF), which entered into force in February 2021, is the largest instrument of the Next Generation EU Fund (with €312.5 billion in grants and €360 billion in loans). The RRF significantly augments the EU’s recovery spending, particularly over the next five years up to 2026. It is available to all Member States, but has a focus on countries most affected by the Covid-19 pandemic. The available grant allocations range from 0.2 per cent to 12.8 per cent of Member State GDP (see Annex IV), in addition to which Member States can request a RRF loan of up to 6.8 per cent of their 2019 GNI.

The agreed Regulation on the Recovery and Resilience Facility sets a climate mainstreaming target for each plan of 37 per cent, for which a specific tracking methodology has been developed. This methodology builds on the Rio markers (see section 2.1.3) and needs to be checked against the ‘do no significant harm’ principle for all components (see more on the governance of the RRF in the next chapter). In addition, guidance published by the European Commission proposes seven spending areas (so-called **flagship areas**) for investment and reform in the green and digital sectors that Member States are strongly encouraged to cover in their plans (see Table 1).

The three green flagship areas on renewables, building renovation and clean funds for additional mobility will ensure that Member States use recovery funding with a view to raised energy and climate ambition, and thus beyond the plans set out in the National Energy and Climate Plans. Support payments for renewables are eligible. The RRF will be centrally coordinated by designated authorities in Member States (e.g. often the economic ministries or agencies affiliated to it). Notably, the funds are supposed to be committed by the end of 2023 and targets should be reached by the end of 2026 in order to contribute to an economic recovery. This means that measures, instruments and reforms proposed by the Member States need to be as “ready” as possible (see Figure 4).

The RRF is used to implement national plans without requiring national co-financing. To access funding under the RRF, each Member State should have submitted a Recovery and Resilience Plan (RRP) by 30 April 2021, which is assessed through the **European Semester** framework (see section 3.1.4). The emphasis on reforms and the synergies between reforms and investment programmes is a distinctive feature of the RRF. Member States, must, for example, address the **country-specific recommendations** issued through the European Semester process to tackle pre-existing national bottlenecks. The plans are assessed on whether the proposed investments

Flagship areas of the Recovery + Resilience Facility		Table 1
Flagship title	Investment areas	
Power-up	This flagship aims to lay the foundation for Europe to become a lead market for green hydrogen, such that hydrogen provides 40% of 500 GW of renewable power by 2030. It includes funding for the installation of 6 GW of electrolyser capacity and the production and transport of 1 million tonnes of green hydrogen across Europe by 2025.	
Renovate	The RRF will fund renovations to improve the energy efficiency of public and private buildings. The RRF aims to contribute to a doubling of the renovation rate by 2025, and to induce more deep renovations.	
Recharge and refuel	This flagship aims to fund one in three of the approx. 1 million charging points needed for electric vehicles and about half of 1,000 hydrogen stations that are needed.	
Connect	This flagship aims to ensure that all of the EU has access to the widest possible uninterrupted broadband 5G connection by 2025.	
Modernize	The EU aims to provide an EU-wide digital identity (e-ID) and ensure the EU has user-friendly digital services by 2025.	
Scale-up	The production of semi-conductors is to be doubled by 2025, in order to produce 10 times as many energy efficient processors. This aims to allow for the doubling of EU companies with advanced cloud services and big data to 32%.	
Reskill & Upskill	By 2025, the EU hopes to increase the share of Europeans aged 16 to 72 with advanced digital skills from 42 to 70%. Investment in digital education will ensure that underperformance in computer and information skills is reduced to less than 15% of 13/14 year-olds. Furthermore, by 2025 the EU aims to ensure that employment is found by at least four in five vocational education and training graduates.	

European Commission. 2020. Annual Sustainable Growth Strategy 2021.

and reforms contribute to the country's long-term resilience, economic recovery, as well as green and digital transitions, including criteria such as:

→ Credibly demonstrate that at least 37 per cent of the plan's measures contribute to the green transition, including biodiversity or to the challenges resulting from it (based on qualitative and quantitative

explanation according to an adjusted climate tracking methodology)

- Specify how all measures respect the "do no significant harm" principle of the EU Taxonomy Regulation (see [technical guidance](#) on reporting of compliance with the DNSH principle)
- Specify in their plan the scope, timeline and expected impact of the proposed measures on the reduction of greenhouse gas emissions or adapta-

tion to climate change, share of renewable energy, energy efficiency and power grid interconnection (in line with the objectives of EU climate law and based on indicators consistent with National Energy and Climate Plans)

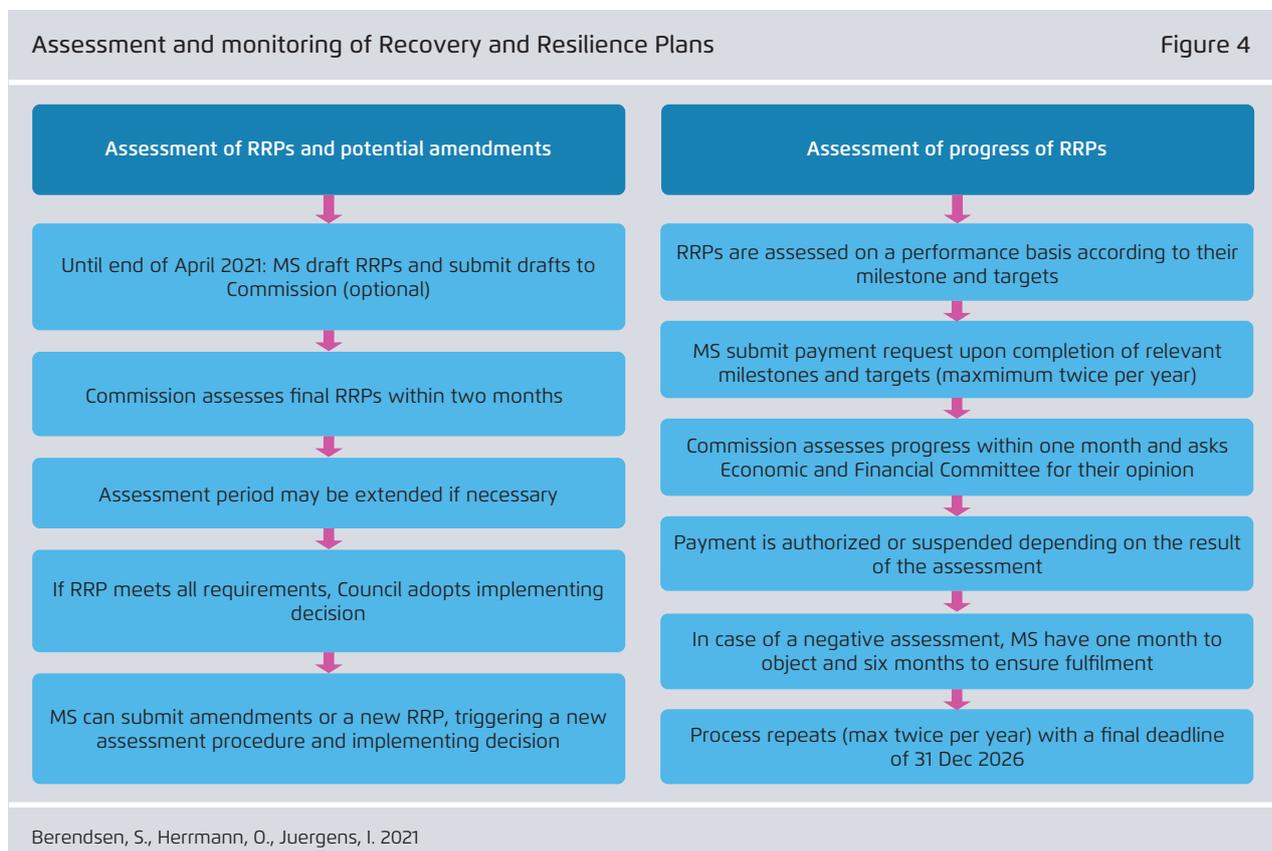
- Outline as appropriate how the proposed measures will help to meet objectives, including those related to waste, water and pollution monitoring; marine and water resources; the transition to sustainable food systems; and the transition towards a more resource efficient and circular economy (to the extent possible, Member States should refer to the environmental objectives defined in the EU Taxonomy Regulation).

Disbursements under the Recovery and Resilience Facility are performance-based. The Commission assesses the achievement of **milestones** and **targets** outlined in the Recovery and Resilience Plans a maximum of two times per year. Notably, the dis-

bursement is based on estimated costs and not linked to costs actually occurred, which makes it very important that the pricing of **components** in the RRP is as accurate as possible.

Thus far, public participation and transparency in drafting the Recovery and Resilience Plans has been largely side-lined, with formal processes missing in most Member States.

In order to support the quick absorption of recovery funds, Member States are explicitly permitted to use their recovery grants through the recently established Renewable Energy Financing Mechanism (REFM) and to contribute financially to renewables projects in another Member State (with the European Commission organising matching). Using the Union Renewable Financing Mechanism exempts the project from state aid scrutiny, and also counts toward the national renewable contribution.



Due to its sheer size, the RRF could also play an important role in providing direct public investment for necessary infrastructure, such as renewables-based hydrogen pipelines. The RRF is also well suited to help Member States to kick-start necessary reforms, including regulatory enhancements, the introduction of regulatory reforms, carbon contracts for difference, or “one-stop shops” that bring together various stakeholders to improve planning (e.g. for an integrated grid that supports renewable hydrogen).

3.1.3 Other relevant, non-MFF EU funds

ETS Innovation Fund (€10 bn between 2020–30)

The [ETS Innovation Fund](#) is not financed through the MFF, but rather through the auctioning of EU ETS allowances. Anticipated to provide around €10 bn in 2020–30, the fund has the specific goal of supporting the commercial demonstration of innovative low-carbon technologies by giving grants to innovation projects.

Modernisation Fund

(Current estimate: €0.64 bn in 2021–2030)

The auctioning of [EU Emissions Trading System](#) (EU ETS) allowances will finance the [Modernisation Fund](#), which will co-finance and de-risk investments that promote renewables, energy efficiency, energy storage, grid improvements, and a just transition for fossil fuel workers. While currently the fund contains about €0.64 bn for 2021–2030, it could grow much larger (up to €14 billion⁸) depending on future ETS carbon prices (2021–2030).

Projects financed by the Modernisation Fund are pre-selected by eligible Member States, who then directly submit investments to the European Investment Bank on a rolling basis. The Modernisation Fund is only accessible to the 10 lower-income EU Member States.⁹ The requests are assessed by an Investment Committee, which is responsible for disbursement decisions (twice a year per Member State). It is not possible for entities other than Member States to submit requests. The implementation of the Fund as well

as monitoring and reporting is the responsibility of the concerned Member States.

EU Renewable Energy Financing Mechanism

The Renewable Energy Directive introduced a binding target that Member State must obtain 32 per cent of gross final energy consumption from renewable sources by 2030. In order to achieve this target, the EU Renewable Energy Financing Mechanism (REFM) allows Member States to invest with grants in renewable energy projects in the territory of other EU countries. These investments contribute to the renewable energy targets of both the ‘contributing country’ and the ‘host country’. The mechanism enables the use of comparative geographic advantages in other Member States, in order to make investment in renewable energy more cost-effective. For example, this allows land-locked countries to invest in offshore projects while enjoying the ‘statistical benefits’ of the project for renewable energy targets (while potentially also using RRF funds).

Member states and private entities can enter money into the REFM, which is then allocated through a competitive tender process administered by CINEA. Host member states retain the right to decide which projects are allowed on their territory and shape conditions for such projects. Contributing states or private entities can indicate preferences (e.g. regarding the tender procedure or the type of technology they are willing to contribute to). REFM grants cover either the installation costs or operations costs of renewable facilities in the electricity, transport or heating & cooling sectors. State aid rules do not apply for projects under the REFM for any of the participating countries.

3.1.4 Monitoring and Technical Assistance in the New EU Budget

The European Semester

The framework for coordination of national economic policies at EU level is called the European Semester, due to its semi-annual cycle. The Semester serves as early warning mechanism for economic or budgetary

imbalances. Based on its elaborate monitoring process, it facilitates national economic policy reforms and alignment across the EU. The European Commission, as guardian of the EU treaties, carries out consultations with stakeholders and policy makers in Member States throughout the year (supported by its European Semester Officers based in the EU representative offices in each Member State) and (through its country teams) provides annual country reports and country specific recommendations for all EU Member States to align their economic and social policies with EU objectives. The European Semester plays an important role in supporting structural reforms, e.g. by linking to DG REFORM, where Member States can request technical support to carry out reforms.

The European Semester is at the heart of the Recovery and Resilience Facility and its structure has been (temporarily) adjusted to fully support the functioning of the RRF. A Commission assessment of the national Recovery and Resilience Plans will determine whether Member States receive RRF funding. Furthermore, the Recovery and Resilience Plans are linked with the Semester, as they will be checked against the country-specific Semester recommendations.

EU-Reform Support Programme (RFP)

The RFP¹⁰ is a new instrument designed to stimulate the implementation of priority reforms¹¹ identified in the European Semester, consisting of financial and technical assistance for Member States to get the appropriate administrative capacity to implement reforms. Most relevant for the green transition is the Technical Support Instrument (€ 0.86 bn) available for all Member States to enlarge their administrative capacity to implement European Semester reforms, including green reforms.¹² Support is tailor-made and does not require MS co-financing (and can be used e.g. to shape economic reforms or write national Recovery and Resilience Plans). So far, over 1,000 reform projects have been executed under the TSI,

including numerous projects related to achieving climate and energy goals.

The lack of relevant skills is a major barrier when it comes to the absorption of funding for green projects, e.g. when it comes to building renovation, administration, digital skills, etc. Here, funding instruments (e.g. the RRF, JTF, CF) as well as the technical support instruments offer the opportunity to bridge the gap by re- and upskilling the workforce.

European Local ENergy Assistance (ELENA)

ELENA is a technical assistance facility operated by the EIB in cooperation with the Commission for large scale bankable sustainable energy investment programmes that mobilize more than EUR 30 million. ELENA covers 90 per cent of necessary project development costs for such projects. Since its launch in 2009 it has mobilized over EUR 7 billion in investments by rewarding about 200 million in technical assistance reimbursements. ELENA supports both public and private entities in developing, implementing and mobilising finance for a clearly defined investment programmes related to sustainable energy (EUR 30 million), sustainable residential (EUR 97 million) and urban transport (€ 5 million). Costs that are eligible for ELENA funding include but are not limited to energy audits, legal/financial advice, business plans, creating tendering procedures and creating project implementation units. Eligible parties can apply by sending in proposals. Examples of current projects include electric busses in Klagenfurt (Austria) and Sustainable Homes in South-Holland (Netherlands).

4 Climate financing needs and opportunities per sector

No single sector or technology can enable the entire economy to deliver the Green Deal and reach Europe's emission targets. The successful path to emission reduction depends upon a wide range of technologies in different sectors, with actors in those sectors being increasingly interconnected. As sectors are highly integrated, it is important to keep in mind that policies and investment decisions do not take place in isolation, but influence each other. The technologies and financing instruments presented in the following four sections (industry, buildings, energy and transport) are meant to give the reader a taste of the most important investment areas and reforms, without going into too much detail. Where possible, we link to the most important policy documents and literature on the topic.

4.1 Low-carbon transition in the industry sector

Decarbonising the industrial sector is a highly complex endeavour, as the sector is very diverse, has highly globalized supply chains and a complex web of stakeholders. The basic materials sector in particular (e.g. steel, chemicals, ammonia, cement) is very energy intensive, and to reach climate targets, a deep transformation is unavoidable. Industrial installations over a certain size fall under the EU ETS (e.g. iron and steel plants and cement, petrochemicals, ammonia and aluminium factories). Industrial sectors still receive free allowances, to prevent carbon leakage.

The industrial sector is highly capital intensive and dominated by private actors. Furthermore, the industrial sector is subject to an increased risk of lock-in effects due to rushed bailouts in the wake of the Covid-19 pandemic. It is important to keep in mind that investment cycles in the industry sector

are substantially longer than in most other sectors – with the year 2050 being only one investment cycle away. Furthermore, because 30 to 50 per cent of industrial assets in the EU steel, chemical and cement sectors will reach the end of their lifetimes before 2030, a regulatory framework that allows the kick-starting of the sector's low-carbon transition is necessary. Table 2 highlights the key cross-cutting technologies and concepts, referencing relevant studies on **investment** needs and trajectories.

Renewable hydrogen technologies

Greening the industrial sector strongly relies on hydrogen as a cross-cutting technology. Supplying renewable hydrogen technology has been promoted as one of the key flagships of the EU's Annual Sustainable Growth Strategy, which aims to "support the instalment of 6 GW of electrolyser capacity and transport of 1 million tonnes of renewable hydrogen across the EU by 2025". The main advantage of hydrogen is that it allows for the large-scale integration of renewables and a means of storing energy, which is especially important in hard-to-abate branches of industry. In addition to applications in the industrial sector, there is demand for renewable hydrogen in aviation and maritime transport, and as part of district heating systems.

For a meaningful transition, it is crucial for the whole system and grid to be smarter and more integrated. There is an urgent need for funding and reforms to improve planning on a national and European level, as well as to spur digital innovation. Notably, while most green hydrogen projects are currently pilot projects, industry experts predict that with the right level of support, the technology will undergo a rapid growth path, similar to that of renewables.

Key technologies and strategies for decarbonising the industrial sector		Table 2
Cross-cutting technologies and concepts	Examples of crucial steps towards carbon-neutrality in the sector	Key literature on investments needs and trajectories
Renewable hydrogen technology	<ul style="list-style-type: none"> → Installation of pipelines → Development of storage capacity → Grid integration → Electrolyser capacity → Technological advances (R&D) 	<ul style="list-style-type: none"> → <i>EU hydrogen strategy 2020</i> → <i>IRENA (2020)</i> → <i>Agora Energiewende and AFRY Management Consulting (2021)</i> → <i>IEA, 2019</i>
Renewable energy for direct electrification and renewable hydrogen	<ul style="list-style-type: none"> → Enhanced deployment of renewables (doubling of roll out pace in next decade) → Grid infrastructure & integration → Increased use of heat pumps for heat supplies <180°C → Increased use of electrode boilers for heat supply up until 500°C → Technological advances (e.g. for high-temperature heat electrification) 	<ul style="list-style-type: none"> → <i>EU energy system integration strategy</i> → <i>EU hydrogen strategy 2020</i> → <i>Agora Energiewende and AFRY Management Consulting (2021)</i>
Carbon capture, utilization and storage	<ul style="list-style-type: none"> → Demonstration and upscaling of the full production process before 2030 → Demonstrate and scale-up the capture of carbon for its use in long-lived products (e.g. concrete) → Combining with biomass for negative emissions via BECCS 	<ul style="list-style-type: none"> → <i>European Technology Platform for Zero Emission Fossil Fuel Power Plants</i> → <i>Kapetaki (2020)</i>
Circular economy	<ul style="list-style-type: none"> → Improved waste collection systems → Improved sorting processes for end-of-life products → Improved product design regulations to allow for better recycling → Improved labelling and certification → Supporting regulatory frameworks and development of demand for recycled products 	<ul style="list-style-type: none"> → <i>Material Economics (2018)</i> → <i>EllenMcArthur (2020)</i>
Sub-sector	Examples of promising technologies	
Chemical sector	<ul style="list-style-type: none"> → Heat and steam generation from power-to-heat → Green hydrogen deployment → Direct electrification (e.g. electric steam crackers) → Bioenergy → Feedstock substitution → Chemical recycling → Decrease of process-related emissions 	<ul style="list-style-type: none"> → <i>Material Economics (2019)</i> → <i>Chiappinelli, Olga et al. (2020)</i> → <i>Agora Energiewende and Wuppertal Institute (2021)</i>
Steel sector	<ul style="list-style-type: none"> → Hydrogen-based direct reduction¹² → Direct electrification → Bioenergy and Bioenergy with carbon capture and storage → Recycling (circular economy concept) → Decrease of process-related emissions 	<ul style="list-style-type: none"> → <i>Material Economics (2019)</i> → <i>Chiappinelli, Olga et al. (2020)</i> → <i>Agora Energiewende and Wuppertal Institute (2021)</i>
Cement Production	<ul style="list-style-type: none"> → Raw material substitution → CCU/CCS and BECCS → Direct electrification and heating → Hydrogen application → Technical performance → Recycling (circular economy concept) → Decrease of process-related emissions 	<ul style="list-style-type: none"> → <i>Material Economics, (2019)</i> → <i>Chiappinelli, Olga et al. (2020)</i> → <i>Agora Energiewende and Wuppertal Institute (2021)</i>

Other resources on investment needs and trajectory in the industry sector: OECD (2017); Agora Energiewende and Wuppertal Institute (2021); IEA, 2019; Hydrogen Europe (2019); Material Economics, (2019)

In 2020, the European Clean Hydrogen Alliance (ECHA) was established with the goal of kick-starting an investment agenda and supporting the scaling up of the hydrogen supply chains across Europe. 2020 also saw the launch of the Renewable Hydrogen Coalition, which exclusively promotes renewable-based hydrogen.

To meaningfully deploy renewable hydrogen by 2030 requires estimated investment needs of at least €430 billion up to 2030 according to the European Clean Hydrogen alliance. The rapid development of the hydrogen economy is not feasible without significant public investment, which is why placing emphasis on intelligent policy instruments such as carbon contracts for difference (CCfDs), which are able to influence both CAPEX and OPEX, is important. Targeted infrastructure investment through MFF and RRF, paired with the necessary funding on a Member State level, could make a crucial difference.

Generally, the key barriers for investments in hydrogen are high upfront investment costs (e.g. for electrolyzers), the perceived risk of investment, limited experience and the lack of suitable infrastructure, resulting in a “chicken and egg” problem. Direct public investment is crucial, especially for R&D expenditure and for grid infrastructure and electrolyser capacity (e.g. via RRF, CF, CEF-E, etc.). Green hydrogen is the key cross-cutting technology, and needs to become economically viable, since it allows the decarbonization of processes that are otherwise difficult to decarbonize. New technologies (such as hydrogen, but also other low-carbon technologies related to ammonia, cement, plastics, and steel) imply investment risk, due to significant CAPEX commitments. Accordingly, grants and other grant-like schemes have to be made increasingly available (e.g. via Horizon and InvestEU).

Given uncertainty surrounding future profitability of many forward-looking green investments, investment outlays can be effectively encouraged with grants that cover most of the additional, greening value of investment in combination with guarantees or loans.¹⁴

Industrial firms need to be strengthened and incentivized to quickly adapt to the “hydrogen economy”. Suitable tools for this include upfront grants, guarantees, concessional loans and other methods to de-risk private investment. A CCfD scheme could reduce financing costs and bridge the cost gap between conventional and low-carbon technologies (particularly in relation to green hydrogen). Facilities that promote new technologies such as the Innovation Fund, Horizon and InvestEU will play an important role in decarbonising industry. Furthermore, the huge firepower of the RRF could serve as an additional funding stream for grant-like schemes such as CCfDs.

While funding instruments such as the RRF are important to kick-start investment, renewable hydrogen is only viable if investments are supported by a long-term policy framework that is able to ensure hydrogen is a feasible technology over the long-run, so that investments do not “evaporate”. A number of reforms are necessary to break down barriers for hydrogen, including addressing the administrative burden and outdated regulations (e.g. for transmission grid infrastructure); regulatory changes such as improved product standards; certification systems to support market transparency; and effective carbon pricing.¹⁵

Circular economy strategies

While the circular economy will be key to decarbonize the industrial sector as a whole (e.g. by making scrap materials available that significantly lower the production emissions), in neither the MFF nor in the RRF does it play a very prominent role, possibly because it is more of a principle rather than a specific technology or sector. Circular economies are also not mentioned as part of the flagships, and also underdeveloped in the EIB Climate Roadmap. Nonetheless, with important milestones such as the EU Circular Economy Action Plan (2020), circular economies are expected to play a major role in decarbonizing industrial sector, if properly incentivized. Key bottlenecks for the application of the “circular first” principle is a lack of R&D funding for innovative technologies and

waste collection infrastructure; lack of incentives and product standards; and lack of support for circular business models and technologies to **retrofit** existing production facilities. Suitable support could be coming from ERDF, LIFE, Horizon Europe, InvestEU and the RRF (e.g. in the form of R&D funding, investments in public waste collection infrastructure, grants for deploying technologies, or policy reforms).

Carbon capture, utilization and storage (CCUS)

Carbon, capture, utilization and storage technology is used to “sequester” carbon dioxide emitted from large point sources so that it is not released into the atmosphere. The development of this technology and infrastructure will also pave the way for one potential negative emissions route via BECCS. After being captured, CO₂ is compressed and transported and either stored (e.g. in geological reservoirs) or further processed for use as a resource (e.g. for fuels, carbonates, polymers and chemicals). High upfront investment costs are the largest barrier to the uptake of CCUS technologies, e.g. for capture technology procurement. Grants, guarantees and other instruments to help with the capital expenditure and mitigate uncertain returns are important (e.g. via Invest EU, RRF). Furthermore, investments in R&D efforts to improve the technology as well as funding for commercial demonstration are crucial for the technology to develop (e.g. via Horizon, InvestEU, etc.).

Decarbonization in the basic materials sector

With steel, plastics, ammonia and cement currently emitting around 16 per cent of CO₂ emissions in the EU, deep emission cuts are essential, but the sectors are widely considered as “hard-to-abate”. Renewable hydrogen, carbon capture and storage, renewable energy technologies as well as circular economy strategies are promising cross-cutting approaches to decarbonize the sector. There is a particularly large demand for renewable hydrogen, as its versatility as an energy carrier allows deployment in a range of production processes.

In each of the sectors, a wide portfolio of sub-sector specific technologies aims at reducing emissions, such

as energy-efficiency technologies, feedstock substitution, and technologies aimed at decreasing process-related emissions. According to a survey by [Chiappinelli et al. 2020](#), with an “estimated investment of 28.9 billion Euro, about 20 per cent of the EU’s basic materials could be produced through low-emission processes or additional recycling by 2025 with technologies that are commercially available or at pilot scale today”. Generally, decarbonization is mostly technically feasible, but many technologies are not yet competitive enough without public financing. Investors in industrial sectors are faced with higher and often uncertain capital expenditures (CAPEX) and uncertain returns due to large fluctuations of ETS prices when opting for low-carbon technologies. Furthermore, operational expenditures (OPEX) are often higher. Thus far, the combination of free allowances under the ETS for most industrial emitters and low ETS prices until recently have not resulted in reduced CO₂ emissions in industry and it will have to be seen to what extent the current price levels and expected ones are sufficient to bring about the non-incremental investments that are needed in this sector. Another barrier is the lack of reliably cheap low-carbon electricity, as investors need certainty in pricing to reduce project risks when opting for direct electrification or other strategies that build on the availability of cheap renewable electricity. Here, hydrogen can play an important role in the future.

Public financing (e.g. via grant-like schemes or concessional loans) play a major role in de-risking private investment and overcome the barrier of high upfront costs. To reach the 2030 climate and energy targets, public financing is needed to translate innovative technologies into actual business cases for commercial scale demonstration (e.g. through InvestEU or the ETS Innovation Fund). To kick-start the economy from the Covid-19 crisis, it is important that RRFs include measures targeting industrial sectors. Reforms, instruments and investment measures need to be ready to go and relatively easy to implement under the RRF, meaning that for the materials sector various instruments are important, including concessional loans and grants, Contracts for Difference, and measures that

increase demand for low-carbon products (e.g. through tax reductions). Carbon contracts for difference play a crucial role, as they are able to both support capital expenditures and offer secure returns for the project.

Horizon Europe and other research innovation focused funds could provide the necessary funding to decrease emissions in the future by providing funding to improve the technology-readiness level of low-carbon technologies and make them accessible on an industrial scale, which would help to reduce project risks. EU funding could specifically allow Eastern and Southern European Member States to transition their industries.

Equally important, a number of structural reforms need to take place in order to decarbonize the basic materials sector, such as dismantling administrative and regulatory barriers, price internalization via sufficient carbon pricing, and labelling and certification schemes, etc. Several EU instruments could support the financing and execution of national reforms (e.g. to improve planning or establish one-stop shops) as well as re-skill and up skill personnel (e.g. RRF, JTF, etc.).

4.2 Low-carbon transition in the building sector

In 2018, the building sector in the EU-28 accounted for 37 per cent of final energy consumed, including 58 per cent of electricity and 66 per cent heat available for final energy consumption. It also accounted for 36 per cent of energy-related GHG emissions (if emissions associated with electricity and heat consumption in buildings would be accounted for the buildings sector). To meet the 2030 emissions targets, GHG emissions from buildings should be reduced by 60 per cent, their final energy consumption by 14 per cent and energy consumption for heating and cooling by 18 per cent compared to 2015. Considering that 75 per cent of the EU's building stock is energy inefficient, 97 per cent do not achieve an "A" energy

performance classification level, and one-third of all buildings are older than 50 years, key decarbonization strategies are medium and **deep renovation** for the increased energy and resource efficiency of residential and non-residential buildings.¹⁶ Complementary strategies include the decarbonization of heating and cooling by switching to renewable energy in the form of solar thermal, geothermal and heat pumps as well as renewables-based district heating, and the increased circularity in the building supply chain. A further strategy is to accelerate the replacement inefficient lights, appliances, and equipment (whether electrical or non-electrical).¹⁷

Energy-efficient building renovation brings other major benefits, such as improved air quality and improved human health, lower energy bills, and reduced energy poverty. In addition, energy-focused retrofitting supports job creation. The European Commission estimates that 160,000 new green jobs will be created in the building sector by 2030 alone. This is why the EU Recovery and Resilience Facility (RRF) calls for doubling the renovation rate by 2025 and encouraging deep renovations. In this context, the Renovation Wave strategy published in October 2020 provides a comprehensive path to increase the rate and depth of renovation in the EU as "a win-win for climate neutrality and recovery" by leveraging an unprecedented volume of resources from the 2021–2027 Multiannual Financial Framework and Next Generation EU. Identification of new niches for domestic climate investment and maximizing synergies with national development priorities is an important area where additional EU support is required, and which the EU instruments are well placed to provide.

The Commission outlines three priorities in their renovation wave efforts:

- Tackling energy poverty and worst-performing buildings
- Renovation of public buildings, incl. schools, hospitals, public administrative offices
- Decarbonization of heating and cooling

These and other key strategies are presented in Table 3.

Key technologies and strategies for decarbonising the building sector		Table 3
Key technologies/ strategies	Examples of crucial steps towards carbon-neutrality in the building sector	Key literature on investment needs and trajectories
Increased energy efficiency		
Deep renovations for reduced energy demand	<ul style="list-style-type: none"> → Technological energy efficiency improvement of building envelopes and their components, such as thermal insulation, e.g. aerogel and vacuum insulated panels and energy-efficient windows, e.g. vacuum tube windows → Other innovations, measures and practices in renovation, e.g. self-cleaning coatings, phase change materials, greenery, shadowing, passive zenithal light guides → All retrofitting measures should follow nearly-zero-energy building (NZEB) principle or even go beyond 	<ul style="list-style-type: none"> → <i>A Renovation Wave for Europe (2020)</i> → <i>BPIE (2020)</i> → <i>BUILD UP (2017)</i>
Deep renovations of public buildings	<ul style="list-style-type: none"> → Priority for hospitals, schools, kindergartens and public housing (as highlighted in Renovation Wave) 	<ul style="list-style-type: none"> → <i>A Renovation Wave for Europe (2020)</i> → <i>Digital Europe (2020)</i> → <i>WBSCD (2021)</i>
Digitally friendly renovation	<ul style="list-style-type: none"> → Installation of smart technologies, e.g. smart meters to match energy demand and supply → Smart thermal control systems 	<ul style="list-style-type: none"> → <i>A Renovation Wave for Europe (2020)</i>
Appliance efficiency	<ul style="list-style-type: none"> → Replace aged building appliances with more efficient ones 	<ul style="list-style-type: none"> → <i>Net Zero 2050 (2020)</i>
Increased renewable energy use		
Low-carbon heating and cooling	<ul style="list-style-type: none"> → Advanced low temperature district heating, using renewables (solar, geothermal) and waste-heat recovery → Decentralized renewable heating, using solar thermal or geothermal heat → Electrification and commercial heat → Zero-carbon gas heating, biomethane from sustainable biomass or green hydrogen; 'last resort' due to limited availability of gas sources → Heat pumps, including large-scale ones 	<ul style="list-style-type: none"> → <i>A Renovation Wave for Europe (2020)</i> → <i>Mathiesen et al. (2019)</i> → <i>McKinsey (2020)</i> → <i>Net Zero 2050 (2020)</i>
Decarbonization of electricity	<ul style="list-style-type: none"> → Decentralized energy supply, e.g. with solar PV roof or façade systems → From consumer to prosumer, in case of excess local energy supply 	<ul style="list-style-type: none"> → <i>Net Zero 2050 (2020)</i> → <i>BPIE (2019)</i> → <i>BPIE (2020)</i>
Electrification of cooking	<ul style="list-style-type: none"> → Phasing out of gas-based cooking and switching to renewable electricity, e.g. induction cooking 	<ul style="list-style-type: none"> → <i>McKinsey (2020)</i>
Circularity in building supply chain		
Reducing embedded carbon in building materials	<ul style="list-style-type: none"> Recycled, zero-carbon, wood or bio-based building materials, Nature-based solutions Recycling and reuse of waste materials 	<ul style="list-style-type: none"> → <i>Net Zero 2050 (2020)</i>

Increased energy efficiency

Accelerating renovation efforts is critical, considering that the current annual renovation rate is only 1 per cent and the rate for deep renovations is as low as 0.2 per cent per year. To achieve the goal of doubling the annual renovation rate to 2 per cent, as outlined in the EU Renovation Wave, the European Commission estimates an additional annual investment need of €90 billion, which will require mobilizing private investment through targeted public incentives. A 2020 [comparative study by the Buildings Performance Institute Europe \(BPIE\)](#), however, shows that a renovation rate of 3 per cent per year with 70 per cent deep renovations is more consistent with a 60 per cent emission reduction (compared to 2015) and a strengthened 2030 target. According to a complementary BPIE brief, this would require annual investment of €243 billion up to 2050, including €179 billion for residential and €64 billion for non-residential renovation. In this scenario, West and Northwest Europe require the most investment, totalling €163 billion per year (€113 billion for residential and €50 billion for non-residential) up to 2050.

BPIE also estimated that to trigger the above renovation investments, EU public funds are required in the amount of €73 billion per year, in the form of direct grants or subsidies. More specifically, in the West and Northwest of the EU, 25 per cent or €41 billion per year of the total investment need should be met by public funds, while in the other EU regions, public funds should cover 40 per cent, or €32 billion, per year. On top of that, BPIE recommends a short-term injection of €13.8 billion per year in targeted public funds to kickstart renovation at an industrial scale, including innovative process optimization, the prefabrication of building modules, digitalized planning and monitoring. Including other minor measures, BPIE concludes that a stimulus package of €90 billion per year would be needed to stimulate a deep wave of renovation in the EU building stock that aligns with the 2030 climate target.

Key instruments to finance accelerated energy renovation include concessional loans and repayment grants that are provided when the project achieves a certain energy efficiency standard. Energy-efficient retrofits are currently financed mainly by private investment, but this needs to be supplemented with loans from green banks and public finance schemes (including bond issuance), especially since many households and companies are suffering from the economic impact of COVID-19. Financing by Energy Service Companies (ESCOs) is growing in importance, enabled by financial and regulatory innovation and accounting standardization for their contracts. Because of its sheer size, the RRF, as a supplement to regional and cohesion spending, could play a key role not only in driving renovation, but also in boosting the EU economy overall by revitalizing the construction sector. National and regional banks play a crucial part in providing finance and investment advice, such as the KfW in Germany, which currently offers near-zero interest rates. At the national level, EU instruments could support financing schemes provided by banks, e.g. through RRF and InvestEU.

The primary funding instrument should be tailored to the building type (e.g. commercial, public, public-rental, owner-occupied or private-rental). For example, grants to Member States at the regional level could be particularly important to support the renovation wave for schools, hospitals and public housing. In particular, the European Regional Development Fund (ERDF) has a strong focus on supporting the energy-efficient renovation of public infrastructure. In addition to financial instruments, there is also demand for improved standardization and technical and administrative assistance,¹⁸ which could be provided through instruments such as the Just Transition Fund, the European Local Energy Assistance (ELENA) facility, and the Technical Support element of InvestEU. Investment is also driven by regulations, including **minimum energy performance standards (MEPS)**, energy certifications, and quality assurance tools.

Increased renewable energy use

In addition to its focus on energy-efficient renovation, the RRF Renovation flagship also highlights the need to decarbonize space heating, cooling energy, and water heating. To meet the 2030 climate target, energy demand for heating and cooling would need to decrease by up to 23 per cent (compared to 2015) and the share of renewables in final energy consumption for heating and cooling would need to increase at the same time to 40 per cent.¹⁹ There are close synergies between energy efficiency and renewable energy measures, as renewable energy-based technologies (such as solar thermal, geothermal, and heat pumps) and renewable energy-based district heating work better with buildings that have low energy demand. Current EU legislation has not yet sufficiently promoted this alignment of both types of measures, and there is a clear need for integrated planning that combines both energy efficiency and renewable energy measures.²⁰

The development of renewable energy for heating requires a reduction in perceived investment risks. This can be achieved through various means, including credit **guarantees** and loan schemes for households. Accordingly, SMEs and municipalities need improved assistance to remove administrative and knowledge barriers, e.g. through one-stop shops. In this context, the Cohesion Fund, the European Regional Development Fund, the EIB's InvestEU as well as the Smart Finance for Smart Buildings Initiative are potential financing tools. Grants to Member States at the municipal level, such as the European Energy Efficiency Fund, could be particularly important to co-finance green district heating and other public renewable energy initiatives. Furthermore, in their national long-term renovation strategies submitted in February 2021,²¹ EU countries such as Denmark also use tax incentives as a tool to motivate the adoption of renewable energy for heating. Regulatory policy targeting energy companies as well as consumers, e.g. in the form of emission caps, can create a demand for renewable solutions, enabled by the use of financial and technical assis-

tance. Here, it is important that policy makers and authorities allow for a sound assessment of renewable energy solutions that suit the particular regional or local context, not least in relation to cost-efficiency.

Circularity in building supply chains

While current strategies to increase energy efficiency and renewable energy use focus on building investors, owners and households, emission reductions in the construction sector supply chain are also crucial for reaching 2030 climate targets. Emissions embedded in building and construction materials and processes currently contribute 8 per cent of total emissions from the residential building sector.²² In their Net-Zero 2050 report from 2020, ECF suggests triggering the demand for low-carbon products through regulatory policies, e.g. with regards to the climate performance of buildings. Additional elements crucial to transforming the building sector include targeted innovation efforts, e.g. in the area of alternative and low-carbon building materials, and a focus on the re- and upskilling of workers, e.g. through formalized certification schemes. The EU ETS Innovation Fund, Built4Europe (as part of Horizon Europe), as well as ELENA and the Technical Support element of InvestEU, among others, are potential funding and reform instruments.

4.3 Low-carbon transition in the transport sector

Mobility and interconnection are cornerstones of European integration and cohesion. While the transport sector provides employment for over 10 million people in the EU, the sector also accounts for about 27 per cent of European GHG emissions and is a major cause of air pollution. Road transport alone constitutes 20 per cent of European GHG emissions. The GHG emissions of the transport sector are currently higher than in 1990, and have been rising since 2013, despite mitigation efforts. Any attempt to meet the EU climate targets needs to include a

phase-out of fossil fuels for transport and address non-CO₂ impacts, especially of the aviation sector. As outlined in the European Green Deal, the EU aims to reduce GHG emissions from the transport sector by 90 per cent in 2050 relative to 1990 levels. The latest Sustainable and Smart Mobility Strategy (SSMS) of the European Commission of December 2020 sets out milestones for making mobility more sustainable (see Table 4). In the transport sector, RRF funds should only be used for zero-emission mobility, while currently some programmes under the MFF like TEN-T do not have this condition. However, the European Commission plans to integrate more stringent emission reduction targets in revisions of many mobility-related regulations and directives, as outlined in the legislative action plan guiding the SSMS. Beyond the SSMS, reaching climate-neutrality of the transport sector should embody the motto “reduce–shift–improve”: that is, *reducing* transportation needs, *shifting* away from cars and airplanes to cleaner transport modes and *improving* the energy efficiency of vehicles and fuels while making them less carbon intensive.

A rather capital-intensive sector, the transport sector will need at least €700 billion of investment per year in the 2021–2030 **business-as-usual scenario** (BAU) of the European Commission, as modelled in the Staff Working Document for the SSMS. It was estimated that working towards a carbon-neutral and clean transport sector will need an additional €130 billion per year between 2021 and 2030 for clean vehicles and alternative fuels infrastructure development. Table 5 below summarizes the important cross-cutting technologies and concepts for achieving the SSMS objectives, including crucial steps towards climate neutrality and important related literature.

Charging Infrastructure for Electric Vehicles

The RRF includes a **flagship** policy that addresses the sustainable transport sector, called Recharge & Refuel (see Table 1); it is stated that “by 2025, the flagship will aim to build one out of the three million charging points needed in 2030 and half of the 1000 hydrogen stations needed”. Apart from only building more charging points, a coherent strategy for charging infrastructure needs to ensure that a grid-friendly system of incentives is installed so that electric cars

Milestones of Sustainable & Smart Mobility Strategy

Table 4

Year	Goal
2030	Minimum 30 million zero-emission vehicles on European roads
	100 European cities are climate neutral
	High-speed rail traffic is doubled
	All scheduled collective travel under 500km should be carbon neutral
	Large scale deployment of automated mobility
	Zero-emission vessels are ready for the market
2035	Zero-emission large aircraft are ready for the market
2050	Nearly all cars, vans, buses and new heavy-good vehicles are emissions-free
	Rail freight has doubled
	High-speed rail has tripled
	The TEN-T is operational for sustainable & smart transport with high-speed connectivity

European Commission, 2020

Key technologies and strategies for decarbonizing the transport sector		Table 5
Cross-cutting technologies / concepts	Examples of crucial steps towards carbon neutrality in the sector	Key literature on investments needs and trajectories
Electric vehicles & charging infrastructure	<ul style="list-style-type: none"> → Incentives for more plug-in electric vehicles (PEV), including higher taxation of fossil fuels, emission standards, zoning restrictions, Minimum Energy Performance Regulations and mandatory phase-outs of combustion engine fuels. → Large roll-out of charging infrastructure (with a special focus on rural areas) → Availability of information on charging locations 	<ul style="list-style-type: none"> → <i>European Commission (2020)</i> → <i>NewClimate Institute (2020)</i> → <i>Agora Verkehrswende (2020)</i> → <i>European Climate Foundation (2021)</i> → <i>Transport & Environment (2020)</i> → <i>Regulatory Assistance Project (2020)</i>
Green Hydrogen	<ul style="list-style-type: none"> → Promote early adoption of (e.g. via public or commercial fleets, specific parts of rail network) → Developing hydrogen fuel cells for shipping and aviation → More R&D Funding → Carbon pricing 	<ul style="list-style-type: none"> → <i>Hydrogen Europe, 2019</i> → <i>European Commission (2020)</i>
Synthetic hydrocarbons or e-fuels	<ul style="list-style-type: none"> → Exclude crop-based biofuels from sustainable aviation fuel definition → Strict sustainability safeguards that ensure that e-fuels are based on 100% renewable energy and CO₂ from air → More stringent performance and mixing requirements → Carbon pricing → More R&D Funding 	<ul style="list-style-type: none"> → <i>Transport & Environment (2020)</i>
Batteries	<ul style="list-style-type: none"> → R&D Funding → Pressure for uptake via <i>car performance standards</i> → Upscaling of production, with focus on competitive advantages → Carbon pricing 	<ul style="list-style-type: none"> → <i>European Commission (2019)</i> → <i>Transport & Environment (2020)</i> → <i>McKinsey (2019)</i> → <i>International Council on Clean Transportation (2019)</i>
Smart Mobility	<ul style="list-style-type: none"> → Artificial intelligence → Autonomous vehicles → Automatic integration of timetables and ticketing → Mobility as a Service (MaaS) and sharing economy → Incentivize virtual communication 	<ul style="list-style-type: none"> → <i>ERTRAC et al. (2019)</i> → <i>McKinsey (2019)</i> → <i>Agora Verkehrswende (2021)</i>

Modal shift (to rail)	<ul style="list-style-type: none"> → Urban planning to reduce distances and promote walking & biking → Promote public transport → Discourage cars and trucks in cities → Making rail a more competitive alternative for short-haul aviation → A coherent strategy for EU co-financing of rail → Phasing-out and eventually banning short-haul aviation → Internalization of external costs across transport modes 	<ul style="list-style-type: none"> → <i>European Court of Auditors (2018)</i> → <i>Transport & Environment (2019)</i> → <i>NewClimate Institute (2020)</i> → <i>European Commission (2020)</i> → <i>GermanWatch (2020)</i>
Sub-sector	Examples of promising technologies	
Automobiles and light-commercial vehicles	<ul style="list-style-type: none"> → Switch rapidly to decarbonized alternative fuels through electrification → Alternative batteries, e.g. solid state batteries with Li-metal anodes 	<ul style="list-style-type: none"> → <i>NewClimate Institute (2020)</i> → <i>Transport & Environment (2020)</i>
Buses and minibuses	<ul style="list-style-type: none"> → Switch to electric buses and minibuses → Electrification using fuel cells 	<ul style="list-style-type: none"> → <i>Transport & Environment (2017)</i> → <i>IKEM (2020)</i>
Heavy-duty trucks	<ul style="list-style-type: none"> → Improvements in operations and logistics → Electrification and fuel cells → Exclude natural gas as sustainable option for fuel 	<ul style="list-style-type: none"> → <i>International Energy Agency (2017)</i> → <i>International Council on Clean Transportation (2019)</i>
Shipping	<ul style="list-style-type: none"> → Ammonia fuelled internal combustion engine (ICE) → Hydrogen fuel ICE → Battery electric powertrain (for short distances) → Wind-assisted propulsion 	<ul style="list-style-type: none"> → <i>Climate Action Tracker (2020)</i> → <i>Transport & Environment (2020)</i>
Sub-sector	Examples of promising technologies	
Aviation	<ul style="list-style-type: none"> → Improvements in fuel efficiency of traditional fuels → Sustainable Aviation Fuels (SAF), e.g. e-fuels or hydrogen → Mandatory phase out of older fleet → Airport charges dependent on carbon emissions → Research on contrail avoidance, weather forecast modelling, lean-burn engine technology to reduce non-CO₂ impacts 	<ul style="list-style-type: none"> → <i>CE Delft (2019)</i> → <i>Transport & Environment (2018)</i> → <i>EASA(2020)</i>
Rail	<ul style="list-style-type: none"> → Electrification of infrastructure → Digitalization (e.g. roll-out of European Railway Traffic Management System) → Investment in interoperable rolling stock and night trains → Efficiency increases through automation of rail and train operations → Coordinated timetabling and traffic management 	<ul style="list-style-type: none"> → <i>European Court of Auditors (2018)</i> → <i>Transport & Environment (2018)</i> → <i>GermanWatch (2020)</i>

are charged during peak feed-in from solar panels and wind turbines, [according to Agora Verkehrs-wende](#).

[Transport & Environment](#) estimates that EUR 20 billion in investment is needed for public charging points and about 60 billion is needed for private points up to 2030. Building charging points infrastructure for electric vehicles is often already viable without public support in many affluent areas and along major traffic arteries, but is still supported through national schemes. EU funds, through e.g. the RRF, are mostly needed in rural and less affluent areas, and the EU needs to set clear timeframes and geographic priorities. Once public money has brought in charging infrastructure in underserved areas, the subsequent local uptake of electric vehicles can create profitable business models for more charging infrastructure in the surrounding areas. The upcoming COM proposals for revisions of the AFID and the TEN-T regulations (both Q2 2021) provide an excellent opportunity to enable such mechanisms. Private sector funding can be attracted via public auctions (see recommendations from the [Regulatory Assistance Project](#)), or with cross-linked tenders that combine installation in profitable areas with mandatory installation in less profitable areas. Private funding could also be unlocked through **carbon contracts for difference**. Traditional financial instruments, like **concessional** loans, grants or debt **guarantees** through EU funds like the RRF, Cohesion Fund, CEF-T & ERDF and EIB loans could further leverage private investments as **blended finance** and can be accessed through the [Cleaner Transport Facility](#). Furthermore, local charging infrastructure could be financed by strengthening the borrowing capacity of municipalities, e.g. by easing borrowing constraints that are dependent on national approval. An addition tool is technical assistance, e.g. provided through a WIF14EU-Model²³ type of system or by strengthening JASPERS.

Green Hydrogen in the Transport Sector

While the electrification of the transport sector is the

most viable and efficient strategy to decarbonize in the short term, green hydrogen is seen as a promising low-carbon fuel in the long term for energy diversification in aviation and shipping. According to [Transport and Environment](#), innovation with renewable hydrogen could also unlock hydrogen as a fuel also for long-distance trucks due to its high energy density, but this depends on concurrent developments in battery and charging infrastructure technology, which look more promising. The EU has spearheaded numerous initiatives for green hydrogen in mobility, e.g. by hydrogen-power buses with fuel cells, but demand for hydrogen has so far not materialized in the transport sector. To encourage private sector funding for hydrogen innovation and deployment, **lead markets** of hydrogen could be created (e.g. by mandating purchasing requirements for shipping or by investing in hydrogen refuelling stations in port areas, potentially through the current updates of Fuel EU Maritime and AFID). Similarly, a contracts-for-difference programme with guaranteed floor prices could enhance early uptake of green hydrogen for shipping and aviation. Furthermore, to encourage uptake of green hydrogen as a transport fuel, the current update of AFID should exclude natural gas and liquefied natural gas (LNG) from the definition of alternative fuels, as in the EU taxonomy. For more on sustainable hydrogen R&D, see section 4.1.

Synthetic Hydrocarbons

Synthetic hydrocarbons are considerably less energy-efficient than electricity. Their use should thus be limited to sectors without many alternatives, like aviation and shipping, and adhere to strict sustainability standards, i.e. be produced from renewable energy that is additional, and from CO₂ that is directly captured from the air. The main concern here is to provide more funding for R&D and incentivized deployment in the aviation industry. Research lines for sustainable aviation fuels include synthetic hydrocarbons that can replace kerosene. In this project, researchers aim to create kerosene by producing syngas that is converted into long hydrocarbon chains, after which they are cut up again into

kerosene fractions. Contemporary Sustainable Aviation Fuels (SAFs) made from biomass are sometimes already mixed with kerosene in **combustion engines**, but often have energy-efficiency and sustainability problems. For example, in 2018 it was estimated that replacing all aviation fuel in the EU with biomass-to-liquid fuel would take up an area about the size of Ukraine for oil crops. An EU-wide mandate with performance and mixing standards for SAFs is expected to be published before Q2 2021, called RefuelEU. Apart from this regulation, stronger incentives for the uptake of SAFs could come from carbon taxation and removal of kerosene subsidies from the revision of the Energy Taxation Directive, and more stringent **EU ETS** caps.

Batteries

Current batteries are already performing well enough to be used in cars. In 2020, about 12.3 per cent of new lightweight passenger vehicles were electrified. To deliver emission-free road transport, batteries can be improved so that they are able to store enough electricity for powering longer-lasting BEV and PEV to replace vehicles with combustion engines in the near future, including larger ones. The focus in the battery sector lies on further innovation, planning ahead for manufacturing, and especially incentivizing deployment to replace fossil-fuel vehicles.

In 2017 the European Battery Alliance (EBA), a collaboration between industry players, was launched by the European Commission to accelerate innovation and sustainability in the European battery sector and to compete with other major battery producers like China. Already some €8 billion has been allocated under the EBA for battery innovation; however, to enhance the competitive advantage of European manufacturers, more funding could be used to quickly develop cheaper batteries with higher capacities (towards 10 GWh by 2025) and higher energy density (towards 500Wh/l), while ensuring the batteries can also be sustainably recycled. The EU funds battery innovation through the **European Institute for Innovation and Technology (EIT)**, which

also provides organizational assistance for research and production. Low-carbon mobility projects and especially pilot lines can also be financed with Horizon grants. The EIB funds scale-ups of key innovation through loans, debt guarantees and equity-type funding. Parts of the ETS Innovation fund are also meant for low-carbon demonstration projects, e.g. for more efficient and powerful batteries.

In 2019, seven member states invested about €3.2 billion through an **Important Project of Common European Interest (IPCEI)** for batteries to 2031, expecting to unlock a further €5 billion in private investment. In January 2021, this was complemented by a second IPCEI for batteries of €2.9 in funding from twelve member states that is expected to unlock about €9.8 billion from 42 industry partners. Projects under current IPCEI's include Northvolt and PSA-Saft, and could manufacture and deploy contemporary lithium-ion batteries with planned factories in Skellefteå (SE), Grünheide (GE), Kaiserslautern (GE) and Douvrin (FR) to supply for EU cars, trucks, vans and other energy applications by 2030. The success of the regional-scale IPCEI projects show that public money for battery innovation can be successful in unlocking significantly higher amounts of private funding for R&D and manufacturing.

The focus of battery innovation should be to push ahead with next-generation advanced battery technology. Key research directions include efforts to improve energy density with better anodes with more silica and/or lithium metals, the use of solid electrolytes and the reduction of cobalt fractions in cathodes. **Transport & Environment** recommends that at least 20 per cent of all battery funding should be used for innovating advanced batteries to keep and expand the EU's competitive advantage in battery technology.

The coordination of Europe's battery innovation, manufacturing and deployment by the European Commission is being spearheaded with the Strategic Action Plan for Batteries of 2018 and a proposal for a

new the Sustainable Battery Regulation (December 2020) with stronger efficiency and circularity targets for battery production. Moreover, stronger regulatory pressure, but also with **carbon pricing** measures, would ensure a faster deployment of BEV.

Smart Mobility

Smart mobility is an umbrella term for automation and the use of artificial intelligence (AI) in the transport sector. Smart mobility has the potential to fundamentally alter the way we operate most modes of transport. The main benefit of smart mobility in the **twin transition** is better fuel efficiency through optimized logistics, thereby contributing to decreasing GHG emissions by lowering energy needs. Digitization can further help with managing and lowering transport demand and accelerating the modal shift. Examples of smart mobility include continuously updated information streams on possible congestion points, or self-driving cars that rely on congestion information for automatic route determination. Other applications include the integration of multiple transport modes in ticketing, thereby using ICT for better interoperability. Imminent developments include automated shipping using big data and robotics to coordinate the efficient flow of products through sea routes, as well as automated infrastructure. Furthermore, digital environments enable a shift to the **sharing economy** and service-based mobility (**Maas**), which decreases the need for production of vehicles, utilizes underused assets and lowers fleet devaluation. The EU's contribution here is to developing innovative mobility concepts; coordinating research through smart mobility initiatives like Shift2Rail; investing in R&D by grants through Horizon; the new thematic partnership on connected and automated driving; LIFE and CEF; equity and loans through the EIB; and technical and networking support through the EIT. The EU can also have a role in making sure that a policy framework is developed that ensures that all new shapes of automated and smart road transport move toward shared mobility systems, a necessary development, according to Agora Verkehrswende.

Modal Shift (to Rail)

In order to make European transport climate-neutral, a shift away from cars and airplanes towards more, walking, cycling, rail and public transport is needed. This shift can be encouraged with policies that enable walking and cycling, with subsidized public transport, with shared mobility systems, and with the discouragement of personal automobiles in cities. **The example component** of the "Recharge and Refuel" **flagship** of the **RRF** shows example strategies for modal shifts that can make the transport within cities and regions more sustainable.

For larger distances, rail is very often the most carbon-efficient transport mode available. Major inroads in the GHG emissions of the transport sector can be made through investment in making rail a more competitive alternative for aviation and road transport; many transport bottlenecks for climate-neutrality are therefore related to rail infrastructure. The European Commission & Parliament designated 2021 as the European Year of Rail, which is meant to give a major boost to developing cross-border rail connections. Across Europe, rail infrastructure remains largely state-owned, but how ownership is organized varies greatly across regions, making financing structures rather complex. Massive investments are needed to reach SSMS goals like doubling of high-speed rail traffic by 2025, tripling high speed rail by 2050 and doubling rail freight by 2050. The COM announced in its Sustainable and Smart Mobility Strategy that it will release an action plan for boosting high-speed rail services (250 km/h or above) in 2021 with fifteen pilot projects. According to a 2018 publication by the European Court of Auditors (ECA), earlier high-speed rail targets adopted by the European Commission failed, because a solid EU-wide strategic approach was missing.

The ECA has estimated that it takes on average about 16 years to build new high-speed rail services, so doubling the length of high-speed rail will be challenging within RRF funding timelines and will strongly increase **current estimations** of investment

need for the rail sector (by about €430 billion between 2020–2030). To accelerate the modal shift to rail, RRF funds could be used in the short term to increase the frequency and quality of rail services, by investing in interoperable rolling stock and night trains, e.g. by equipping trains with more than one signalling system for cross-border services. Moreover, HSR is not needed everywhere; some areas could do with sound and punctual regular rail network; the choice to develop new rail infrastructure, both regular and high-speed, should be based on a sound cost-benefit analysis.

Investment in rail infrastructure often takes the shape of direct public investment by national governments, but the EU can help with grants and debt with co-financing via CEF, ERDF, the Cohesion Fund and with RRF funds. Moreover, there are numerous funding paths with EIB loans, e.g. through InvestEU, the Marguerite Fund II and EFSI. Electric rail and rolling stock are also eligible for investment through EIB Green Bonds. However, according to [Germanwatch](#) only 25 per cent of transport-related EU funds and co-financing opportunities are used for rail projects, while 50 per cent is used for building new roads instead. Roads can more easily be built within legislative terms for political gains, while rail infrastructure development is perceived as too expensive and tedious. Moreover, rail planning and engineering capacities are lacking across Member States, which needs to be addressed to get more rail infrastructure projects in the pipeline.

There should be a sharp focus within CEF on connecting rail-networks across MS borders and for core TEN-T network corridors, [resolving key bottlenecks](#) and missing cross-border links that are currently outside the scope of TEN-T. EU co-funding should become decisively dependent on demand-side need assessments for rail-lines and on the allowance of on-track competition for rail operation tenders. These regulatory changes could be made through implementing the Fourth Railway Package and a new action plan for cross-border rail for Q3 2021. In

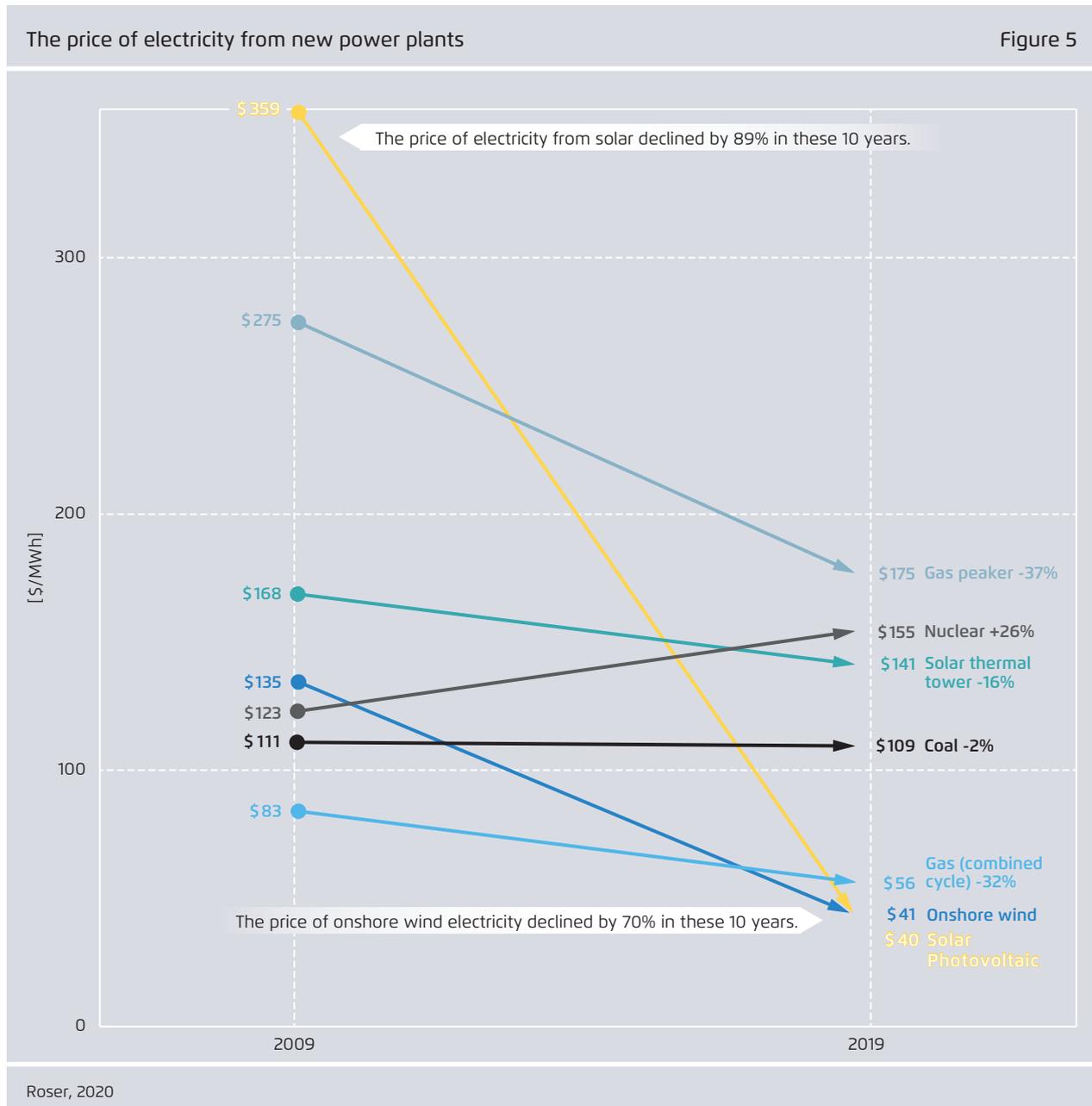
addition, a level playing field for rail needs to be created by removing kerosene subsidies, installing a kerosene tax via the revision of the Energy Taxation Directive, more stringent EU ETS caps, full auctioning of EU ETS allowances for aviation, and reductions to rail track access charges.

4.4 Low-carbon transition in the energy sector

The complete decarbonization of the electricity sector is needed in order to meet 2050 targets. For example, five to eight times the current market share of onshore wind and solar energy is needed up to 2050, but less mature technologies also need sufficient upscaling. Costs for renewable energy have been declining over the past decade such that renewables in the power sector have become cost-competitive, even in relation to existing and new-build fossil fuel production, as shown Figure 5.

Investments to remove bottlenecks, e.g. missing grid infrastructure or lack of integration with other carriers, are urgently needed for the development of the sector, in addition to policy reforms e.g. to improve permitting and rules that allow new actors to enter the market.

Innovative technologies, especially when it comes to the storage and smart distribution of electricity, have to be significantly supported by the public sector in order to meet energy and climate targets. See Table 6 for an overview of relevant key technologies and steps toward a low-carbon energy sector. In the energy sector, funding instruments that de-risk private capital and provide support for high capital investments are crucial, as well as funding for clean energy technologies. In eligible countries, the funding available through the Modernisation Fund, which is targeted at modernising energy systems, has the potential to play an important role in meeting investment needs. Net-zero emission targets will furthermore not be achievable without major acceleration in



clean energy innovation and the upgrading of existing technologies. R&D funding as well as funding for pilots and marketization (e.g. through Horizon and InvestEU) are crucial.

Grid infrastructure and smart networks

Today, Europe's energy system is still built on separate energy supply chains and energy sources are rigidly linked to specific sectors (e.g. gas and electric-

ity networks are planned and managed independently) as highlighted by the EU Strategy for Energy System Integration. To remove this bottleneck, grid investments are integral to the deployment of renewables, these investments need to be prioritized more consistently. With investment cycles averaging 20-60 years, this is a pivotal moment for Europe's energy system in the effort to reach the 2050 targets. Here, cross-border projects could

Key technologies and strategies for decarbonizing the energy sector

Table 6

Cross-cutting technologies / concepts	Examples of necessary steps	Key literature on investments needs and trajectories
Grid infrastructure	<ul style="list-style-type: none"> → Smart grids, smart appliances, smart demand-side management → Network infrastructure → Improvements in integration with other carriers (e.g. hydrogen or district heating) → Advancements in applying 'multidirectional' energy systems (e.g. through vehicle-to-grid) → R&D investments → Policy reforms for more flexibility and demand side response, aggregation 	<ul style="list-style-type: none"> → <i>EU Strategy for Energy System Integration (2020)</i> → <i>OECD (2017)</i> → <i>McKinsey&Company (2010)</i>
Storage Technology	<ul style="list-style-type: none"> → R&D investments → Battery manufacturing 	<ul style="list-style-type: none"> → <i>IRENA, 2017</i> → <i>Miller & Carriveau, (2018)</i> → <i>Child et al. (2018)</i> → <i>Artelys, European Commission, Enerdata, Trinomics (2020)</i>
Sub-sector	Examples of promising technologies	
Solar PV	<ul style="list-style-type: none"> → Capacity to produce, transport, store, sell and use <ul style="list-style-type: none"> • state-of-the-art roof-top solar PV and solar heating systems • Utility-scale PV → R&D in next generation solar technologies (e.g. new design features to reduce costs) 	<ul style="list-style-type: none"> → <i>SolarPower Europe and LUT University, (2020)</i> → <i>Trinomics (2017)</i> → <i>IEA (2019)</i>
Wind (on- and offshore)	<ul style="list-style-type: none"> → Capacity to produce, transport, store, sell and use <ul style="list-style-type: none"> • On-shore wind • Off-shore wind → Accelerated re-powering → R&D in next generation technologies (e.g. advances turbine scaling, floating off-shore wind turbines) 	<ul style="list-style-type: none"> → <i>IEA (2019)</i> → <i>IEA (2020)</i> → <i>GWEC (2020)</i> → <i>Wind Europe (2019)</i> → <i>Girard, Kemfert, Stoll (2021)</i>
Other	<ul style="list-style-type: none"> → Capacity to produce, transport, store, sell and use <ul style="list-style-type: none"> • Sustainable Biomass • Ocean power • Enhanced geothermal systems → R&D expenditure 	<ul style="list-style-type: none"> → <i>IEA (2019)</i> → <i>IEA (2020)</i> → <i>Strengers & Elzenga (2020)</i> → <i>IRENA (2016)</i> → <i>Vision for deep geothermal (2018)</i>

IEA, 2020; EU Commission, 2016; EU Commission, 2020

benefit specifically from EU funding. Subsidies as well as eased access to finance play a major role in developing grid infrastructure; the CEF Energy programme and InvestEU are key vehicles in this regard. CEF specifically strengthens cross-border interconnections, in particular for electricity transmission, and the revised rules of the Trans-European Networks for Energy (TEN-E) ensure that measures are consistent with climate neutrality objectives. By 2030, an electricity interconnection target of 15 per cent has been set. To speed up grid infrastructure development, projects from the projects of common interest list could be accelerated.

The role of EU instruments focused on Member States, like the Recovery and Resilience Facility, Cohesion Policy and REACT-EU, could be to address financing needs in areas where the private and or public sector is not very engaged, such as electricity transmission (e.g. for offshore wind), crossborder interconnectors, and the digitization of electricity distribution networks. Administrative barriers relating to delayed permits for grid connections or lack of skilled staff that leads the planning processes could be overcome through reforms (e.g. supported by the RRF, JTF or CF).

Storage technology

Improved storage technology, together with a smart and integrated system, is key for making full use of renewable energy sources such as solar and wind power, and they have a positive effect on a range of services. Furthermore, improved storage technology is crucial for sectors such as transport (e.g. for electric vehicles) as well as buildings and industry. In 2017, the European Battery Alliance was launched to scale up innovation and manufacturing of batteries in Europe (see transport chapter). The lack of suitable storage technology is one of the key barriers to generate round-the-clock clean power and properly harness the advantages of intermittent sources like wind and solar. Funding for R&D and large-scale demonstration projects that improve the roll-out of viable storage systems are important (e.g. through

InvestEU, Horizon Europe or RRF). Currently, however, energy storage technologies are more inhibited by lack of project financing rather than by limits to the technology. High capital costs and a lack of incentives for large-scale projects are particularly meaningful barriers. Here, grants, subsidies, and instruments like power purchase agreements for energy storage, could make a crucial difference (e.g. via RRF, InvestEU, CF, ERDF, etc.). Furthermore, national reforms need to be put in place that encourage long-term planning and break down administrative barriers (e.g. via the reform element in RRF or Technical Assistance).

Renewable energy technologies

The private sector drives the deployment of already mature technologies – such as solar PV and on/offshore wind – in markets where favourable regulatory conditions. However, public measures play an important role for creating favourable investment environments and incentives, especially when it comes to securing stable cash flows for investors (e.g. through guarantees, market responsive support schemes, tradable certificates and premiums). The maturity of the technology plays an important role when selecting a revenue stabilization measure (e.g. concessional loans through EIB).

Financing has been less of a bottleneck than finding bankable projects and overcoming excessive administrative and regulatory complexity (e.g. permitting procedures). For instance, on- and offshore wind technologies have a high technological readiness level, but in recent years have suffered from regulatory and administrative burdens, rather than financing bottlenecks. It is estimated that around 15 per cent of overall development costs of wind power projects in Europe are related to administrative costs. As many renewable energy projects are nearing the end of their product-lifetime and getting less efficient, re-powering gains importance across the EU, but the procedure generally faces high regulatory burdens. Instruments under the MFF and RRF could be used to help national administrations to overcome

these burdens as well as comprehensive transposition of the clean energy package rules on permitting and authorization. National reforms or the training of personnel for integrated planning could be supported, for example, by technical support instruments and RRF, CF or JTF.

The public sector plays an important role when creating the right incentives, including revenue stabilization mechanisms and tradable certificates. The EIB has a full range of financial instruments that these kinds of technologies require (either directly or through national development banks/private banks), including equity finance, mezzanine finance, and loans and guarantees. One important aspect that the EIB should address (if required) is the development of a bankable project pipeline and the provisioning of Technical Assistance to potential project developers.

Advanced and new renewable energy technologies

Despite the success of technologies like onshore wind and solar, investment in next generation modules are important to increase efficiency and grid integration, to tap new develop locations (e.g. with floating wind turbines), and to reduce costs. Performance of commercial PV systems could be greatly improved, leading to higher penetration rates and better integration with smart grids. By contrast, bioenergy technologies should be ideally to be used in transport and industry, with decreasing reliance in the power and heat sector, where alternatives are plentiful.

Less mature renewable energy technologies also need to be further developed for climate and energy targets to be achieved. For example, geothermal technologies require additional R&D to accelerate cost reductions and deploy novel solutions as pilot projects. Ocean power (e.g. ocean thermal energy conversion, salinity gradient power and ocean current technology) is also a promising technology that still needs to advance to maturity.

Investments in R&D (e.g. through Horizon and InvestEU) as well as scale-up and demonstration

projects are crucial along the entire value chain. Suitable instruments such as green public procurement or grants can help to build a project pipeline. In general, it is very important that support frameworks are technology specific. High and uncertain upfront costs could be overcome by grant-like instruments, subsidies, etc. At the same time, it would be beneficial if governments and regulators already begin to develop suitable policy frameworks, guidelines and standards, in order to ease the deployment process.

5 Outlook

The start of this watershed decade for energy and climate policy was marked by the struggle against a global pandemic, which will continue to shape our economies and society in the coming years. The foregoing discussion highlighted yet again that to prevent catastrophic climate change, Europe's recovery needs to be a catalyst for a healthy future; indeed, every euro of public spending needs to be allocated effectively in order to deliver on the EU Green Deal. The mission and goals have been clearly formulated; we know what technologies to develop and deploy; we can estimate investment needs; and we have gained significant experience with suitable financial instruments and necessary reforms over the last decades. Thus, we have already paved the road to a "climate action decade"; the only task now is to begin the journey. With the MFF and the RRF in place, the EU has put a historic volume of funding on the table. It is now important that beneficiaries (including local and national governments, businesses, etc.) rise to the challenge, and harness this opportunity for forward-looking investment and policy reform.

For the EU to meet its climate targets, enormous amounts of capital will need to be raised and absorbed quickly by the market. There is no time to waste, especially when it comes to sectors with a high risk of carbon lock-in (e.g. certain capital-intensive industries). The recovery from the economic crises caused by COVID-19 has unleashed large amounts of public stimulus, both at the EU and national levels. However, this guide has also emphasized that the massive amount of investment needed to reach the net-zero emission economy cannot be tackled by public funding alone. Private investment needs to play a major role in the transition.

Mobilizing private capital requires governments to establish the right framework conditions and incentives that will set future expectations and build

investor confidence. Technologically, the EU is better positioned today than some years ago. There are a number of low-carbon technologies available at competitive prices. However, private investors often do not have incentives to make use of these technologies, or face different kinds of barriers. The EU and Member states have already developed effective policy toolkits that tackle many of these issues and have started reforming financing instruments so as to encourage the crowding in of private investment. But enhancements are still needed at the EU and Member State levels in various domains. Indeed, in addition to improving planning and streamlining administrative processes, significant investments in human capital need to take place.

In addition, public funding programmes need to be tracked and monitored effectively, so that the necessary degree of scrutiny is applied. At the EU level, a strong monitoring and sanction system could, for instance, be ensured through a reformed EU Semester, which could also support the strengthening of sustainable investment and additional fiscal reforms. In the coming years, multiple important policy processes will take place in parallel that will be important to help the EU and Member States contribute as much as possible to delivering on the Green Deal and reaching the revised 2030 targets. These processes need to be as closely aligned with the Green Deal as possible. For example, the Just Transition Plans and operational programmes for the Cohesion Fund must work towards bringing Europe closer to carbon neutrality. Member States have to transition to the new Clean Energy Package, while the new "Fit for 55" legislative package is being issued. Provisions in this regard will go a long way to ensuring the reforms develop as needed to make optimal use of resources. The revision of the National Energy and Climate Plans in 2023 will also be crucial, as this will shape the strategy of various government depart-

ments at the national level, and will need to reflect raised climate ambition.

In upcoming political decisions on various issues – including, for example, the EU Taxonomy, energy taxation or EU ETS reforms – it will be imperative to ensure policy coherence, transparency, the setting of proper incentives, and long-term cooperative planning at the EU level if we want to make markets work effectively for climate-friendly investment.

6 Annexes

6.1 Annex I: Glossary & Abbreviations

Annual Sustainable Growth Strategy	ASGS	Strategic guidelines that outline the EU's economic and employment policy priorities for a year. In 2021, it is focused on implementing the RRF.
Blended Finance Instruments		The strategic use of finance to attract or mobilize additional funds through other EU financial instruments, member state co-financing, or private sector investment to achieve policy objectives. Instruments are often designed to provide financial safety nets or hedge certain risks through e.g. credit insurance facilities.
Business-As-Usual Scenario	BAU	A baseline scenario that examines the consequences of continuing development of current trends in e.g. the economy, demographics, technological innovation, climate change and human behaviour. Often refers to an outcome of a scenario analysis, e.g. as a contrast to the outcomes of EUCCO scenarios.
Carbon contracts for difference	CCfDs	CCfDs are policy instruments for supporting the deployment of new ultra-low carbon projects by ensuring a guaranteed carbon price to make up the cost-difference relative to a reference technology. They can be designed to reduce the up-front investment cost for developers, give creditors a higher-security for their loans and also minimize the downstream costs for consumers. CCfDs work to accelerate R&D and ensure new innovative low carbon/deep decarbonization technologies become commercially viable sooner relative to conventional technologies and have a shorter time period required for commissioning.
Carbon capture, utilization and storage	CCUS	Carbon capture and storage (CCS) and carbon capture and utilization (CCU) technologies that aim to capture CO ₂ emissions from point sources, such as industrial sources, to prevent emissions from entering the atmosphere.
Cleaner Transport Facility	CTF	Initiative of the EIB to support the funding of the development and deployment of cleaner vehicles and their needed infrastructure. It is a one-stop shop that provides technical assistance and access to transport-related loans of the EIB itself and grants, loans, debt guarantees of CEF, TEN-T, Horizon and through JASPERS (technical assistance) and ELENA (technical assistance).
Component		Recovery and Resilience Plans should be composed of reforms and investments grouped into components. A component is a constituent element or a part of the RRP. Each component should reflect related reform and investment priorities in a policy area or related policy areas, sectors, activities or themes, aiming at tackling specific challenges, forming a coherent package with mutually reinforcing and complementary measures.
Concessional loans		Also known as "patient debt", these are loans that allow more flexibility on the part of the borrower, often in terms of longer maturities, longer grace periods, lower collateral requirements, subordinated debt or technical assistance. Concessional loans are often issued by financial non-governmental organizations or development banks as opposed to commercial banks.

Deep renovation		Achieve a 60% reduction of energy demand in a given building, as compared to 30% for shallow renovations and 40% for medium renovations.
Do no significant harm principle	DNSH	Principle under the EU Sustainable Finance Taxonomy: there are six environmental objectives to which no significant harm should be done: (i) climate change mitigation, (ii) climate change adaptation, (iii) water and marine resources, (iv) the circular economy, (v) pollution prevention and control, and (vi) biodiversity and ecosystems. For the RRF, technical guidance has been published on the application of the principle.
European Fund for Strategic Investment	EFSI	Also known as the Juncker Plan. Initiative launched in 2015 by the EIB Group and the COM to boost the economy by mobilizing private financing for strategic investments.
European Innovation Council	EIC	A one-stop shop for disruptive and innovative start-ups and SMEs to obtain funding (grants & equity), advice and networks to develop and accelerate business ideas to contribute to the European Green Deal and the Recovery Plan for Europe.
European Institute for Innovation and Technology	EIT	Independent body of the EU, founded in 2008 as part of Horizon. It spurs innovation and entrepreneurship through thematic innovation communities that describe Europe's greatest challenges, including Climate-KIC, InnoEnergy and UrbanMobility. The EIT activities include advice on fundraising, strategy, HR and networks for entrepreneurs. They also promote the integration of innovation and entrepreneurship in Europe's higher education.
European Semester	ES	An annual cycle of coordination and monitoring of the EU's economic policies and national budgets.
European Flagships		In the 2020 Annual Sustainable Growth Strategy Commission has identified a number of common challenges that Member States are facing in the form of seven European Flagships: (1) Power up, (2) Renovate, (3) Recharge and Refuel, (4) Connect, (5) Modernize, (6) Scale-up, and (7) Reskill and upskill.
Green Public Procurement		A voluntary instrument streamlining and promoting the sustainable production and consumption of goods and services by the EU's public institutions with comprehensive and verifiable environmental criteria.
Green Bonds		A fixed-income instrument to finance climate-related or other environmental projects, often linked to specific assets like hydropower projects. The first green bonds were issued by the World Bank in 2009. They are often combined with tax incentives to make them a relatively attractive investment. The sustainability of green bonds is verified by third parties.
Guarantee		A financial commitment of third-party (guarantor) to repay a percentage of losses in case a borrower cannot honour his repayments to a credit provider, both interest and principal components. Guarantees are insurance policies that often allow investors some financial breathing space to invest a larger share of their funds.
Investment		The RRF uses a broad concept of investment as capital formation in areas such as fixed capital, human capital and natural capital. This would also cover for instance intangible assets such as R&D, data, intellectual property and skills.

Important Projects of Common Euro-pean Interest	IPCEI	Special projects that can promote the innovation of a specific technology up to industrial scale on the basis of a common European interest. This allowance is rather new as innovations are generally only regionally allowed as R&D projects to avoid unfair competition between MS. IPCEI's are currently limited to microelectronics and batteries but an IPCEI for hydrogen technology is being implemented.
Lead market		In innovation theory, a first sub-market where a specific innovation can be early adopted to spur adoption also by other "lag" markets, e.g. by internationalization. Policies to create lead markets are focussed on creating demand for a specific technology or concept.
Minimum Energy Performance Standards	MEPS	Regulations that require buildings to meet a minimum performance standard, specified in terms of a carbon or energy rating or minimum renovation measures, by a certain deadline or at a certain point in the natural life of the building, e.g. at the time of sale or when other construction work is undertaken.
Mobility as a Service	MaaS	Denotes a shift away from personally owned modes for transportation towards shared vehicles that can be booked, planned through joint digital channels. Examples for urban mobility include the business models of companies like Uber and Lyft.
Multiannual Financial Framework	MFF	Also called the financial perspective, the MFF is a 7-year framework regulating the EU's annual budget by setting ceilings of spending for broad policy themes.
National Energy and Climate Plans	NECP	EU countries needed to establish a 10-year integrated national energy and climate plan (NECP) for the period from 2021 to 2030 to show how they meet the 2030 energy and climate targets (within the Energy Union governance).
Next Generation EU	NGEU	The temporary instrument designed to boost the recovery from the COVID-19 pandemic, includes the recovery and Resilience Facility
OECD Rio Marker System		Identification system for financing activities that promote sustainable development under the 1992 Rio Convention. Includes markers related to climate mitigation, adaptation, biodiversity, desertification and a more general "environment" marker for development projects.
Power Purchasing Agreement	PPA	PPAs are long-term contract where a business or public entity agrees to purchase electricity directly from an energy generator, with agreed price terms for the sake of financial stability often for a period of 15 to 25 years.
Quasi-equity		Quasi equity instruments are long-term financial instruments, with multiple variants that fall between debt and equity, including subordinated loans, convertible bonds and preferred stocks. Can be more complicated and costly to administer.
Recovery and Resilience Facility	RRF	Makes €672.5 billion in loans and grants available to support reforms and investments undertaken by EU countries with the aim to mitigate the economic and social impact of the coronavirus pandemic and declared objective to make economies and societies more sustainable, resilient and better prepared for the challenges and opportunities of the twin transition
Recovery and Resilience Plan	RRP	Every Member States wishing to access recovery funding under the RRF has to prepare a Recovery and Resilience Plan.

Repayment grant		Grant repayment, i.e. if the project achieves a certain energy performance level.
Structural reforms		Structural reforms generally refer to liberalizing economic structures in the national context, including making labour markets more adaptable, liberalizing services, altering taxation systems and restructuring the welfare state.
Technology Readiness Level	TRL	A method of estimating the maturity of a technological innovation, originally developed by NASA but with common EU definitions. It consists of 9 levels of "readiness", ranging from "basic principles observed" to "actual system proven in an operational environment".
Territorial Just Transition Plans	TJTP	Central element of the EU Just Transition Mechanism, which defines territories in which the Just Transition Fund will be used and outlines challenges in each territory, development needs and 2030 targets.

6.2 Annex II – Fund sizes and climate shares for relevant funds under the MFF and NGEU

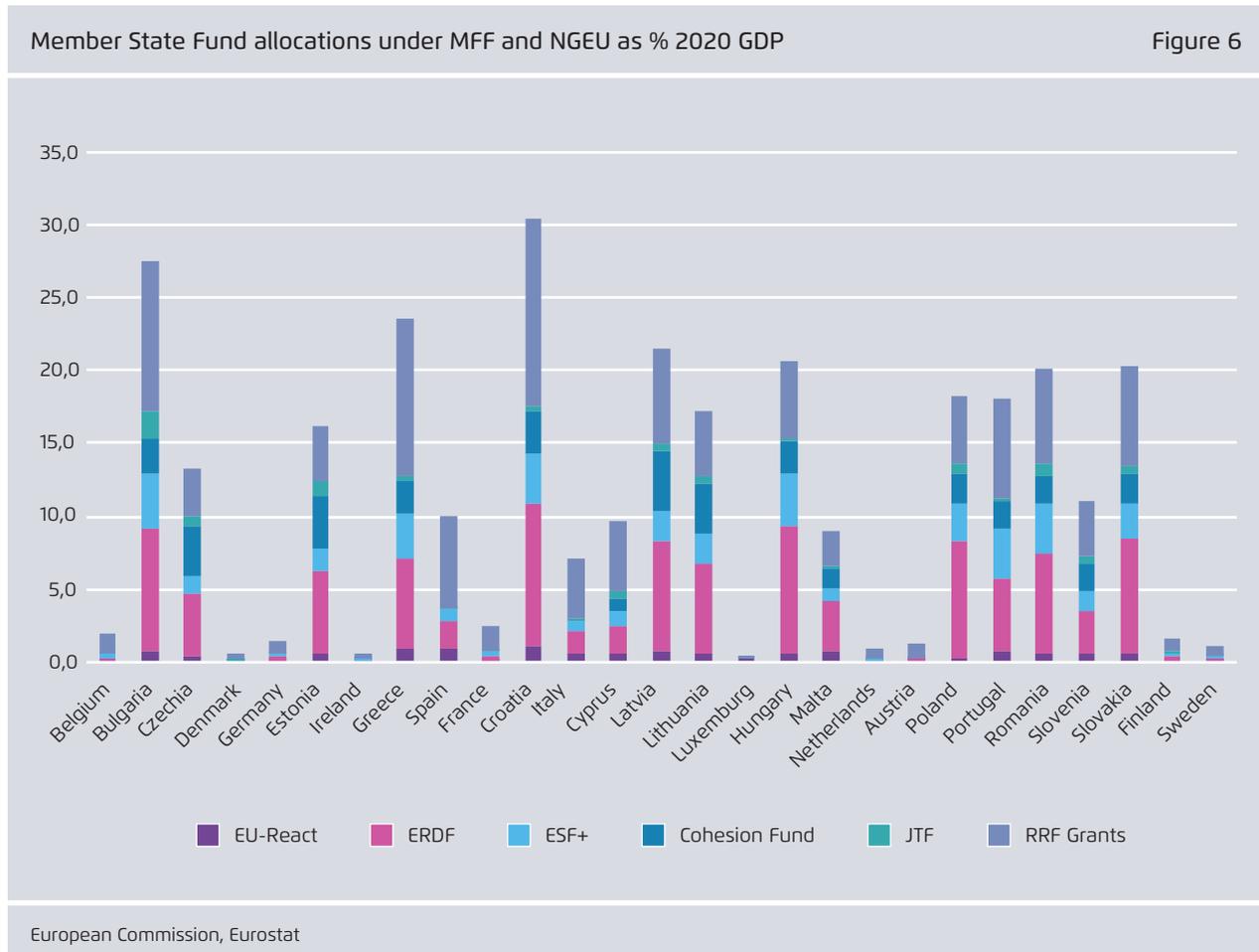
Relevant funds for Europe's low-carbon transition

Table 7

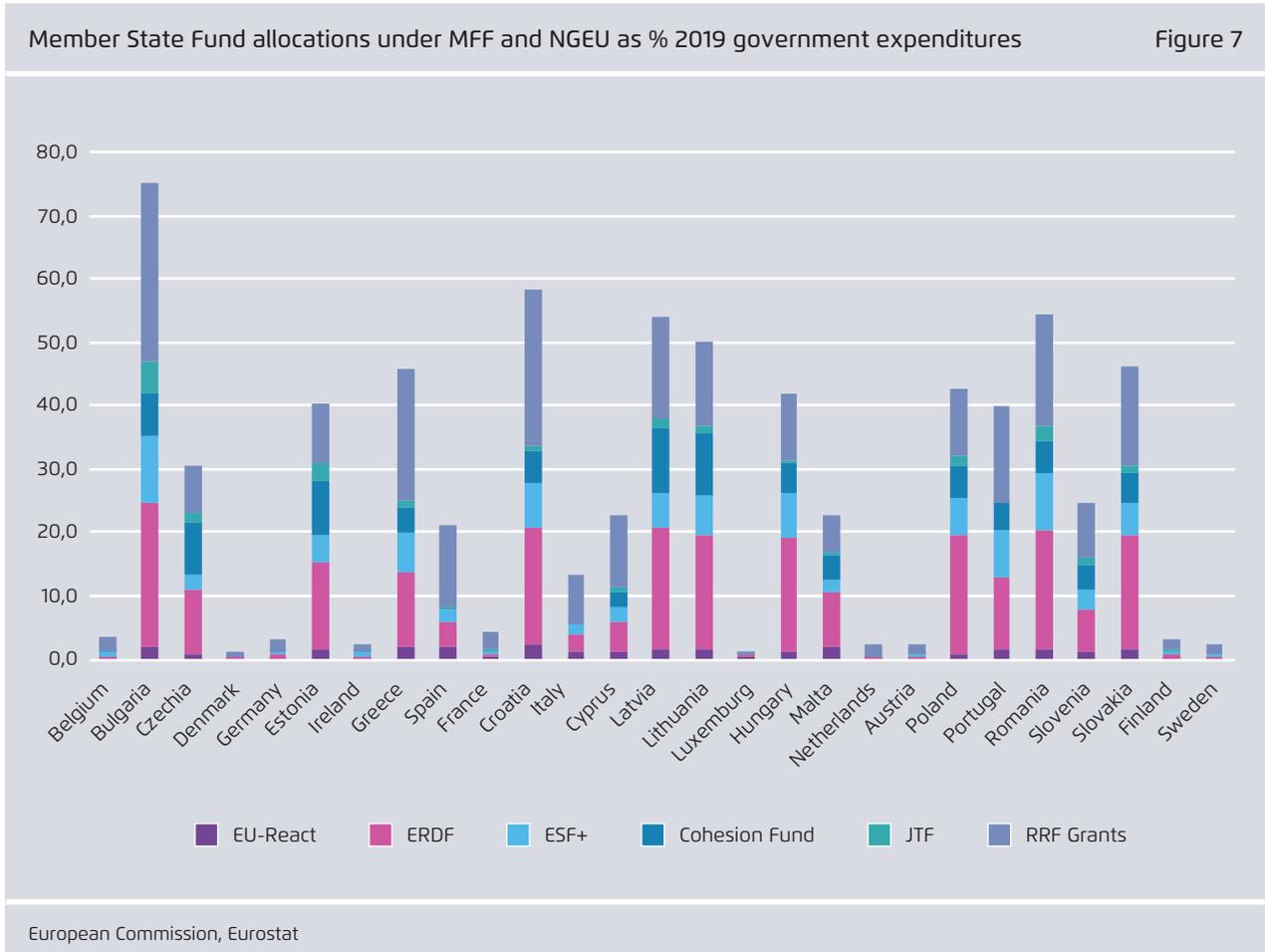
MULTIANNUAL FINANCIAL FRAMEWORK and Next Generation EU 2021–2027 (in 2018 prices)	Total fund size in € billion	Climate share in € billion	Climate share in %
Colours: Combined fund size, MFF, NGEU, Other			
Recovery and Resilience Facility	672.5	248.8	min 37%
Of which grants	312.5	115.6	
Of which loans	360	133.2	
Horizon Europe	84.9	29.7	min 35%
InvestEU Fund (via MFF and RRF)	9.4	2.8	min 30%
Resulting EU Budget Guarantee (estimation)	26.2	7.9	min 30%
Expected total investment triggered	372	111	min 30%
Programme for Environment and Climate Action (LIFE) via MFF	4.8	2.9	61%
of which for Circular Economy & Quality of Life (current prices)	1.3	1.3	100%*
of which for Clean Energy Transition (current prices)	1.0	1.0	100%*
Connecting Europe Facility – Transport (via MFF)	25.8	15.5	min 60%
Connecting Europe Facility – Energy (via MFF)	5.8	3.5	min 60%
Connecting Europe Facility – Digital (via MFF)	2.0	1.2	min 60%
European Regional Development Fund via MFF	191.0	57.3	min 30%
Of which at least 8% dedicated to sustainable urban development	15.3	15.3	100%
Cohesion Fund	43.0	15.9	min 37%
Just Transition Fund under MFF	17.5	5.3	min 30%**
REACT EU (under NGEU)	47.5	11.9	min 25%
European Social Fund+ (via MFF)	88.0	26.4	min 30%*
ETS Innovation Fund (non-MFF)	10.0	10.0	100%*
*Assumption, as no specific share is indicated			
**Fund includes a range of other climate-related criteria (e.g. fossil fuel exclusion), see: link			

European Commission, 2021 and fund specific documents, see section 3.1

6.3 Annex III – Member State Fund allocations under MFF and NGEU



Fund allocations are expressed in 2018 prices, except for RRF Grants (2020 prices). In addition to RRF grants, MS countries may request a loan up to 6.8 per cent of their 2019 GNI from the EUR 360 billion loan share of the RRF, allocations of RRF loans are yet to be determined based on need. Also excludes proposal-based funding, e.g. through Horizon, CEF, Life.



Fund allocations are expressed in 2018 prices, except for RRF Grants (2020 prices). Next to RRF grants, MS countries may request a loan up to 6.8 per cent of their 2019 GNI from the EUR 360 billion loan share of the RRF, allocations of RRF loans are yet to be determined based on need. Also excludes proposal-based funding, e.g. through Horizon, CEF, Life.

Endnotes

- 1 For a comprehensive overview, see FI-Compass. (2020). Stocktaking Study on Financial Instruments by Sector. See https://www.fi-compass.eu/sites/default/files/publications/Stocktaking_study_on_financial_instruments_by_sector_-_Final_report_0.pdf.
 - 2 (see e.g. Juergens et al. 2012, Novikova et al. 2019 for Germany; Hainaut et al. 2019 for France; Valentova et al. 2019 for the Czech Republic; and Kamenders et al. 2019 for Latvia).
 - 3 For key literature on the role of public financing, see: Berendsen, S., & Juergens, I. (2020). Die Finanzierung des Green Deal während und nach „Corona“: Apologie einer zentralen Rolle staatlichen Handelns in der Erreichung gesellschaftlicher Ziele. Ifo Institut, 10/2020(73). <https://www.ifo.de/DocDL/sd-2020-06-2020-06-10.pdf>; Mazzucato, M. (2018), The entrepreneurial state: Debunking public vs. private sector myths, Penguin Books, London.; Jacobs, M. und M. Mazzucato (Hrsg., 2016), Rethinking capitalism: Economics and policy for sustainable and inclusive growth, Wiley-Blackwell, The Political Quarterly.; Deleidi, M., M. Mazzucato und G. Semieniuk (2019), »Neither crowding in nor out: Public direct investment mobilising private investment into renewable electricity projects«, University of London, SOAS Department of Economics Working Paper No. 226, London.; Jones, A. W. (2015), »Perceived barriers and policy solutions in clean energy infrastructure investment«, Journal of Cleaner Production 104, 297–304; Lamperti, F., M. Mazzucato, A. Roventini und G. Semieniuk (2019), »The green transition: Public policy, finance, and the role of the State«, Vierteljahrshäfte Zur Wirtschaftsforschung 88(2), 73–88.; Polzin, F., F. Egli, B. Steffen und T. S. Schmidt (2019), »How do policies mobilize private finance for renewable energy? – A systematic review with an investor perspective«, Applied Energy 236, 1249–1268; Deleidi, M., M. Mazzucato und G. Semieniuk (2019), »Neither crowding in nor out: Public direct investment mobilising private investment into renewable electricity projects«, University of London, SOAS Department of Economics Working Paper No. 226, London.; Polzin, F., F. Egli, B. Steffen und T. S. Schmidt (2019), »How do policies mobilize private finance for renewable energy? – A systematic review with an investor perspective«, Applied Energy 236, 1249–1268; Truger, A. (2016). "The golden rule of public investment – a necessary and sufficient reform of the EU fiscal framework?", IMK Working Paper 168–2016.
 - 4 As multiple country-level focused studies show, see: Novikova, A., A. Klinge, H. Hainaut, I. Cochran, I. Juergens und J. Emmrich (2019), Überblick zu den Investitionsströmen der Energiewende in Deutschland und Frankreich: Vergleich von Methoden und ausgewählte Ergebnisse, September 2019. Institut für Klimaschutz, Energie und Mobilität (IKEM) und the Institute for Climate Economics (I4CE), Berlin, Paris.; Novikova, A., K. Stelmakh, A. Klinge und I. Stamo (2019a), Climate and energy investment map of Germany, Status Report 2016, Institut für Klimaschutz, Energie und Mobilität (IKEM), Berlin.; Valentová, M., J. Knápek und A. Novikova (2019), Climate and Energy Investment Map – Czechia. Status Report 2017: Buildings and Renewable Energy Supply and Infrastructure, Czech Technical University, Prague; Kamenders A., C. Rochas und A. Novikova (2019), "Investments in Energy Efficiency and Renewable Energy Projects in Latvia in 2018", Riga Technical University (RTU); Kenkmann, Juergens, I., H. Amecke, R. Boyd, B. Buchner, A. Novikova, A. Rosenberg, K. Stelmakh und A. Vasa (2012), Die deutsche Landschaft der Klimafinanzierung. Climate Policy Initiative; Juergens, I., C. Piantieri, M. Hessenius, D. Rusnok und S. Berendsen (2019). How to Assess Investment Needs
 - 5 European Court of Auditors (2020), "Tracking climate spending in the EU budget", Luxembourg: European Court of Auditors. European Court of Auditors (2016), "Spending at least one euro in every five from the EU budget on climate action: ambitious work underway, but at serious risk of falling short", Special Report no 31 of 2016.; Nesbit M., T. Stainforth, K. Hart, E. Underwood, G. Becerra (2020), "Documenting climate mainstreaming in the EU budget - making the system more transparent, stringent and comprehensive", report for the European Parliament, Policy Department for Budgetary Affairs.; Sweatman and Hessenius (2020). "Applying the EU Taxonomy": Lessons from the Front Line. (link)
 - 6 In the Common Provisions Regulation (CPR) for shared management funds, including for the EU cohesion policy funds, the EU co-financing rates are set at 85% for less developed regions (whose GDP is less than 75% of the EU-27 average), 60% for transition regions (whose GDP is between 75% and 100% of the EU average) and 40%
-

- for more developed regions (GDP over 100% of the EU average).
- 7 The Netherlands, for example, focussed on the Annex 5 region of Groningen, but also proposed to distribute JTF funds to post-industrial regions in other parts of the country. See link.
 - 8 €14 billion is the current projection by the European Commission, see: (accessed on 21 April, 2021. Other estimates included figures as high as €25 bn.
 - 9 Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia.
 - 10 The RFP consists of: Reform Delivery Tool: €22 billion for financial reforms as identified in European Semester, still to be developed with a pilot project in Portugal. The Reform Delivery Tool is performance-based grant for Member States and is designed as an incentive to deliver on key economic reforms. Technical Support Instrument: €0.84 billion available for all Member States to enlarge their administrative capacity to implement European Semester reforms. Convergence Facility: €2.16 billion for extra financial (€2 billion) and technical (€0.16 billion) support for states that are making demonstrable steps towards accession to the euro.
 - 11 The lack of integrated, coherent and effective planning as well as persistent legal barriers is a major barrier when it comes to the roll-out of low-carbon projects and technologies. Even for mature technologies like wind power, unnecessary legal and administrative hurdles prevent a fast roll-out and increase prices. EU and national reforms need to be put in place to overcome these barriers, and this can be done also by making use of this technical assistance.
 - 12 It is a demand-driven technical support tool for Member States to design and implement any COVID-19-relief reform that can also be related to e.g., green tax reforms. The support can take numerous shapes, including but not limited to both in-house and external legal, strategic or scientific advice, trainings or expert visits.
 - 13 "For instance, it takes some €160-200 million to convert a typical EU steel installation coming to end-of-life to hydrogen. In the road transport sector, rolling out an additional 400 small-scale hydrogen refuelling stations (compared to 100 today) could require investments of €850-1000 million." From: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf; for examples of hydrogen application in the steel sector please see: <https://www.agora-energiewende.de/en/publications/no-regret-hydrogen/>
 - 14 As a rule, to prevent distortion of the incentive system provided by the EU ETS, support from EU instruments is not available for activities under the Emissions Trading System (ETS).
 - 15 See Material Economics. Industrial Transformation 2050 - Pathways to Net-Zero Emissions from EU Heavy Industry. (2019). See link. For more information on how these investment needs have been calculated, see Juergens et al. (2020). Critical review of the potential contribution of the European Commission proposal for an EU Recovery and Resilience Programme and a new Multiannual Financial Framework to achieving the objectives of the Green Deal and the 2030 and 2050 climate targets. A study prepared for Agora Energiewende. Accessible via link.; Chiappinelli, Olga et al. (2020) : A green COVID-19 recovery of the EU basic materials sector: Identifying potentials, barriers and policy solutions, DIW Discussion Papers, No. 1921, Deutsches Institut für Wirtschaftsforschung (DIW), Berlin
 - 16 In this guide, we mostly focus on renovation rather than newly constructed buildings. For new construction, it would be important to ensure all new buildings comply with near-zero energy buildings, etc.
 - 17 It is also increasingly acknowledged as unlikely that energy efficiency improvement and the increased use of renewable energy will be enough to offset for the increasing energy demand and GHG emissions driven by numerous factors, especially the growing floor area per capita. Therefore, it is absolutely crucial to promote sufficiency approaches that aim to reduce demand for new floor area, materials, and appliances as well as to avoid demand for unnecessary thermal and electrical energy consumption. For instance, research illustrates that the per capita emission reduction of sharing a household with an additional member is 24% for European households. See Ivanova, D., and M. Büchs, 2020: Household Sharing for Carbon and Energy Reductions: The Case of EU Countries. *Energies*, 13, 1909, <https://doi.org/10.3390/en13081909>.
 - 18 Analysis of the implementation of the European Structural and Investment Funds in selected member states during the last twenty years has revealed that workable implementation arrangements and the provision of additional technical support throughout all stages project preparation and implementation process are critical for the implementation of financial instruments and achievement of intended results. The experience of Member States provides ample examples of successful technical assistance, well aligned to the actual measures

for all stakeholders involved, and not very successful practices due to its fragmentation and weak alignment to actual measures, which either contributed to implementation, or on the contrary jeopardized it. See: Novikova, M., Olshanskaya, M., Dunkel, M. 2020. Lessons learned for international climate policy from the programming, implementation, and monitoring of the European Structural and Investment Funds in EU Member States. Berlin: Institute for Climate Protection, Energy and Mobility (IKEM), 2020.

- 19 Preliminary assessment of renovation strategies
- 20 As BPIE (2020, p. 20) states, "while the long-term renovation strategies should foster policies for a highly energy efficient and decarbonised building stock, the specific measures that Member States should consider in these strategies according to the official guidance do not directly encourage the decarbonisation of energy used in buildings. Similarly, the national heating and cooling plans required by the Energy Efficiency Directive to support the growth of highly efficient heating technologies are disconnected from the analysis of demand-side measures in buildings." For more information, see BPIE (2020). On the way to a climate-neutral Europe – Contributions from the building sector to a strengthened 2030 climate target. Retrieved from [link](#).
- 21 Preliminary assessment of renovation strategies
- 22 NetZero 2050
- 23 The WIFI4EU model denotes a method where municipalities and other lower administrative entities directly apply for funding to develop local infrastructure, like currently under CEF Telecom for local broadband internet. This circumvents bureaucratic barriers on the Member State level and can furnish municipalities with the funding that most appropriately fits their local needs, e.g. for EV charging infrastructure.

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