I4CE
INSTITUTE FOR CLIMATE ECONOMICS
Une initiative de la Caisse des Dépôts et de l'Agence Française de Développement

European Climate Investment Deficit report

An investment pathway for Europe's future

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I4CE is a non-profit research organization that provides independent policy analysis on climate change mitigation and adaptation. The Institute promotes climate policies that are effective, efficient and socially-fair. The 40 experts engage with national and local governments, the European Union, international financial institutions, civil society organizations and the media. The work covers three key transitions – energy, agriculture, forest – and addresses six economic challenges: investment, public finance, carbon pricing, development finance, financial regulation and carbon certification.

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The information and opinions expressed in this report are the sole responsibility of the authors.

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EXECUTIVE SUMMARY

Abstract:
Climate investments in the EU economy grew by 9% in 2022. Institute for Climate Economics report finds that the European Green Deal is gaining economic momentum but investments in modernising energy, transport, and buildings must still double for the EU to hit 2030 climate targets.

Climate investments made today shape Europe's future

To mitigate climate change and ensure Europeans can access clean, affordable, and secure energy, the EU set itself several ambitious targets for 2030.

Reaching them requires significant investments in the EU economy. **Investments made today shape Europe's future**. Renovating a home reduces energy demand for the next decades, making the economy more resilient to fossil fuel crises. Building a new wind power plant increases the amount of cheap renewable electricity the European industry can access to build its competitive sustainability.

In addition to their positive climate impacts, **climate investments promote many EU policy priorities**. Wind and solar power deployment **decreases electricity prices and thus helps contain inflation** (IEA, 2023c). The deployment of heat pumps strengthens EU **energy security** by reducing its dependence on Russian gas (Bruegel, 2023b). The replacement of internal combustion engine vehicles with battery-electric ones reduces air pollution and improves **public health** (EEA, 2023). Climate investments are also critical to create lead markets for the European industry to build its competitive edge in the global cleantech race (I4CE, 2023e). Finally, those investments are a democratic imperative as European citizens consistently want the EU to keep prioritising climate action (Eurobarometer, 2023).

Better tracking public and private climate investments will help measure structural changes in the EU economy. This report estimates the **climate investment deficit, i.e. the difference between A) the total investment needs required annually by 2030**, to achieve the EU 2030 targets **and B) the actual public and private climate investments happening in the EU economy** in the latest available year.

This climate investment deficit is a key predictor of the structural progress achieved by the EU economy: the smaller the deficit, the more the EU economy delivers structural changes. Looking beyond headline figures, **a granular analysis helps understanding the roots causes of the climate investment deficit** as investments in some sectors are doing better than in others, with sectors that can even be in a situation of climate investment surplus.

However, **the EU lacks a consistent tool to ensure the yearly monitoring of the climate investment deficit**. This is why **the European Scientific Advisory Board on Climate Change**, a scientific group created by the EU Climate Law and attached to the European Environment Agency, **recently called on the EU to 'strive for a more granular and accurate overview of required and actual investments in climate mitigation to monitor and assess progress'** (European Scientific Advisory Board on Climate Change, 2024).

This report helps fill this knowledge gap.

Climate investments in the EU27 economy grew by 9% in 2022, reaching 407 billion euros in 22 sectors

This report tracks the EU27 public and private investments made in 22 sectors (including wind power, building renovation, electric cars, and others presented in **Figure 2**) that are critical to the transformation of the energy, building and transport systems. **Investments in those sectors have been growing by 9% between 2021 and 2022, reaching 407 billion euros in 2022 – or 2.6% GDP.**

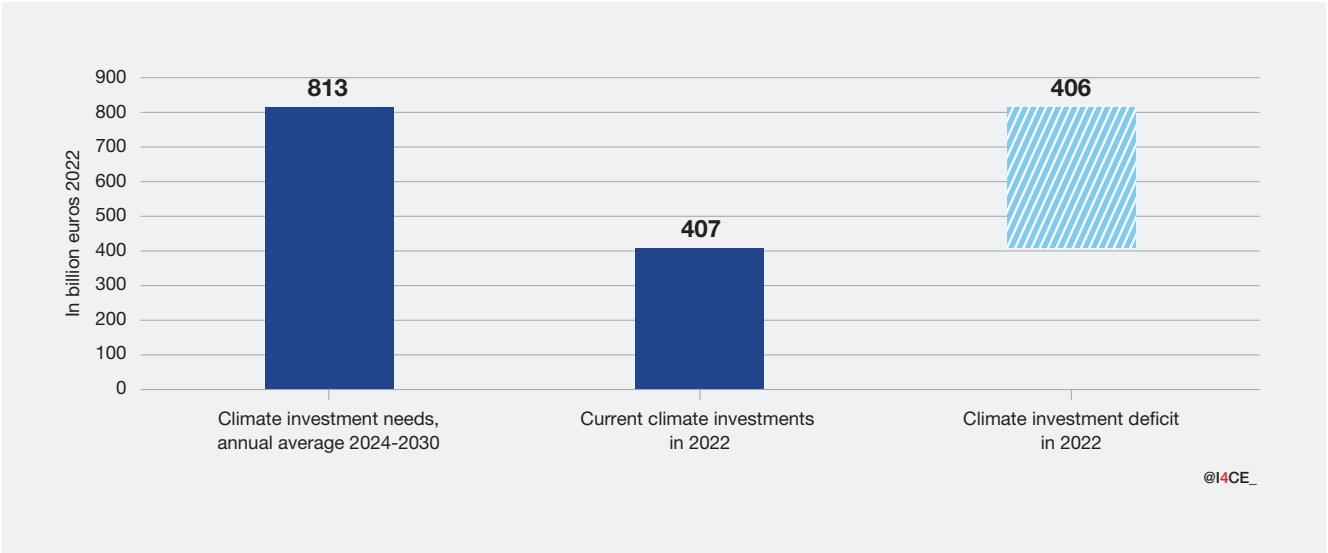
At a granular level, our research found that recent trends in EU27 investments in our covered sectors vary. Investments in solar panels and electric cars increased significantly. **Heat pump investments even doubled between 2020 and 2022**. This suggests that the EU economy is going in the right direction in those sectors, albeit too slowly given the EU level of ambition. Our research however found **wind power investments collapsing in 2022, down to their lowest levels since at least 2009.**

The European economy needs to double its level of climate investments to deliver the EU 2030 targets

Our research compared 2022 levels of investments with the levels of investments needed each year forward to deliver the EU 2030 targets in each one of the 22 sectors covered in this report, covering roughly buildings, transport and energy **systems. This leads to an overall average yearly investment need of at least 813 billion euros, or 5.1%, of EU GDP.** As real-economy investments reached 407 billion euros in 2022, this leaves a **European climate investment deficit of 406 billion euros per year**, or 2.6% GDP. By comparison, **explicit and implicit fossil fuel subsidies in the EU have increased and reached 290 billion euros in the year 2022** (IMF, 2023).

In other words, **current levels of public and private investments represent already half of total investments needed to occur every year** to deliver on the EU 2030 targets for the energy, buildings, and transport sectors. **Yet doubling those investments is essential to deliver** the economic, geopolitical and climate benefits EU policy makers committed to.

FIGURE 1. THE CURRENT CLIMATE INVESTMENT DEFICIT IN THE ENERGY, BUILDINGS AND TRANSPORT IS ESTIMATED AT €406 BN EUROS PER YEAR



Source: I4CE. All figures are in billion euros 2022. On the left, this graph represents the average climate investment needs for the EU to reach its climate objectives in the energy, buildings and transport systems (813 billion euros). It compares them to the 2022 investments for the same perimeter (407 billion euros). The difference between them gives the climate investment deficit (406 billion euros).

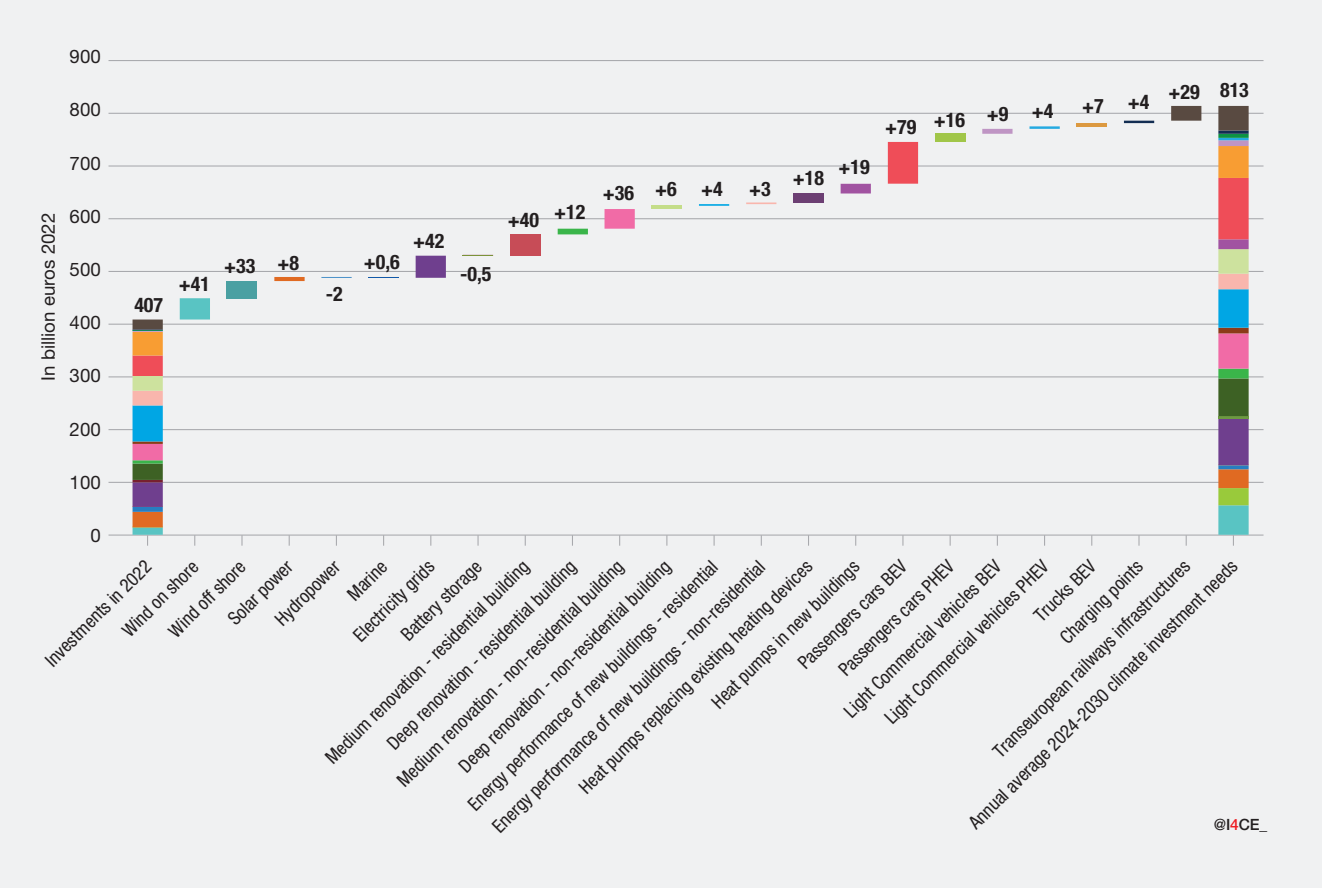
Hydropower and battery storage lead the way, wind power is struggling

Looking at all the 22 sectors covered by this report, our research points out that in only two sectors, hydropower and battery storage, 2022 climate investments were higher than the annual investment needs for those two sectors. They are therefore in a situation of climate investment surplus.

All 20 other sectors suffer from a climate investment deficit, of varying proportions. For instance, 2022 investments in wind power represent only 17% of total annual investment needs. Conversely investments in solar panels represent already 78% of total annual investment needs.

In absolute terms, the climate investment deficit in some critical sectors would be relatively easy to bridge. For instance, **closing the climate investment deficit in charging points for electric vehicles would require additional public and private investments of only 4 billion euros per year** (cf. Figure 2).

FIGURE 2. THE EU OVERALL CLIMATE INVESTMENT DEFICIT IS THE SUM OF 22 SECTORAL EU CLIMATE INVESTMENT DEFICITS AND SURPLUSES. THE BIGGEST DEFICITS ARE IN WIND POWER, ELECTRICITY GRIDS, ENERGY-RENOVATION OF BUILDINGS, HEAT PUMPS, RAILWAY AND ELECTRIC PASSENGER CARS



Source: I4CE. All data are in euros of 2022. This graph indicates the split of the climate investment deficit by sector. The climate investment deficit corresponds to the difference between the annual average investments that are needed for the EU to reach its 2030 targets and the investments that occurred in 2022. For example, for the onshore wind power sector, the climate investment deficit of 41 billion euros corresponds to the difference between the average investment needs (55 billion euros) and the 2022 investments (14 billion euros).

Assess better: EU institutions should develop their own transparent and comprehensive yearly monitoring of the EU climate investment deficit

Given its significance, the European Commission needs to **better assess and address** the EU Climate Investment Deficit, or risks seeing the Green Deal failing to deliver on its economic, social and environmental promises. To better assess the climate investment deficit, EU institutions should build on this report's research and deliver their own, **needs-driven and more accurate, granular and comprehensive** assessment:

- **More accurate**: access to data has been a challenge, especially when it comes to the building sector. Whenever faced with different methodological options, we consistently opted for the most conservative one. This may lead to some under-estimation in some sectors, and over-estimation in others.
- **More granular**: our report relies on EU27 data. A more granular approach could look at national and regional data that are relevant for national and local public policies. National governments and research organisations may use the methodology I4CE developed for France and the EU, and adapt it to be applied to a specific national economy.
- **More comprehensive**: our report only covers 22 sectors in the energy, building, and transport systems. Due to a lack of access to reliable data, critical sectors such as industry, agriculture, and climate change adaptation are not covered by this report.

The Institute for Climate Economics (I4CE) is pursuing and expanding its analysis to provide an up-to-date annual estimate that can be used by the EU Commission, Council and Parliament, as a new mandate is set to begin after the 9 June 2024 elections.

Address better: closing the European Climate Investment Deficit with an EU long-term climate investment plan

Addressing the climate investment deficit requires a comprehensive approach that involves existing and future regulations, carbon pricing systems, and public finance schemes. Given the scale of the current deficit, and the expected reduction in EU climate funding in the years to come (Bruegel, 2023a), some additional EU public funding is likely required to contribute to closing the Climate Investment Deficit.

A granular assessment of the climate investment deficit informs the debate over the right articulation of public funding and private financing. By their very nature, some sectors depend on public funding, such as the renovation of primary schools. Some even depend on a degree of EU-level funding, such as the trans-European interconnection of electricity and railway infrastructure. Others, may largely rely on private finance if the right framework conditions are set. **The quantity, nature and sectoral targeting of EU funding will therefore depend on the economic sectors concerned and political choices.**

This report concludes with a list of several political questions that are beyond the scope of our research. A debate on a future EU long-term climate investment plan should answer them. This includes the public funding tools to crowd-in private funding, the role of Member State public funding that can be supported by EU funds and policies and/or constrained by EU fiscal rules, as well as the debate on potential sources of new EU funding, and their articulation with overall EU policy priorities.

To nurture this debate, this report provides granular and transparent evidence to support informed decisions by EU citizens and policymakers, before and after the 9 June 2024 EU elections.

METHODOLOGY: THIS REPORT DEPLOYS A FULLY TRANSPARENT METHODOLOGY, WHICH BUILDS ON THE INSTITUTE FOR CLIMATE ECONOMICS (I4CE) TEN-YEAR EXPERIENCE IN LEADING SIMILAR RESEARCH IN FRANCE

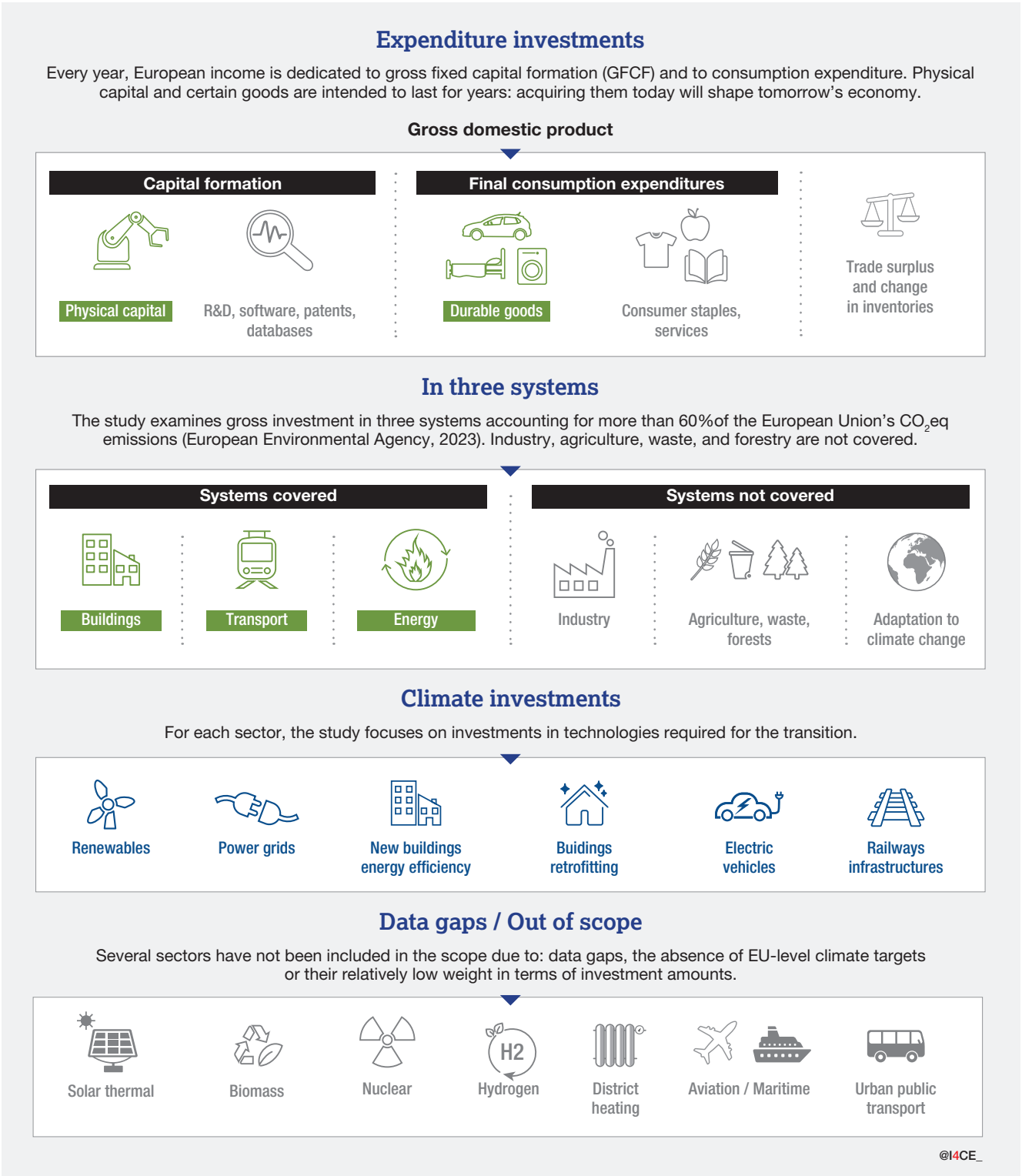
This report's methodology builds on I4CE's ten-year experience in developing a methodology to track climate investments in France. Every year, **I4CE publishes its Landscape of Climate Finance in France** (I4CE, 2023b), **a tool that is now commonly used by the French Government and Parliament**. Using a similar methodology, our research analysed official EU legislation and documents to estimate climate investment needs, while relying on sources to estimate the levels of investments occurring in those same sectors in the EU economy in recent years. The methodology is presented in this report (cf. **Methodological summary p.5**, section 5 and annexes). The authors remain available for further details and access to data.

This report only looks at gross capital expenditure investments, neither net-investments nor profitability. It measures total acquisition costs, not the net investments compared to a reference scenario. For example, buying an electric car at €34,000 rather than an internal combustion engine car at €27,000 leads to a gross investment of €34,000 but a net investment of only €7,000. This report furthermore ignores the long-term profitability of such investments - electric cars have lower operational expenditure than their internal combustion engine equivalent. Our research finally did not analyse the economic benefits of positive externalities, such as the choice for an electric car leading to cleaner air, thus reducing public health spending.

METHODOLOGICAL SUMMARY

This report estimates gross climate investments required to meet the 2030 objectives set by EU legislation. These investments encompass both public and private investments. The average investment needed between 2024 and 2030 is compared to 2022 levels. All data are in euros 2022. See the Methodology section for more information.

FIGURE 3. SCOPE OF THE CLIMATE INVESTMENT OVERVIEW



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INTRODUCTION. CLIMATE INVESTMENTS: THE KEY TO UNLOCK THE GREEN DEAL

The political momentum of the European Green Deal

European Commission President Ursula von der Leyen made climate action her top policy priority. In her words, climate change is "the greatest responsibility and opportunity of our times" (Von Der Leyen, 2019) that the European Union will address through a new set of policies: the European Green Deal.

The European Green Deal constitutes the EU policy answer to rising concerns about climate change. Those concerns have been voiced by the European Parliament declaring a "climate emergency" (European Parliament, 2021) while a political consensus emerged around the objective to make the EU climate neutral by 2050, with the European Council, officially endorsing this objective in December 2019 (European Council, 2019) before it was enshrined in the 2021 EU Climate Law.

Politically, the Green Deal is the EU answer to citizens calling for further EU climate action. This has been mostly visible with the Fridays for Future demonstrations that started in 2018. It is also reflected in surveys, where climate change is regularly named by citizens as the top[1], or one of the top policy priorities they wish to see the EU tackle.

In terms of climate policies, the European Green Deal started on an already comprehensive set of EU climate tools. As soon as 1993, the European Commission, then led by Jacques Delors, included environmental concerns in its White Paper on 'Growth, competitiveness, and employment – the challenges forward into the 21st century'. It then considered climate change to be among the "forms of pollution [that] are threatening not only local ecological systems, but also the natural balance of the entire planet" (European Commission, 1993). In the 1990s and 2000s, the EU developed a set of legislations to integrate the EU energy market, price carbon, promote building's energy efficiency, boost renewables, reduce CO_2 emissions from cars. Most of those policies came under the umbrella of the Energy Union political project during the Juncker Commission (2014-2019), before becoming part of the European Green Deal.

During the 2019-2024 EU mandate, the European Commission, Parliament and Council overhauled a whole set of regulations and directives, leading to the adoption of new EU targets in a range of sectors that pertain to renewable electricity generation, energy-efficient buildings, or electric vehicles to name a few. In the first edition of our Climate Investment Deficit Report, we look at the investment challenge that comes with delivering on those new EU policy objectives.

Climate investments are a key indicator of Green Deal progress

Estimating the EU Climate Investment Deficit is one key way to track the EU progress towards its own climate objectives. Climate change mitigation investments are critical when it comes to assessing the structural changes of an economy and its capacity to reduce greenhouse gas emissions in the short, medium, and long term.

Investment decisions made now shape our climate future. For instance, investing in the renovation of a building today will lead to a structural decrease in energy demand and related greenhouse gas emissions for decades. Tracking climate investment therefore helps measure structural changes in the EU economy. The climate investment deficit therefore constitutes a key indicator of the structural progress achieved by the EU economy. Other indicators like greenhouse gas emissions, or renewable electricity output, are useful but can be heavily affected by conjunctural factors, such as mild winters or windy years.

Climate Investments are a good proxy to understand if the EU is on a path to reach the policy objectives set out in the EU Climate Law, as well as in sectoral regulations (such as the EU renewable energy target set into the renewable energy directive). Yet, as underlined by the European Climate Neutrality Observatory (ECNO, 2023), the EU currently has no consistent tool to ensure the yearly monitoring of the **EU climate investment deficit**, *i.e.* the difference between A) the total investment needs required annually by 2030 to achieve the EU 2030 targets and B) the actual climate investments happening in the EU economy currently.

1 For example, in a field study performed during the Eurobarometer, QA14 in late 2021, polled citizens said 'climate change and the environment' was the top priority for the Future of Europe (44%), slightly ahead of 'health' and 'a stronger economy, social justice and jobs' (40%), way ahead of migration (26%) or digital transformation (11%) (European Union, 2022).

There is currently no annual EU Climate Investment Deficit assessment at EU level

At EU level, there is a patchwork of estimates of the climate investment deficit, notably from the European Commission. The European Commission estimates the climate investment gap at around 477 billion euros per year (European Commission, 2023d), but with little transparency on their methodology (*e.g.* it is unclear what is exactly included in the transport investment needs).

Furthermore, the Commission investment deficit estimate is not an annual exercise, but rather an estimate of the gap between historic climate investments in the 2010s and climate investment needs in the 2020s, therefore unfit to provide an estimate that could be updated every year and become a dependable public policy tool that policy makers can base their decisions upon.

Other institutions, such as the International Energy Agency, the International Renewable Energy Agency (IRENA) or BloombergNEF (BNEF) (Cerniglia & Saraceno, 2022) estimate investment needs to reach net-zero CO_2 emissions by 2050 but do not provide any detail about their methodology or do not disclose the investment needs by sector. Some other institutions estimate the past and current climate investment made at EU level each year, notably the European Investment Bank (EIB), based on databases from the IEA and the OECD (EIB, 2023).

There is therefore a need for an independent and consistent yearly analysis of the EU Climate Investment Deficit. This is why the European Scientific Advisory Board on Climate Change, a scientific group created through the EU Climate Law and attached to the European Environment Agency, recently called (European Academies Science Advisory Council & Secretariat, 2021) on the EU to 'strive for a more granular and accurate overview of required and actual investments in climate mitigation to monitor and assess progress'.

This report contributes to filling this research gap.

This report deploys a methodology based on I4CE's French Landscape of Climate Finance

This report presents findings based on the methodology developed by the I4CE Landscape of Climate Finance in France (I4CE, 2023b). Since 2014, the Landscape has been gradually estimating climate and fossil investments made in France from 2011 until now, and documents their short-term outlook. It compares current investments with the needs based on the French Long-Term Strategy. In the latest edition, published in December 2023, the investment needs are assessed against France's draft National Energy and Climate Plan (NECP) (I4CE, 2023b).

Using a similar approach, this report estimates the investment required to achieve the EU 2030 objectives in three major systems of the economy: energy, buildings, and transport. It compares these investment needs with the investments made in the same systems in previous years in the EU (see **Section 5**). Due to data gaps, it excludes industry, agriculture, forestry and climate change adaptation.

This report presents:

1. An overview of the climate investment deficit for the energy, buildings and transport systems;
2. Detailed results of the climate investment deficit for the energy system, including renewable energy and power grids; but excluding biomass, hydrogen and solar heating;
3. Detailed results of the climate investment deficit for the buildings system, including energy renovation of buildings, energy-efficiency of new building construction and heat pumps deployment in residential buildings; but excluding district heating, biomass heating, and climate change adaptation investments;
4. Detailed results of the climate investment deficit for the transport system, including electric vehicles and trans-European railways infrastructures, but excluding planes, ships and urban public transport.

1. OVERVIEW. CLIMATE INVESTMENTS IN THE EU ECONOMY INCREASE BUT STILL NEED DOUBLING TO CLOSE THE CLIMATE INVESTMENT DEFICIT

KEY MESSAGES

- To mitigate climate change and ensure Europeans can access clean, affordable, and secure energy, the EU set itself several ambitious targets for 2030.
- This report tracks the **EU27 public and private investments made in 22 sectors** that are critical to the transformation of the energy, building and transport systems. **Investments in those sectors have been growing by 9% between 2021 and 2022, reaching 407 billion euros in 2022 -or 2,6% GDP[2].**
- Reaching the EU 2030 targets requires at least 813 billion euros[3], or 5.1%, of EU GDP, of public and private investment are needed every year from 2024 to 2030 in those 22 sectors alone.
- Our research therefore estimates the **climate investment deficit** in the EU economy (i.e. the difference between the level of climate investments happening in the EU in the present in sectors inside the scope of our report; and the total investment needs required annually by 2030 to achieve the EU 2030 targets), **to be of at least 406 billion euros per year, or 2.6% of the EU GDP.**
- In other words, current public and private climate investments in those 22 sectors therefore represent already 50% of what is needed to reach its 2030 climate goals. **Doubling those investments is essential to deliver** the economic, geopolitical and climate benefits EU policy makers committed to.
- These levels of investments are a strict minimum, as the scope or this report is limited (*e.g.* industry is excluded due to data gaps). The report assumes future economic conditions that can be improved by further public and private investment in research and development, or degraded in case of supply chain shocks.
- **EU policy makers urgently need to better assess and address the EU Climate Investment Deficit, or risk seeing the Green Deal fail to deliver** on its economic, social and environmental potential. Addressing the investment challenge is therefore critical for the credibility and continuity of the European Green Deal.
- Addressing the EU climate investment deficit requires a comprehensive approach that involves existing and future regulations, carbon pricing systems, and public finance schemes. **Additional EU funding is likely required** to contribute to reduce the EU Climate Investment Deficit, especially in sectors that are trans European by nature. The quantity, nature and sectorial targeting of EU funding will depend on the economic sectors and **political choices**. A debate on a future **EU long-term climate investment plan** should be the vehicle for such technical and political discussions.

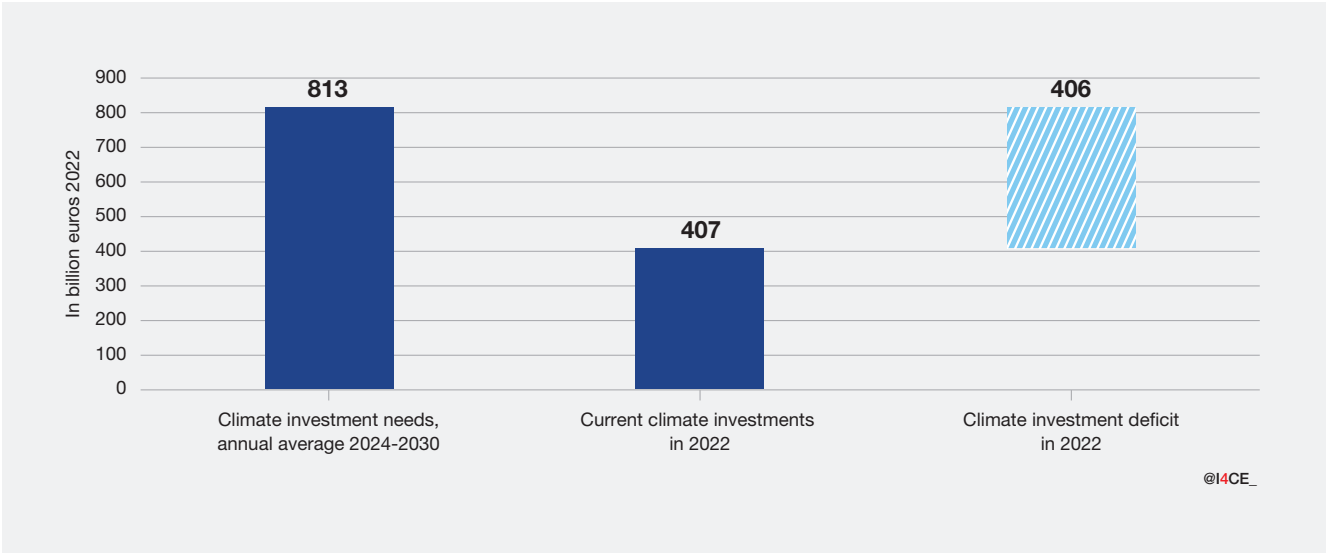
The EU has set itself a range of specific sectoral targets to be achieved by 2030. This includes targets such as doubling the energy renovation rate of existing buildings (European Commission, 2020), or achieving 510 GW of wind power installed capacity (European Commission, 2022b). Achieving those targets requires investments in those specific sectors of the EU economy. Using the latest available investment costs for each area covered in this study (see Methodology Annexes), our research estimates that around 813 billion euros, or 5.1% of the EU GDP, would need to be invested in those sectors in the EU economy, every year until 2030, for the EU to achieve those targets.

The EU economy already invests hundreds of billions of euros in sectors covered by our study. Overall, our research estimates that 2022 climate investments in those sectors reached a level of 407 billion euros, or 2.6% of the EU GDP.

Building on this, our analysis suggests that the current climate investment deficit in the EU economy is currently at 406 billion euros, or 2.6% of the EU GDP. In other words, the current level of investments in renewable energy, electricity grid, energy-efficient buildings, and electric vehicles represent around 50% of the yearly investments that are needed for the EU to deliver its 2030 targets.

2 EU-27 GDP: 15 905.3 billion euros in 2022. Eurostat, 2024 https://ec.europa.eu/eurostat/databrowser/view/nama_10_gdp/default/table?lang=en
3 All data in this report are in constant 2022 euros.

FIGURE 4. THE CURRENT CLIMATE INVESTMENT DEFICIT IN THE ENERGY, BUILDINGS AND TRANSPORT IS ESTIMATED AT €406 BN EUROS PER YEAR



Source: I4CE. All figures are in billion euros 2022. On the left, this graph represents the average climate investment needs for the EU to reach its climate objectives in the energy, buildings and transport systems (813 billion euros). It compares them to the 2022 investments for the same perimeter (407 billion euros). The difference between them gives the climate investment deficit (406 billion euros).

By conducting a granular analysis of each sector covered in our study, three key research findings come to light:

1/ There is an investment deficit in each of the three systems and 22 sectors covered in our report, with two exceptions: hydropower and battery storage. 2022 climate investments in hydropower were 2 billion euros higher than the yearly investment needs to deliver the EU 2030 target in this sector. For battery storage, 2022 climate investments in battery storage were 0.5 billion euros higher. In other words, for these sectors, our research found no deficit, but a surplus[4].

2/ Several sectors have a minor investment deficit with a trend and ongoing policy measures that suggest that this deficit will be less significant in the coming years. For instance, there is only an 8 billion euros deficit in solar (33 billion euros of investment needs, 28 billion euros of actual investments; cf. **section 2.1**), and one of only 4 billion euros for charging points for electric vehicles (6 billion euros of investment needs, 2 billion euros of actual investments).

3/ Several sectors suffer from a very significant investment deficit that has even widened recently. This is especially the case for wind power that suffers from a 74 billion euros deficit (89 billion euros of investment needs, 15 billion euros of actual investments). 2022 investments levels were at the lowest levels since 2009 (cf. **section 2.1**).

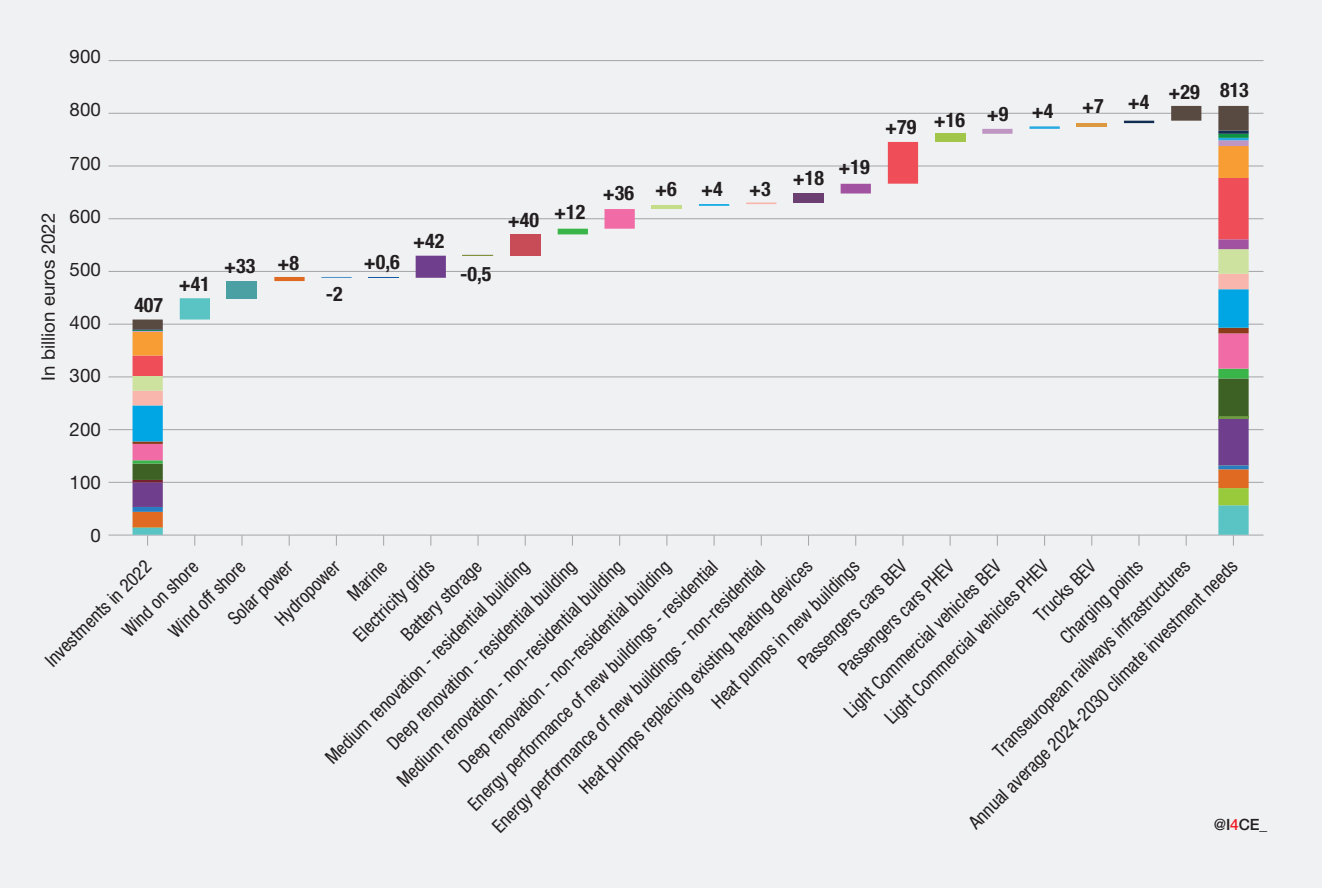
1.1. 22 sectors of the Energy, Buildings and Transport systems are covered in this report

These investment needs estimated in this study represent a minimum. The estimates provided are not exhaustive in scope and only cover the buildings, transport, and energy systems. The climate investment needs in agriculture, industry, research and development, and adaptation to climate change are not considered. Additionally, the scope of investments is also limited within the three systems studied, due to a lack of data at the EU level. The analysis of the energy system only considers investments made in the power sector and does not include for instance biomass, solar heat or geothermal. In the transport system, the analysis does not include several investments in rail and public urban transport infrastructure nor clean aviation or maritime.

Furthermore, when presented with a methodological choice on investment needs, we have consistently opted for the most conservative methodological option. This led this report to a likely under-estimation of real-economy investment needs.

4 For hydropower, this may be contingent as hydropower investments saw a 2 billion euros increase between 2021 and 2022, due to the installation of almost 1 GW of hydropower plants in Portugal in 2022. But without that investment, actual investments would have been almost equal to investment needs.

FIGURE 5. THE EU OVERALL CLIMATE INVESTMENT DEFICIT IS THE SUM OF SECTORAL EU CLIMATE INVESTMENT DEFICITS AND SURPLUSES. THE BIGGEST DEFICITS ARE IN WIND POWER, ELECTRICITY GRIDS, ENERGY-RENOVATION OF BUILDINGS, HEAT PUMPS, RAILWAY AND ELECTRIC PASSENGER CARS



Source: I4CE. All data are in euros 2022. This graph indicates the split of the climate investment deficit by sector. The climate investment deficit corresponds to the difference between the annual average investments that are needed for the EU to reach its climate objective by 2030 and the investments that occured in 2022. For example, for the onshore wind power sector, the climate investment deficit of 41 billion euros corresponds to the difference between the average investment needs (55 billion euros) and the 2022 investments (14 billion euros).

1.2. Economic conditions shape investment needs

The estimation of investment needs assume favourable economic conditions. In particular, they presuppose a supply that can be met by labour and equipment at prices close to or below current levels. Rapidly increasing demand can lead to bottlenecks if supply is not properly supported and sized. Furthermore, future prices are uncertain and are based on assumptions about price trends for the main sectors. Several investment costs are expected to fall by 2030, particularly for wind and solar PV power plants and electric vehicles.

1.3. This report only looks at gross investments

Our analysis only looks at gross investments, not net investments compared to a fossil-fuel baseline. For instance, in our analysis, we estimate the cost of an electric car to be around 34,000 euros in 2030. Our approach being centred on gross investments, the cost of the alternative (a petrol-powered internal combustion engine car) does not impact our climate investment deficit estimate.

Macroeconomists may also be interested in a complementary, net-investment approach. Such an approach would compare the cost of the climate investments with its alternative. For instance, it would look at the cost of both an electric car (34,000 euros) and of an internal combustion engine car (27,000 euros), leading to a gross climate investment of 34,000 euros and a net climate investment of 7,000 euros.

1.4. Most climate investments are economically profitable

Our analysis does not look at the profitability of those investments. Economically, by and large, the climate transformation of the EU economy is about investing capital expenditure (CAPEX) to save operational expenditure (OPEX). For instance, building a new offshore wind power park requires much more CAPEX than building a fossil gas power plant. However, once built, the former generates electricity at a near-zero cost, while doing the same with gas is expensive due to the cost of fossil gas. Even if this analysis is beyond the scope of this report. Readers are therefore invited to remember that most of the climate investments tackled in our report are profitable under current market conditions. This becomes increasingly the case when externalities (job creation, energy security, less climate change impacts, better public health) are accounted for.

1.5. Closing the deficit as soon as possible

Each year, any unmade investment will contribute to an increase in the climate investment needs of the following year. To prevent the climate investment deficit from growing every year, policy makers should urgently better assess and address policy options to close the climate investment deficit.

Furthermore, all figures in our report are in 2022 constant euros. Because of inflation, future prices in current euros will be higher.

2. THE ENERGY SYSTEM: AT LEAST 122 BILLION EUROS OF ADDITIONAL INVESTMENTS ARE NEEDED TO ACHIEVE THE EU 2030 RENEWABLE ENERGY TARGETS AND STRENGTHEN POWER GRID INFRASTRUCTURES

KEY MESSAGES

- Electricity is the backbone of the future European clean energy system. The EU has set itself the objective to go from 20% of its final energy coming from renewables in 2020, to 42.5% by 2030. This translates into significant renewable power capacities deployment. Meanwhile, the EU also set itself interconnection electricity grid targets[5] to ensure energy security and meet rising electricity needs.
- According to our estimates for the energy system, achieving the EU 2030 targets entails at least 225 billion euros, or 1.4% of EU GDP, of public and private investments every year from 2024 to 2030.
- The EU economy already invests in renewable energy sources and power grids. In 2022, 103 billion euros were invested in those specific technologies, or 0.6% of its EU GDP.
- Building on those two research findings, this report estimates the EU climate investment deficit in the energy system, (*i.e.* the difference between the level of climate-friendly investments happening in the EU in the present; and the total investment needs required annually by 2030 to achieve the EU climate objectives), to be of at least 122 billion euros per year, or 0.8% of EU GDP.
- The investment deficit is especially significant in wind power, driven by the EU's objective to deploy wind power capacity at a faster pace by 2030, and power grids. Power grid investments are required to integrate new renewable energy capacities and to support increased electrification.
- Climate investment in the energy system has stagnated or even fallen in recent years, failing to meet the growth required to achieve the objectives of the European Union. This is especially true for the wind energy sector, which has experienced a 52% decrease in investment in 2022 compared to 2021, reaching its lowest level since 2009.
- Estimating the profitability of those investments goes beyond the scope of this report. Yet, addressing the climate investment deficit in the energy sector is key for the EU to rebound after the 2021-2023 fossil gas shock, and make electricity more secure and affordable.

The adoption of the Renewable Energy Directive in 2023 raised the EU binding renewable energy target for 2030 to 42.5%. Achieving this target will require massive increase in capacities, especially in wind power, solar photovoltaic (PV) and related grid investments, which entails higher investment needs.

To achieve these EU targets, our research estimates that around 225 billion euros, or 1.4% of the EU GDP, would need to be invested in the energy system in the EU economy, every year until 2030.

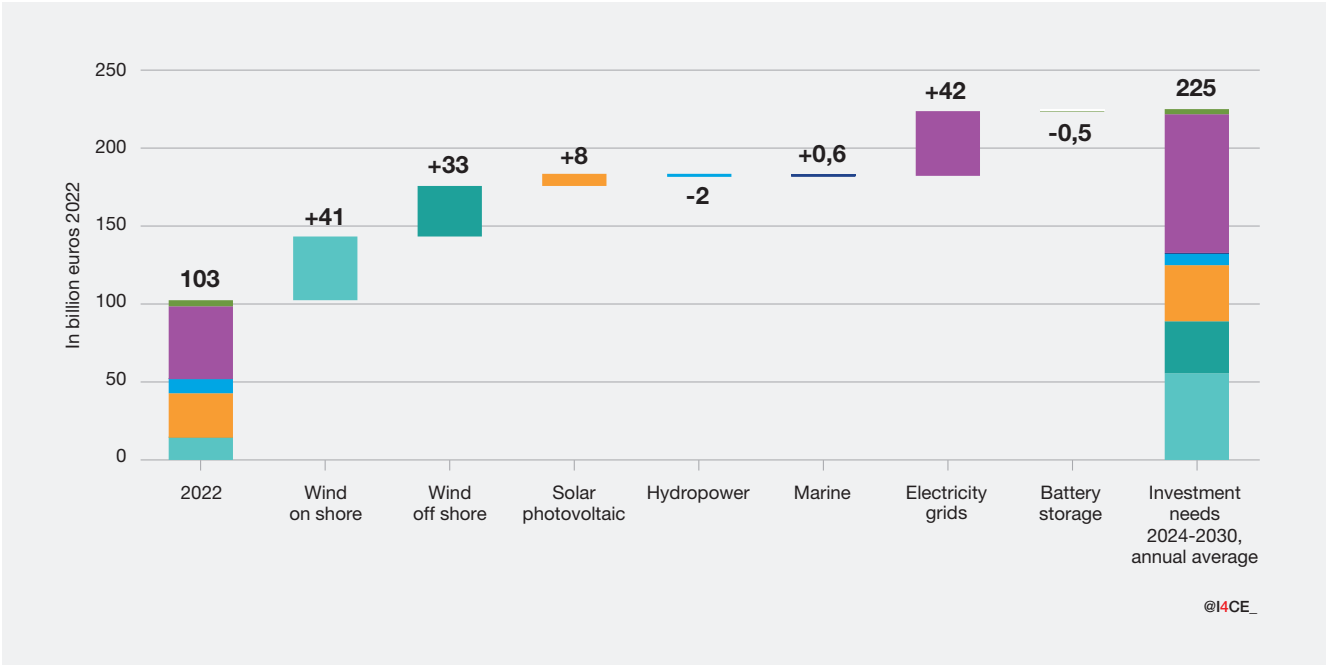
The EU economy already invests in the energy system to achieve these objectives. Overall, looking at the latest EU-27 consolidated data for this system, our research estimates that 2022 climate investments in the EU economy reached a level of 103 billion euros, or 0.6% of EU GDP.

Building on this, our analysis suggests that the current climate investment deficit in the EU economy – *i.e.* the gap between the yearly investments needs in 2024-2030, and the investments that occurred in 2022 – is currently at 122 billion euros, or 0.8% of the EU GDP. The current level of climate investments in the energy system, represent around 46% of the yearly investments that are needed for the EU to deliver its 2030 targets.

Investment needs between now and 2030 are primarily driven by the renewable energy capacity deployment targets set by the European Union, particularly in the wind energy sector, which represent 39% of total investment needs. Power grids will require significant investments as well, as they represent 39% of total investment needs. The investments in power grids relate to the modernisation and extension of the networks, to support the integration of new renewable energy capacities, as well as the increased electrification needs of buildings and industry.

5 The EU has set an interconnection target of at least 15% by 2030 to encourage EU countries to interconnect their installed electricity production capacity.

FIGURE 6. THE CLIMATE INVESTMENT DEFICIT IS ESTIMATED AT €122 BN. INVESTMENT NEEDS ARE DRIVEN BY WIND POWER AND ELECTRICITY GRIDS, WHICH TOGETHER ACCOUNT FOR 95% OF THE ADDITIONAL NEEDS



Source: I4CE. All data are in euros 2022. 2022 investments are based on actual data. This graph represents the distribution of the climate investment deficit for the energy system. For each sector, the investment deficit exists compared the investment required to meet the European regulation to 2022 investments. For instance, 41 billion euros of additional investments are needed annually between 2024 and 2030 in wind on shore. Investment needs are averaged between 2024 and 2030.

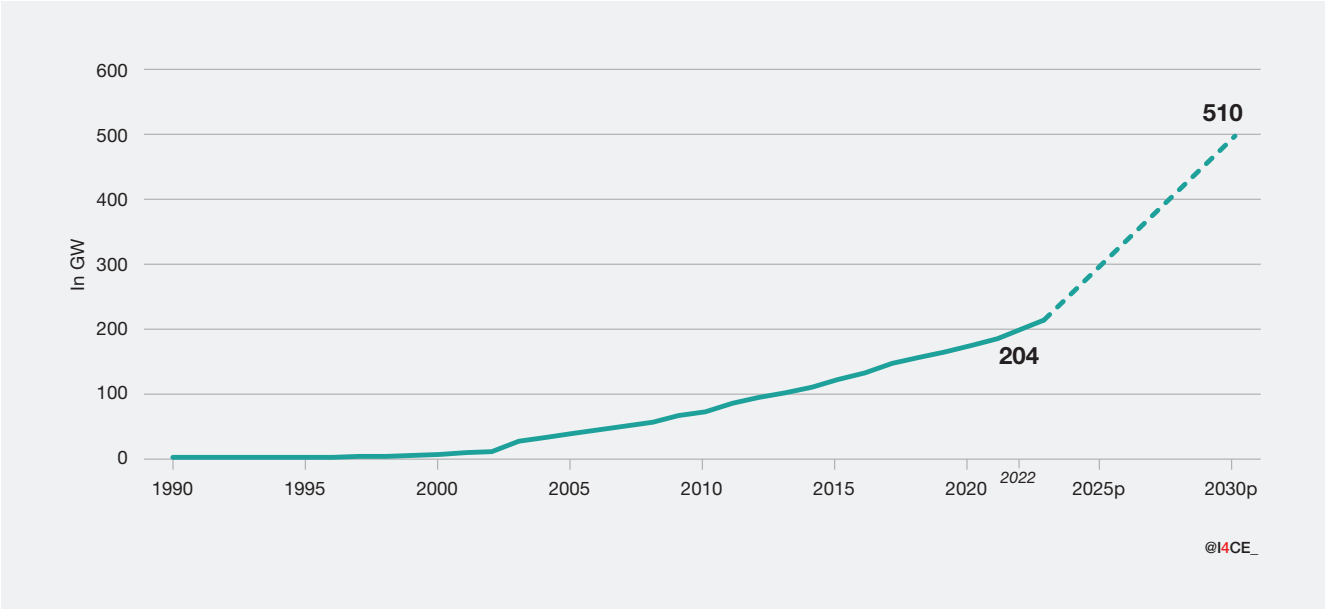
These investment needs are a minimum. The estimates provided are not exhaustive in scope as they do not include investments in biomass, waste, as well as renewable heat, such as geothermal heat, district heating or solar thermal. As the EU does not have precise objectives to develop nuclear energy, it remains outside the scope of our report.

2.1. Wind Power: a struggling sector in need of a pathway to scale

The European Commission, in its RepowerEU plan (European Commission, 2022b) and European Wind Power Action Plan (European Commission, 2023a) aims to achieve a total installed capacity of 510 GW in 2030, including both onshore and offshore wind. This objective implies more than doubling the current capacities between now and 230. This translates to an average annual installed capacity increase of 42 GW compared to 16 GW installed in 2022. Regarding offshore wind, EU Member States, as part of the Trans-European Networks for Energy (TEN-E) (2023), agreed to deploy 111 GW of offshore wind capacity by 2030.

In addition to these additional capacities' targets, a growing percentage of wind turbines will need to be replaced. The lifetime of a wind turbine is around 20 years (WindEurope, 2023b). Since 2003, wind turbine installations have significantly increased, indicating a need for renewal in the next decade. By the end of the decade, the amount of investment linked to renewals of existing wind power capacities will represent around 15% of total investment needs.

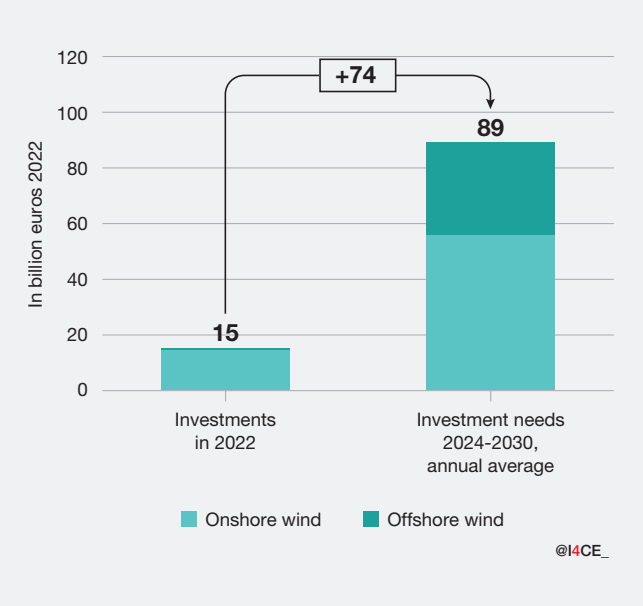
FIGURE 7. EU TARGETS WILL REQUIRE A LEAP IN ANNUAL WIND CAPACITY INSTALLATIONS BETWEEN 2024 AND 2030



Source: I4CE based on Eurostat, WindEurope and RepowerEU. This graph represents total wind power installed capacities in GW. In 2022, the total wind power installed capacities was 204 GW. 510 GW are expected to be installed by 2030 according to RepowerEU's 2030 targets. The data up to 2023 represents the actual installed data; the 2023 landings have been estimated by WindEurope (WindEurope, 2024). The data between 2024 and 2030 have been projected on a linear basis.

Using the latest available investment costs from the IEA (see **section 2.3**), our research estimates that around 89 billion euros would need to be invested in wind power in the EU economy on average, every year until 2030, for the EU to achieve its targets. According to WindEurope (WindEurope, 2023a), 15 billion euros has been invested in wind power in 2022, giving a climate investment deficit of 74 billion euros. Investment in wind power capacity deployment has decreased between 2021 and 2022. Offshore wind power capacity investment even reached its lowest level since 2009 at 400 million euros in 2022 (WindEurope, 2023a) (see **section 2.5**). The investment costs for wind power capacities used to estimate these investments are detailed in **section 2.3** and were obtained from the IEA (IEA, 2023b).

FIGURE 8. ACHIEVING EU CLIMATE TARGETS IN WIND POWER WILL REQUIRE €89 BN PER YEAR BETWEEN 2024 AND 2030, LEAVING A CLIMATE INVESTMENT DEFICIT OF €74 BN IN 2022

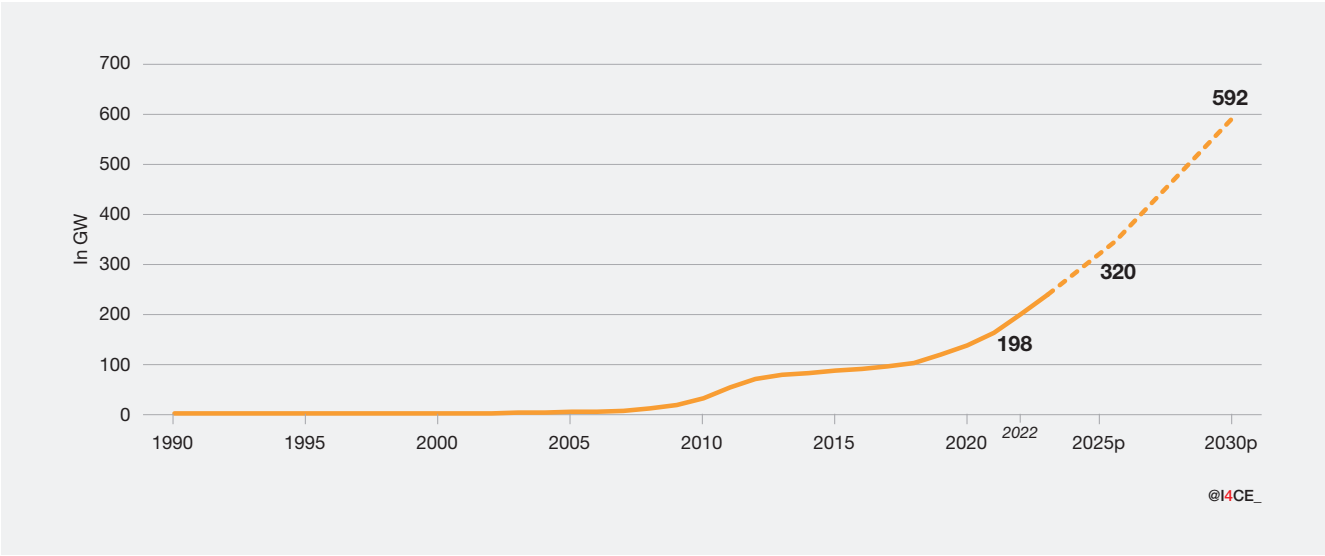


Source: I4CE and WindEurope. All data are in euros 2022. 2022 investments in wind power are estimated at 15 billion euros by WindEurope. The annual average investments needed to meet the EU's climate objectives are estimated at 89 billion euros between 2024 and 2030. The difference between these two levels of investment corresponds to the climate investment deficit, estimated at 74 billion euros.

2.2. Solar Power: reinforcing current trends should help put this sector on track

As part of the REPowerEU plan (2022), the European Commission aims to bring online over 320 GW of solar photovoltaic by 2025 and almost 600 GW by 2030, compared to 200 GW installed today. This corresponds to an annual capacity installation of more than 50 GW, compared to 36 GW in 2022. The increase in installation rate is consistent with the rate observed over the past five years. Unlike wind power, the need to replace solar panels is limited over the next decade. Solar panels have a lifetime of around 25 years, and their installation began to take off in 2010.

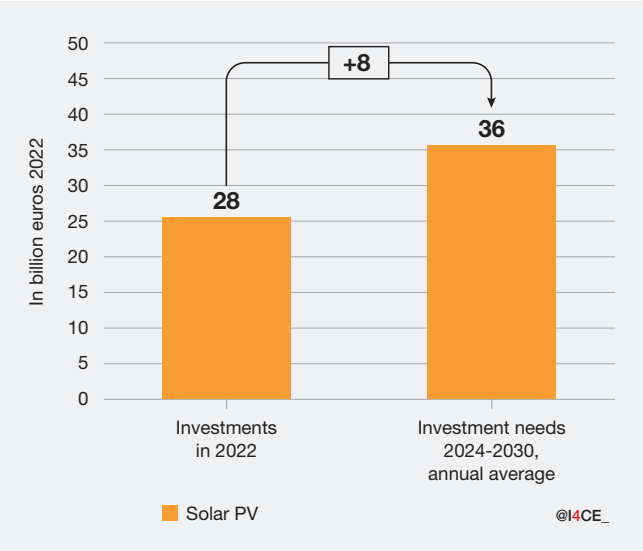
FIGURE 9. EU TARGETS WILL REQUIRE AN INCREASE IN SOLAR PV CAPACITY INSTALLATIONS BETWEEN 2024 AND 2030, IN LINE WITH RECENT TRENDS



Source: I4CE based on Eurostat and RepowerEU. This graph represents total solar PV installed capacities in GW. In 2022, the total solar power installed capacities was 198 GW. 320 GW are expected to be installed by 2025 and 592 GW by 2030, according to RepowerEU's 2030 targets. The data up to 2023 represents the actual installed data; the 2023 landings have been estimated. The data between 2024 and 2030 have been projected on a linear basis.

Using the latest available investment costs from the IEA (IEA, 2023b) (see **section 2.5**), our research estimates that around 36 billion euros would need to be invested in solar PV in the EU economy, every year until 2030, for the EU to achieve its targets. Our research also estimates that 28 billion euros has been invested in solar PV in 2022, giving a climate investment deficit of 8 billion euros. Future investment needs increase because more solar panels need to be installed to reach the EU 2030 target. This increase in the investment needs is however partly offset by decreasing cost assumptions over the decade (see **section 2.3**).

FIGURE 10. ACHIEVING EU CLIMATE TARGETS IN SOLAR POWER WILL REQUIRE €36 BN PER YEAR ON AVERAGE BETWEEN 2024 AND 2030, LEAVING A CLIMATE INVESTMENT DEFICIT OF €8 BN IN 2022



Source: I4CE. All data are in euros 2022. 2022 investments in solar PV are estimated at 28 billion euros. The annual average investments needed to meet the EU's climate objectives are estimated at 36 billion euros between 2024 and 2030. The difference between these two levels of investment corresponds to the climate investment deficit, estimated at 8 billion euros.

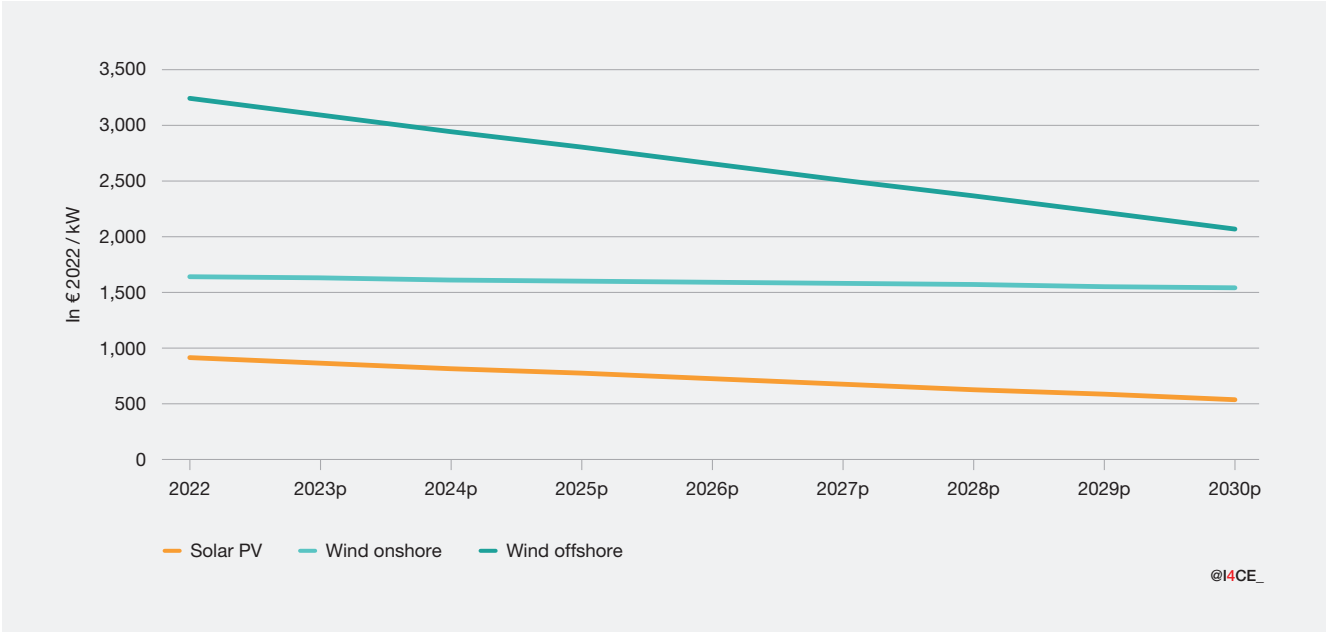
2.3. Favourable projections for cost reductions of renewable energy sources are key for Europe's competitiveness

To estimate the investment needs in renewable energies by 2030, we have mainly used the International Energy Agency (IEA)'s energy investment cost projections. In its World Energy Outlook report (IEA, 2023b), the IEA reported several investment cost assumptions for renewable energy according to several scenarios. Our estimates use assumptions from the IEA Announced Pledge Scenario, assuming that the policies announced by every country will take place in due time.

The IEA projects a decrease in investment cost for renewable energy, especially for offshore wind and solar PV. Wind investment costs are expected to decrease by 5.7% annually for offshore wind between 2022 and 2030 and by 1% annually for onshore wind. For Solar PV investment cost, the IEA even plans a 6.4% annual reduction between 2022 and 2030 (see **Figure 11**). These cost reduction assumptions are primarily due to anticipated learning rates associated with the scaling up of deployment and technological innovation.

These assumptions regarding lower investment costs partially offset the increase in installed capacity, thereby reducing the need for investment in these sectors. It is important to note that future prices are highly uncertain and are based on assumptions about price trends for the main sectors. They are expressed in euros 2022 and do not include inflation projections for the next decade. They presuppose a geopolitical context that does not lead to significant disruptions in supply chains.

FIGURE 11. THE IEA ANTICIPATES A DECREASE IN RENEWABLE ENERGY INVESTMENT COSTS BY 2030, ESPECIALLY FOR OFFSHORE WIND AND SOLAR PV



Source: I4CE from the IEA. The data are in euros 2022 per kW of capacity installed. Data for 2022 and 2030 are from the IEA, World Energy Outlook 2023, Announced Pledge Scenario. The data between 2022 and 2030 have been projected on a linear basis.

2.4. Power grid and battery storage investments are required to integrate more renewable energy and to support electrification

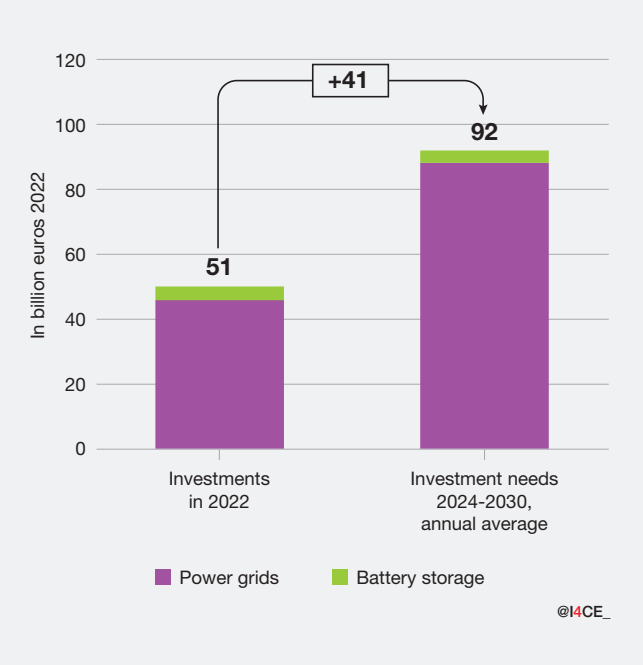
Electricity networks are the backbone of the EU's internal energy market and are thus essential for enabling the green transition. The expected increase in the European Union's electricity consumption, and the connection of new renewable energy capacities to the grids, will require significant investments between now and 2030. These investments concern both transmission and distribution grids. Transmission networks carry electricity at high voltage over long distances across and between states while distribution networks connect electricity to the final consumers.

Our research estimates that around 89 billion euros would need to be invested in power grids every year between 2024 and 2030. Distribution grid investments account for 63% of these investment needs. According to the European Investment Bank (EIB, 2024), based on the IEA data (IEA, 2023a), 47 billion euros has been invested in both transport and distribution power grids in 2022, leading to a climate investment deficit of 42 billion euros.

Additional renewable energy capacities will generate a need for additional grid infrastructures, including cross-border infrastructures between Member States. A rising demand in electrification, due for example to industry electrification, heat pump installations, or railways infrastructure deployment will also generate a need for investments, especially in distribution grids. Investment needs in grids modernisation have also been considered, as around 40% of Europe's distribution grids are over 40 years old and need to be modernised (European Commission, 2023b).

Investments in battery storage amounted to 4.2 billion euros in 2022 (EIB, 2024). According to the European Resource Adequacy Assessment, from ENTSO-E (2022), 4.4 GW of battery storage capacities on average need to be installed annually between 2024 and 2030. It includes both residential and utility-scale installations. According to ENTSO-E's estimated investment costs for these two technologies, the average annual investment requirements between 2024 and 2030 are 3.7 billion euros. This results in an investment surplus of 0.5 billion euros.

FIGURE 12. 92 BILLION EUROS WILL BE NEEDED EVERY YEAR BETWEEN 2024 TO SUPPORT GRIDS EXTENSION AND MAINTENANCE, AS WELL AS BATTERY STORAGE DEVELOPMENT

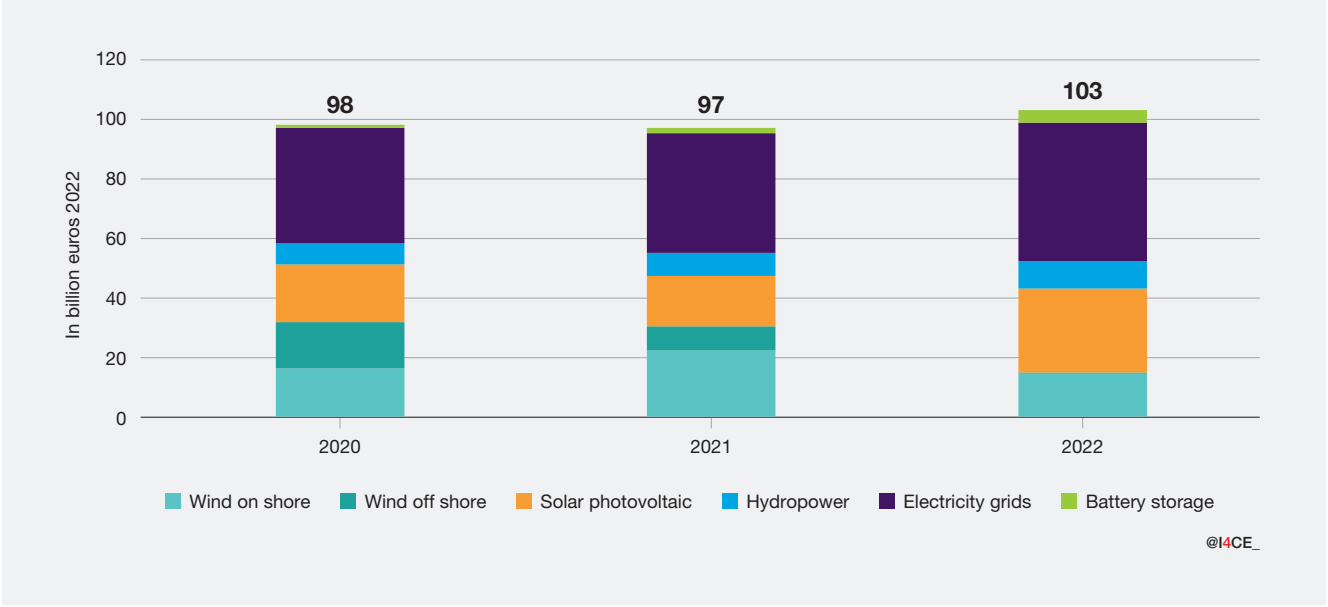


Source: I4CE and EIB. Investment amounts are expressed in euros 2022. 2022 investment data comes from the EIB, based on the IEA data. Projected investment data for the period 2024-2030 are derived from Eurelectric (Eurelectric et al., 2021) and TSOs data.

2.5. With stagnating climate investments, recent years show the EU heading off-track

Climate investments in the energy system amounted to 103 billion euros in 2022. They have remained relatively stable in 2020 and 2021, and increased slightly in 2022 (see **Figure 13**). The increase in investment in 2022 is primarily attributed to solar PV and power grids. The increase in investments in these two sectors counterbalanced a substantial decrease in the wind energy sector, which was halved between 2021 and 2022.

FIGURE 13. CLIMATE INVESTMENTS IN THE ENERGY SYSTEM ARE STAGNATING IN RECENT YEARS DUE TO A DECLINE IN WIND POWER INVESTMENTS, OFFSET BY AN INCREASE IN SOLAR PV AND POWER GRIDS INVESTMENTS



Source: I4CE from WindEurope (2023), Eurostat (2024), IRENA (2023), the IEA (2023b), the EIB (2024). All data are in euros 2022. They represent the climate investments in the energy system between 2020 and 2022.

A drop in wind power investments in 2022, at its lowest level since 2009

In 2022, investment in onshore wind power amounted to around 14.3 billion euros, which corresponds to an 8 billion euros decrease (excluding inflation) compared to 2021. Offshore wind power has also experienced a similar trend, with investment in 2022 dropping to 0.4 billion euros, a decrease of 7.9 billion euros compared to 2021 (excluding inflation). Overall, investment in the wind energy sector in 2022 was at its lowest level since 2009 (WindEurope, 2023a).

According to WindEurope, this decrease in investments in the wind energy sector is mainly due to unfavourable financing conditions and supply chain challenges. The increase in interest rates, triggered by central banks to contain inflation, has led to higher borrowing costs. In reaction, investors are postponing the signing of long-term debt agreements, which affects the financing of new wind power capacities. In addition, over the last two years, supply chain, commodity and logistical costs have risen by up to 50%. As a result, original equipment manufacturers have added this price indexation to their contracts, leading to lower achievable rates of return for developers and investors.

Lower investments in wind power, partly offset by higher investments in solar PV

Solar PV investments, however, have increased by 10.9 billion euros (excluding inflation) in 2022. 36.4 GW of new solar PV capacity were connected to the grids, a 23% increase compared to 2021. This solar PV boom in the EU is mainly due to an increasing demand for residential and commercial and industry solar PV, as a result of rising electricity prices. Households and businesses are turning to solar as a way to protect themselves from rising energy bills (SolarPower Europe, 2022). In several Member States, regulatory choices have also accelerated solar PV deployment in 2022.[6]

Climate investment in the energy system has stagnated in recent years. Yet, annual investment in renewable energy and electricity grids needs to increase significantly if the European Union is to meet its climate targets by 2030. The implementation of ongoing legislation and policy actions, as well as further support measures, are critical to reduce the climate investment deficit year after year.

6 In Germany, for instance, attractive feed-in premiums for medium- to large-scale commercial systems boosted solar investments. In Poland, the shift from net-metering to net-billing since April 2022 led to a rush of installations in the first quarter of the year in the small-scale rooftop segment.

3. THE BUILDING SYSTEM: AT LEAST 137 BILLION EUROS OF ADDITIONAL INVESTMENTS IN BUILDINGS ENERGY-EFFICIENCY AND HEAT PUMPS ARE NEEDED FOR CLIMATE AND ENERGY SECURITY

KEY MESSAGES

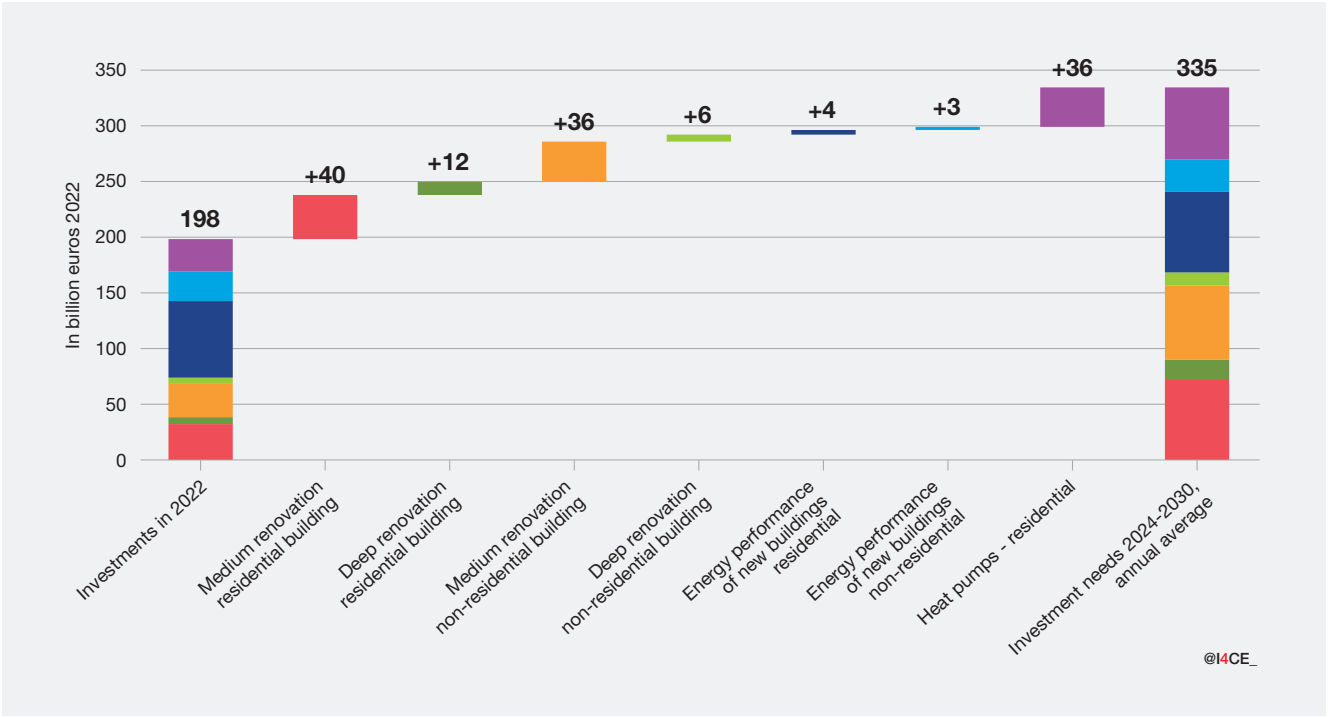
- The energy efficiency of new and existing buildings has been a long-standing are of EU policy action. In 2020, The European Commission launched the Renovation Wave that originated the recast of the Energy Performance of Buildings Directive (EPBD). It aims to at least double the rate of building renovations by 2030. The EPBD also requires all new buildings to meet Nearly Zero Energy Buildings (NZEB) standards since 2021. Finally, the REPowerEU plans to deploy 30 million heat pumps by 2030 compared to 2020 (European Commission, 2022b).
- For the building system, making the EU 2030 targets a reality entails at least 335 billion euros, or 2.1% of EU GDP of public and private investments every year from 2024 to 2030.
- The EU economy already makes climate investment in the building system. In 2022, 198 billion euros were invested in buildings energy renovation, energy efficiency of new buildings and heat pump deployment, or 1.2% of EU GDP.
- Based on those two research findings, this report estimates the EU climate investment deficit in the building system, (*i.e.* the difference between the level of climate-friendly investments happening in the EU in the present; and the total investment needs required annually by 2030 to achieve the EU climate objectives) to be of at least 137 billion euros per year, or 0.9% of EU GDP.
- Building energy renovation represents almost half of the total climate investment needs of the building system. Meanwhile, the energy efficiency requirements for new buildings are expected to remain similar to current levels. Finally, the heat pump installation needs between now and 2030 will require a doubling of current heat pump investments.
- Finding recent and accurate data to determine past investments in building energy renovation and NZEB investments proved challenging. Investment data until 2022 presented in the following section are estimates that should be treated with caution. Of all the sectors covered in this report, building renovation is where access to reliable, open and up-to-date data was the biggest challenge.

In 2020, the European Commission launched the Renovation Wave (European Commission, 2020). It aims to boost the renovation of Europe's buildings to make them more efficient. In particular, the Renovation Wave aims to at least double the renovation rate by 2030 and to promote deep renovation (see **Box 1**). To meet these objectives, the Renovation Wave has led to the revision of the European Building Performance Directive (EBPD) (European Commission, 2021d), as part of the Fit For 55 legislative package. The agreement is currently being finalised. Regarding energy efficiency in new buildings, the last revision of the EPBD (2018) already set new targets for the current decade. All new buildings in Europe should be Nearly Zero-Energy Buildings (NZEB)[7] by 2021. These new EU objectives will lead to further investment needs in the coming years.

Climate investment needs for the EU to achieve these objectives in the building system are estimated at 335 billion euros per year between 2024 and 2030. That represents 2.1% of EU 2022 GDP. The EU economy has invested 198 billion euros in 2022 (1.2% of EU GDP), leaving a climate investment deficit of 137 billion euros for the building system (0.9% of EU GDP). These investment needs include both residential and non-residential buildings. Building energy-renovation accounts for almost 50% of the total investment needs.

7 According to Article 2(2) of the EPBD an NZEB '… means a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby'. The NZEB standards may vary among EU Member States.

FIGURE 14. THE CLIMATE INVESTMENT DEFICIT IS ESTIMATED AT €137 BN. INVESTMENT NEEDS ARE DRIVEN BY ENERGY EFFICIENCY RENOVATION NEEDS



Source: I4CE. All data are in euros 2022. 2022 investments are based on actual data. This graph represents the distribution of the climate investment deficit for the building system. For each equipment, the investment deficit exists compared the investment required to meet the European regulation to 2022 investments. For instance, 40 billion euros of additional investments are needed annually for medium renovation in residential buildings. Investment needs are averaged between 2024 and 2030.

Buildings climate investments include building energy renovation investments, energy-related items in new building construction corresponding to NZEB standards and investments in heat pumps installations. Climate investments in buildings energy-renovation only include investments in medium and deep renovation (see **Box 1**). They exclude heating device replacement, which is covered separately. Non-energy renovation items are not considered in the scope. Climate investments in new buildings construction correspond to investments that are made in building envelope renovation meeting NZEB standards. Heat pumps have been covered in a separate section. Other heating devices have not been included in the scope of analysis.

It is important to acknowledge that there is a significant lack of data at the European level regarding both the energy renovation of buildings and the construction of new buildings meeting NZEB standards. Most of the available data are from 2016 (European Commission. Directorate General for Energy. *et al.*, 2019). Therefore, the data for past and current investments presented in the following sections are estimates, derived from this aforementioned European Commission report, and should be treated with caution.

3.1. Buildings energy renovation: Doubling renovation rates entails doubling investment in both medium and deep renovation

The European Union aims to at least double the renovation rate by 2030. For residential buildings, for example, this means achieving a medium renovation rate of 2.2% and a deep renovation rate of 0.4% (see **Table 1**).

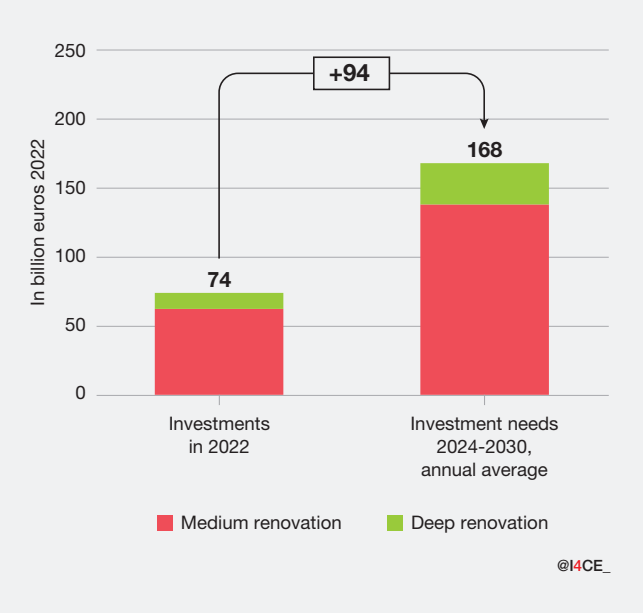
TABLE 1. RENOVATION RATES BY TYPE OF RENOVATION FOR RESIDENTIAL AND NON-RESIDENTIAL BUILDINGS

	Current	2024-2030 objectives
Residential - medium renovation	1.1%	2.2%
Residential - deep renovation	0.2%	0.4%
Non-residential - medium renovation	2.1%	4.2%
Non-residential - deep renovation	0.3%	0.6%

Source: I4CE and European Commission. Current renovation rates are 2016 data and are from (European Commission. Directorate General for Energy. et al., 2019).

Doubling energy renovation rates implies an increase in energy renovation investments. Climate investment needs for the EU to achieve these objectives are estimated at 168 billion euros per year between 2024 and 2030. The EU economy has invested 74 billion euros in 2022 in energy renovation, giving a climate investment deficit of 94 billion euros for the building system. Investments in deep renovation account for 18% of these investment needs. These investment needs concern both residential and non-residential buildings equally.

FIGURE 15. ACHIEVING EU CLIMATE TARGETS IN DEEP AND MEDIUM ENERGY RENOVATION WILL REQUIRE €168 BN PER YEAR ON AVERAGE BETWEEN 2024 AND 2030, LEAVING A CLIMATE INVESTMENT DEFICIT OF €94 BN IN 2022



Source: I4CE. All data are in euros 2022. 2022 investments in medium and deep renovations are estimated at 74 billion euros. The annual average investments needed to meet the EU's climate objectives are estimated at 168 billion euros between 2024 and 2030. The difference between these two levels of investment corresponds to the climate investment deficit, estimated at 94 billion euros.

BOX 1. DEEP RENOVATION AND MEDIUM RENOVATION DEFINITIONS

- We have included medium and deep renovations in our scope, in accordance with the criteria adopted by the European Taxonomy[8].
- An energy renovation means the change of one or more building elements, according to EPBD Art. 2, 9 (*i.e.* building envelope and technical building systems), having the potential to significantly affect the calculated or measured amount of energy needed to meet the energy demand associated with one or several building services, such as: space heating and cooling, hot water, ventilation, lighting, etc.
- The depth of a building energy renovation corresponds to the primary energy savings achieved with a specific measure or package of measures that have been implemented in a calendar year (European Commission. Directorate General for Energy. *et al.*, 2019). Four renovation depths can be identified:
  - Below threshold ($x < 3\%$ savings);
  - Light renovations ($3\% \leq x \leq 30\%$ savings);
  - Medium renovations ($30\% < x \leq 60\%$ savings);
  - Deep renovations ($x > 60\%$ savings).
- The different depths do not necessarily need to cover a specific minimum number of measures but are just classified depending on the savings achieved compared to the primary energy performance level of the building in the calendar year before the energy renovation.

8 A building renovation complies with the EU Taxonomy if it leads to a reduction of primary energy demand (PED) of at least 30 %. https://ec.europa.eu/sustainable-finance-taxonomy/activities/activity/351/view

The investment costs of energy renovation for both medium and deep renovation correspond to building envelope insulation costs including roof, basement, and walls insulation costs, as well as windows replacement. They do not include non-energy related renovation items. These costs vary among the different member states considering the cost of labour and raw materials in each country (European Commission. Directorate General for Energy. *et al.*, 2019). No increase in renovation cost has been projected over the 2024-2030 period. The investment needs are mainly determined by the volume of building renovations required to achieve the EU's climate objectives.

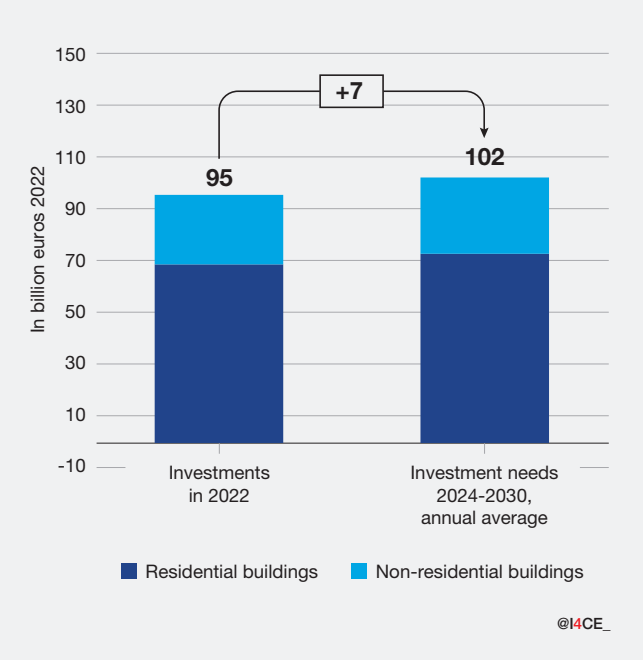
3.2. Energy performance of new building construction: the investment needs keep pace with volume

The recast of the Energy Performance of Building Directive (2018) requires all new buildings to be NZEB from 2021. Based on projections for the EU building stock in 2030 estimated by the European Commission (2021d), we have estimated an increase in the housing stock of around 1.2% per year. Additionally, we have estimated an increase of 1.3% in non-residential building stock. We have assumed that the NZEB share of new buildings is 100% from 2021. This is a strong and conservative assumption (see **Box 2**).

102 billion euros are needed annually to be invested in building envelope insulation of new buildings between 2024 and 2030. These investments are driven by the number of annual new buildings constructed. In 2022, the investments amounted to 95 billion euros, giving a climate investment deficit of 7 billion euros. These investments concern both residential and non-residential buildings although the investment needs in the residential sector represent approximately 70% of the total investment needs.

The investment costs for achieving NZEB standards represent the total cost of insulating the new building. It includes roof, basement, and walls insulation costs, as well as the cost of double- or triple-glazed windows. It does not include every other non-energy related construction costs. Nor does it include a change of heating system, which is covered in a separate section. These costs vary among the different member states considering the cost of labour and raw materials in each country (Cravezero, 2018). No increase in investment cost has been projected over the 2024-2030 period.

FIGURE 16. ACHIEVING EU CLIMATE TARGETS IN ENERGY EFFICIENCY OF NEW BUILDINGS WILL REQUIRE €102 BN PER YEAR ON AVERAGE BETWEEN 2024 AND 2030, LEAVING A CLIMATE INVESTMENT DEFICIT OF €7 BN IN 2022



Source: I4CE. All data are in euros 2022. 2022 investments in energy efficiency of new buildings are estimated at 95 billion euros. The annual average investments needed to meet the EU's climate objectives are estimated at 102 billion euros between 2024 and 2030. The difference between these two levels of investment corresponds to the climate investment deficit, estimated at 7 billion euros.

BOX 2. UNCERTAINTY ON DETERMINING CURRENT CLIMATE INVESTMENTS IN NEW BUILDINGS

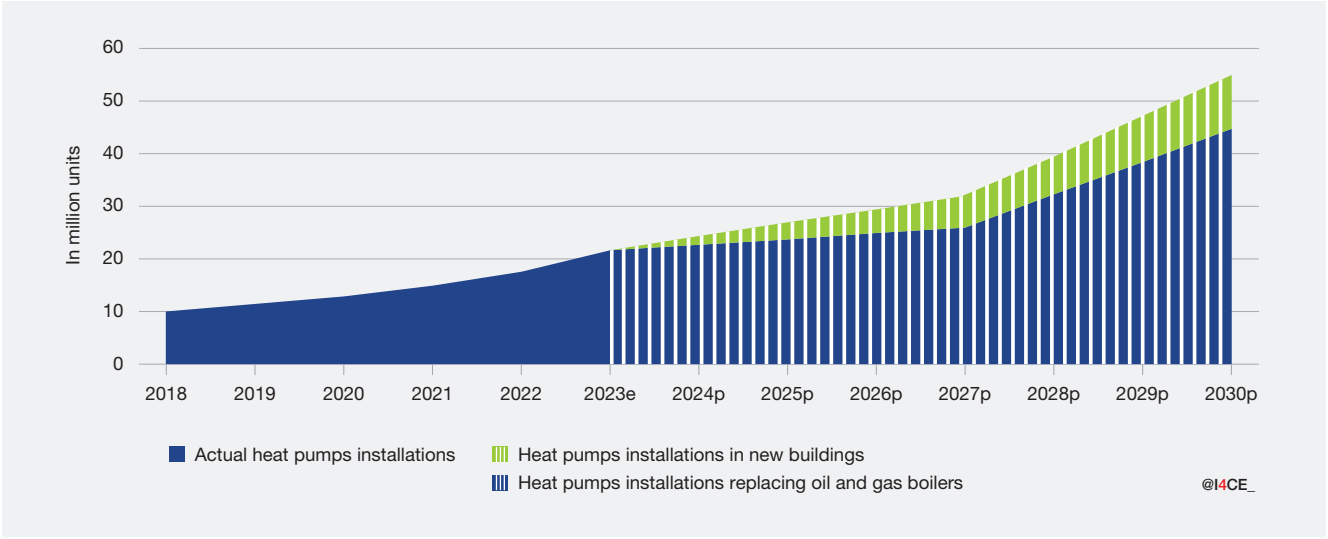
The climate investment deficit in NZEB energy-related investments presents significant uncertainties. An incertitude remains on the 2022 investment, as no recent information on the number of buildings meeting NZEB criteria are available at EU level. The latest available data dates back to 2016.

Our methodology assumed that all new buildings met NZEB standards since 2021. In 2016, around 21% of new residential buildings in the EU were considered NZEB, compared to 15% in 2012. For non-residential buildings, it was 11% (European Commission. Directorate General for Energy. *et al.*, 2019). This is a strong assumption, as there is currently no data available on the exact number of new buildings that meet NZEB standards. Therefore, we have opted for this more conservative approach in our estimates.

3.3. Heat pumps: rising demand driven by the climate and energy security needs to replace oil and gas boilers

The REPowerEU Action Plan and the Green Deal Industrial Plan of the European Commission foresees the installation of 10 million heat pumps by 2027 (European Commission, 2022b); and 30 million heat pumps by 2030 (European Commission, 2022a), compared to 2020. These heat pumps are supposed to be mainly hydronics. The objective of these heat pumps deployment is mainly to replace existing oil and gas boilers in existing dwellings. We also assumed that 10 million heat pumps will be deployed in new residential buildings, in line with JRC assumptions (JRC, 2023). It is assumed that heat pumps will be deployed in approximately 90% of new dwellings. These estimations represent a total heat pump stock of 54 million units in 2030.

FIGURE 17. THE EU HEAT PUMP STOCKS IS EXPECTED TO REACH 54 MILLION UNITS IN 2030, THREE TIMES MORE THAN IN 2022

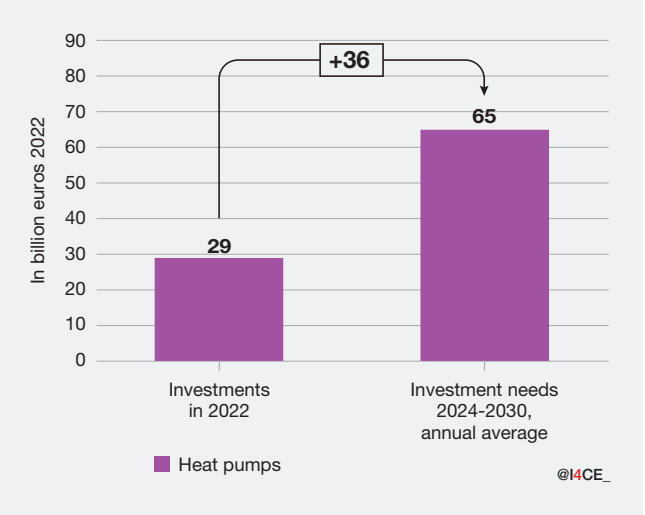


Source: I4CE. Stock is defined as the accumulated sales. This graph represent total stock of heat pumps in the EU until 2030. In 2022, the EU stock of heat pumps was 17 million. The EU expect the installation of 10 million additional units by 2027 and 30 million additional units in existing buildings by 2030, compared to 2020. 10 million units are also expected to be installed in new buildings. Data until 2022 are real data, based on EHPA market reports (EHPA, 2023). The 2023 landings have been estimated.

Achieving EU climate objectives for heat pumps deployment will imply 65 billion euros per year of investments between 2024 and 2030. The heat pumps 2022 investments were estimated at around 29 billion euros, giving a climate investment deficit of 36 billion euros. The investment needs in heat pumps are mainly driven by the EU objectives of heat pumps deployment in volumes.

The estimate of heat pumps investment needs uses the average investment cost of air-water heat pumps in the European Union. These investment costs differ between Member States. Based on IEA data by country (IEA, 2021), the average investment cost for air-water heat pumps in the EU have been estimated to be around 13,000 euros in 2022. It is assumed that the investment cost will remain constant until 2030. It should be noted that 30% of sales in 2022 corresponded to air-air heat pumps, which have a lower investment cost than air-water heat pumps (around 5,000 euros in 2022).

FIGURE 18. ACHIEVING EU CLIMATE TARGETS FOR HEAT PUMPS WILL REQUIRE €65 BN PER YEAR ON AVERAGE BETWEEN 2024 AND 2030, LEAVING A CLIMATE INVESTMENT DEFICIT OF €36 BN IN 2022



Source: I4CE. All data are in euros 2022. 2022 investments in heat pumps deployment are estimated at 29 billion euros. The annual average investments needed to meet the EU's climate objectives are estimated at 65 billion euros between 2024 and 2030. The difference between these two levels of investment corresponds to the climate investment deficit, estimated at 36 billion euros.

4. THE TRANSPORT SYSTEM: AT LEAST 147 BILLION EUROS OF ADDITIONAL INVESTMENTS ARE NEEDED IN ELECTRIC VEHICLES AND LONG-DISTANCE RAILWAY INFRASTRUCTURE

KEY MESSAGES

- To reduce CO_2 emissions from transports, the European Union has adopted a set of policies that includes the deployment of electric vehicles, as well as the promotion of long-distance train infrastructures. Between 2024 and 2030, making EU targets in these sectors a reality entails 253 billion euros of investments per year or 1.6% of the EU GDP. Other modes of transportation, such as urban or maritime transport, were excluded from our research. The transport climate investment presented is then only a minimum needed for the decarbonization.
- The EU economy already invests in clean mobility. In 2022, 106 billion euros, or 0.7% of EU GDP, were invested primarily in battery electric cars, chargeable hybrid cars and long-distance rail infrastructure, covering 42% of overall investment needs.
- This report estimates the climate investment deficit (difference between the level of climate-friendly investments happening in the EU in the present; and the total investment needs to be required annually by 2030 to achieve the EU climate objectives) in transport to reach 147 billion euros, or 0.9% of EU GDP per year between 2024 and 2030.
- Passenger cars and vans make up the lion's share of the needs. With a gap of 108 billion euros, their deployment is key for bridging the deficit. Favouring battery electric vehicles over more expensive and more polluting chargeable hybrid vehicles would be a political choice that would reduce the investments needed in the EU economy.
- Electric charging points will enable the transition to clean road transport. Our research finds that 4 billion euros of additional investment every year would likely be sufficient to support electrification.
- The 2030 objective for trans-European trains requires more investment than the total funds currently allocated to railway infrastructures across Europe. If Europe aims to decarbonize long-distance travel, given the public nature of such infrastructure, a leap in public investment is needed.

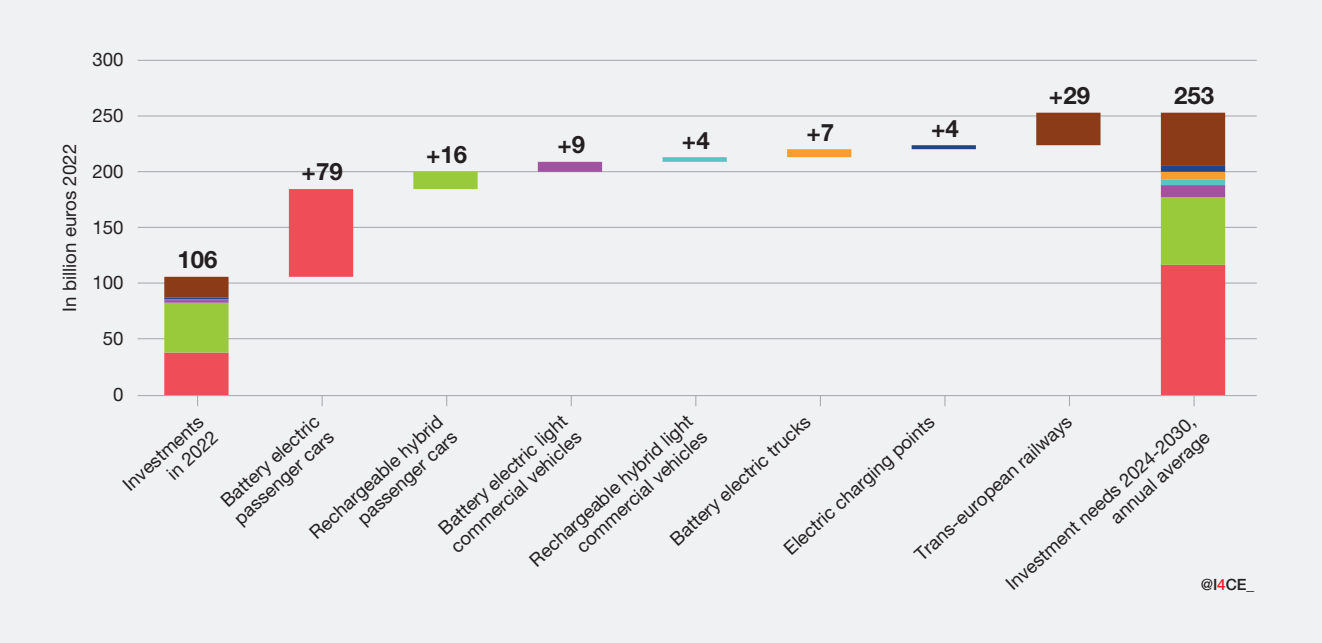
The need for climate investments in the sectors covered in this section originates from the main newly agreed regulations of the European Green Deal.

- For road transport, the policies and scenarios considered are based on EU regulations aimed at reducing greenhouse gas emissions from new vehicles. These regulations set emissions standards for passenger cars, light commercial vehicles (or vans), and heavy-duty vehicles. The deployment of electric technologies is necessary to meet this ambition.
- Supporting the uptake of electric vehicles, the Regulation on the deployment of alternative fuels infrastructure (2023) set mandatory deployment of public charging points.
- For rail transport, the European Union wants to increase the rail transport modal share by developing trans-European long-distance railways. The Trans European Transport – Network regulation (TEN-T) defines certain rail projects as high-priority infrastructure for 2030. These "core Network" projects were used to estimate investment needs. The impact of the future revision of TEN-T, is analysed in the rail section.

Climate investment needs for the EU to achieve its climate objectives in the transport system are estimated at 253 billion euros per year between 2024 and 2030. That represents 147 billion euros more than what is being invested today.

Investment needs between now and 2030 are primarily driven by the electrification of vehicles, accounting for 78% of the total deficit or 115 billion euros. Supporting this technological shift, charging points additional investments represent 3.6 billion euros, or only 2% of the total deficit. Trans-European Railways, with a deficit of 29 billion euros, have the second-highest need of additional investments (20%). This ignores investment needs in key transport systems for reducing CO_2 emissions not covered by this report due to lack of data, such as urban public transport.

FIGURE 19. THE CLIMATE INVESTMENT DEFICIT IS ESTIMATED AT €147 BN. ROAD TRANSPORT NEEDS ARE DRIVEN BY BATTERY ELECTRIC PASSENGER CARS, REPRESENTING 54% OF THE ADDITIONAL NEEDS, WHILE TRANS-EUROPEAN TRAINS ACCOUNT FOR 20%



Source: I4CE. All data are in euros 2022. 2022 investments are based on actual data. This graph represents the distribution of the climate investment deficit for the transport system. For each technology, the investment deficit compares the investment required to meet the European regulation with 2022 investments. For instance, 79 billion euros of additional investments are needed annually for battery electric passenger cars. Investment needs are averaged between 2024 and 2030.

The investment needs are a minimum as the scope of the study does not include all investments needed for the transport transition to clean mobility. Maritime and air transport have not been considered. For rail transport, because of data gaps, maintenance and other projects for railways have not been included. For road transport, vehicles manufacturing sites and investments in battery production capacities have not been included as well. Not all the technologies and segments of heavy-duty vehicles are covered. Buses and plug-in hybrid technologies were not included. For charging points, investment needs for the electricity grid are included in **Section 2**.

BOX 3. GROSS INVESTMENTS FOR ELECTRIC VEHICLES

Investments are defined as gross investments. It measures total acquisition costs, and not the net investments compared to a reference. For example, a household can choose between an electric car at €34,000 and a fossil car at €27,000. In this case, buying the electric car requires a gross investment of €34,000 but a net investment of only €7,000 (= €34,000 minus €27,000). As a consequence, the cost of the alternative (a petrol-powered internal combustion engine car) does not impact our climate investment deficit estimate.

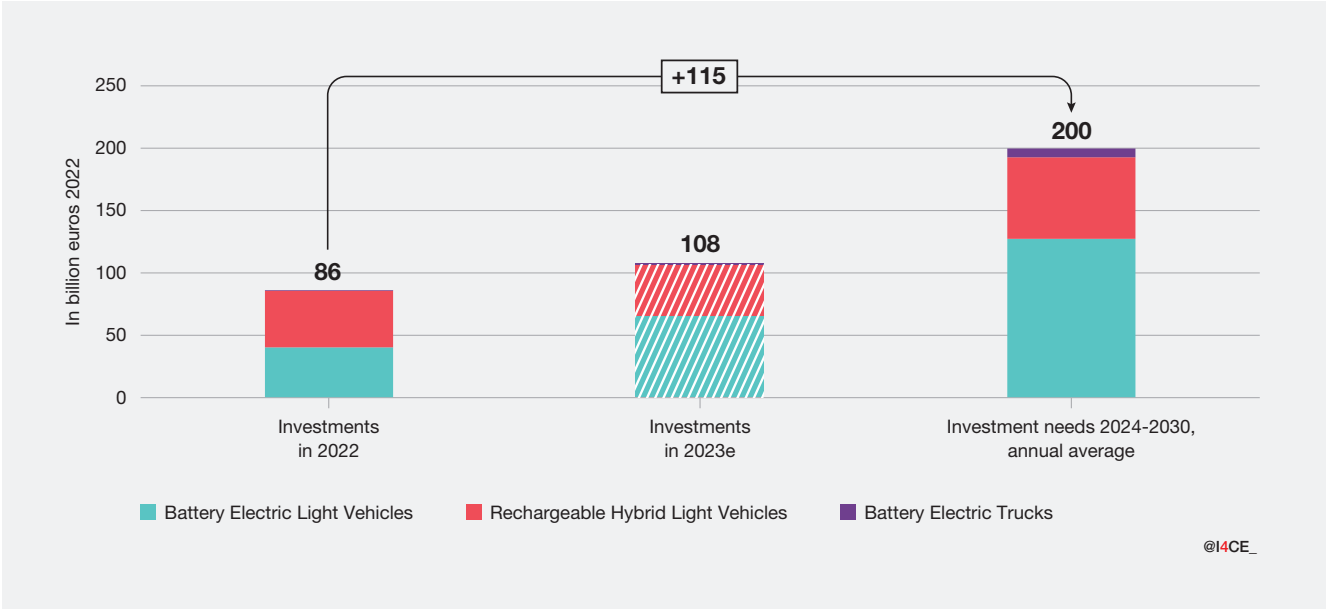
This precision is useful for policy-making, as investment includes both private and public spendings. In the specific case of electric cars, the challenge is to ensure that private investments are re-rerouted from fossil cars to electric cars. This involves guiding the same economic actors (households and businesses), who purchase new cars from the same suppliers and retailers, to pay for the extra upfront cost of investing €34,000 instead of €27,000.

4.1. Electric vehicles account for the lion's share of the climate investment deficit in the EU transportation system

The electrification of the European fleet is driven by the ambition to limit CO_2 emissions of new vehicles. The European Union has established CO_2 emissions performance requirements for vehicles to contribute to achieving the Union's target of reducing its greenhouse gas emissions. The regulation strengthening the CO_2 emission performance standards (2023) sets a reduction of emissions per km in 2030 of 55% compared to 2021 levels for passenger cars and 50% for light commercial vehicles. A similar regulation for Heavy-Duty Vehicles is currently discussed. The European Commission proposed by 2030 a decrease of emissions of 45% compared to the level set for 2019 (European Commission, 2023c). This target has been used as a reference.

200 billion euros per year (1.3% of EU GDP) are required on average between 2024 and 2030 to meet the objective as set out in these regulations. In 2022, 86 billion euros were invested, leaving a deficit of 115 billion euros. Battery light vehicles – passenger cars and vans – represent 76% of the sectorial investment deficit. Battery trucks account only for 6% of the road deficit, but the needs are increasing rapidly. Compared to 2022 levels, investments in 2023 have increased of 22 billion euros to 108 billion euros.

FIGURE 20. INVESTMENTS IN ELECTRIC VEHICLES ARE INCREASING IN 2023, BUT AN ADDITIONAL €115 BN IS STILL NEEDED TO CLOSE THE CLIMATE INVESTMENT DEFICIT



Source: I4CE. All data are in euros 2022. 2023 investments are estimated based on the sales trends observed during the first three quarters of the year. Investment needs are required investments for electrifying the new vehicle fleet sold every year to meet the CO2 emissions standards of 2030. Light vehicles include passenger cars and light commercial vehicles.

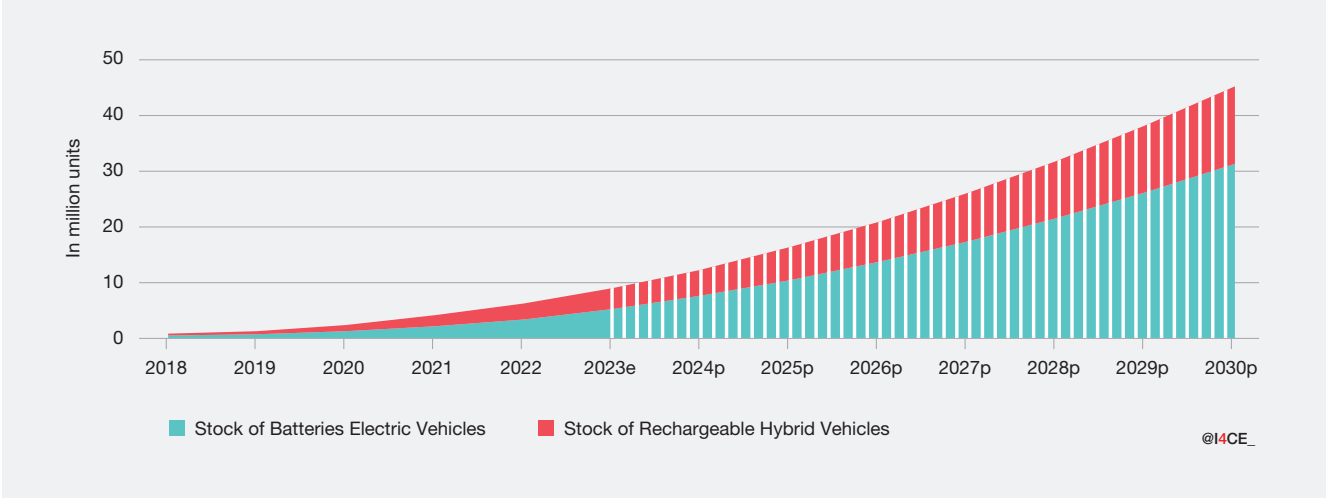
The investment needs are driven by increasing sales of electric vehicles. Over the years, these sales will increase the stock of electric vehicles. Compared to 3.3 million battery electric vehicles (BEV) and 2.8 million plug-in (chargeable) hybrid vehicles (PHEV) in 2022, the EU fleet is expected to reach 31 million BEVs and 14 million PHEVs in 2030. This fleet estimates that the entire car market will follow past trends, with a technology mix that meets the 2030 emission targets. These estimations are based on various Staff Working Documents of the European Commission (see Methodology Annexes).

In 2030, 41% of passenger cars are expected to be BEVs[9] and 15% are expected to be PHEVs (European Commission, 2021a)[10]. For light commercial vehicles, the breakdown would be respectively 35% and 13% in 2030, while 16% of trucks are expected to be BEVs (European Commission, 2021b). Plug-in hybrid trucks have been excluded from the scope of the study because of a lack of data on their possible prices.

9 Hydrogen vehicles have been modelled as battery electric vehicles.

10 For passengers cars, shares have been estimated from this source. In order to take into account that the Regulation strengthening the CO_2 emission performance standards (2023) has a target for passenger cars not calculated in the SWD, we average shares from different scenarios (see Methodology Annexes).

FIGURE 21. THE STOCK OF ELECTRIC VEHICLES IS EXPECTED TO REACH 45 MILLION UNITS BY 2030, SEVEN TIMES MORE THAN IN 2022



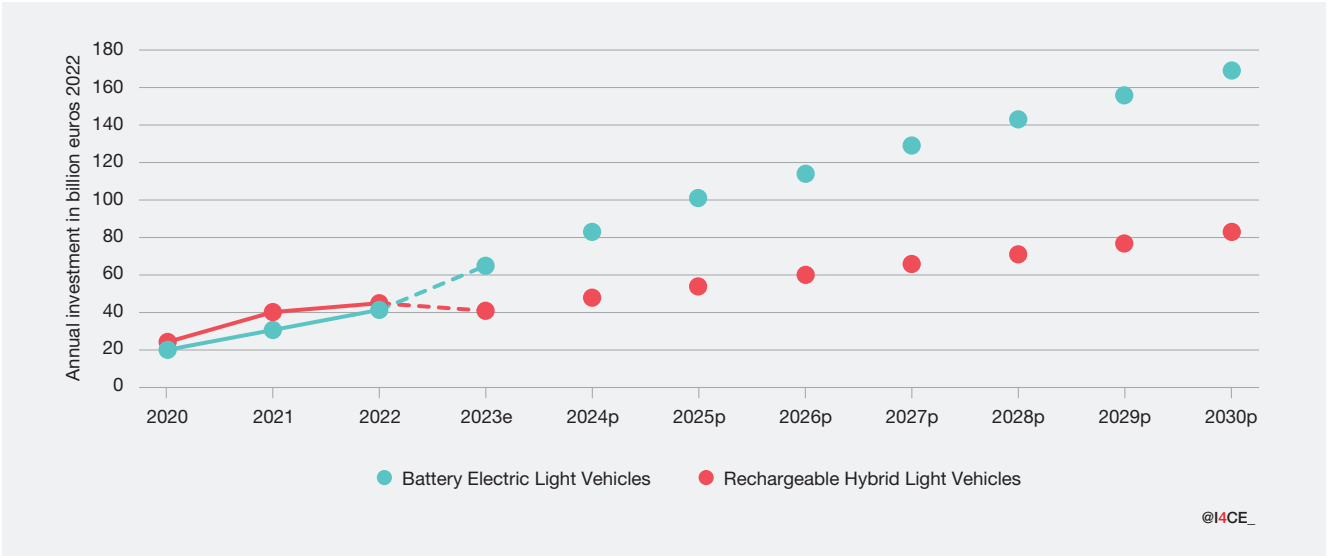
Source: I4CE. Stock is defined as the accumulated sales. Vehicles include passenger cars, light commercial vehicles, and trucks. Data up to 2023 are based on actual sales. Sales for 2023 are estimated based on the sales trends observed during the first three quarters of the year. Between 2024 and 2030, sales of electric vehicles are modeled as a percentage of total car sales. The percentages are linearly projected between 2023 and the 2030, based on the mix provided by the European Commission. Total sales are assumed constant, based on the average value of the last decade (see Methodology Annexes).

Increasing investment needs through time are not driven by costs. If the price of battery capacities continues to decrease due to economies of scale, it is also assumed that new electric vehicles will have greater range, resulting in larger capacity batteries, for an overall cost that remains relatively stable compared to today (I4CE, 2023b). The prices of electric vehicle are based on conservatives assumptions using the simplest version of cars. Thus, options, with limited utility for climate, are not considered.

Investment in electric vehicles is showing promising development, but current investments are not aligned with future needs. Scrutinising the separate technologies, the capacity of PHEVs and trucks to meet their respective investment needs is uncertain:

- The recent uptake in BEV investments makes meeting minimum deployments more likely, but they should continue to increase (see **Figure 22**). To meet the 2030 target, investments need to grow at an average rate of 15% per year. 2023 growth exceeded this value, increasing by 61% compared to 2022. For the first time, BEV spendings overtook PHEV spendings.
- Current trends in PHEV investments are not aligned with increasing needs. The scenario proposed by the European Commission requires an increase in investments in PHEV of about 10% per year compared to 2023 levels. However, current investments in PHEV are stagnating. If this trend would continue, an extra effort for BEV would be required to maintain the same overall CO_2 emission reduction.

FIGURE 22. ELECTRIFYING THE NEW VEHICLE FLEET REQUIRES SCALING UP INVESTMENTS FOR BATTERY ELECTRIC VEHICLES AND RECHARGEABLE VEHICLES BEFORE 2030



Source: I4CE. All data are in euros 2022. Figures between 2020 and 2023 are showing investment based on actual data. 2023 investments are estimated based on the sales trend observed during the first three quarters of the year. Investments between 2024 and 2030 are investments required to meet the 2030 objective of reducing CO_2 emissions of the new vehicle fleet. Light vehicles include passenger cars and light commercial vehicles.

- Electric Heavy-duty vehicles are in their early days, but investments must grow fast to respect targets for 2030. Investments in electric heavy-duty vehicles have shown an acceleration since 2020 from 0.1 billion euros to 1 billion euros in 2023. On average between 2024 and 2030, 7.7 billion euros are needed, up to 11 billion euros in 2030. Looking more closely at volumes, the needs are driven by the electrification of trucks above 16 tons. They represent more than 80% of the sales of all battery trucks in 2030. This category, however, represents around 40% of the electric sales of trucks for 2022 (Mulholland & Rodríguez, 2023).

Supporting a shift from PHEVs to BEVs for light vehicles would reduce the investment needs for the transition. In line with the European Commission's estimation, plug-in hybrid vehicles are taken into account. Overall, they represent 65 billion euros of yearly investments. Compared to battery electric vehicles, these vehicles are currently around 35% more expensive for passenger cars, and emit CO_2. An increase in BEV sales and a decrease in PHEV sales, compared to European Commission estimation, would achieve the same climate objective at a lower cost.

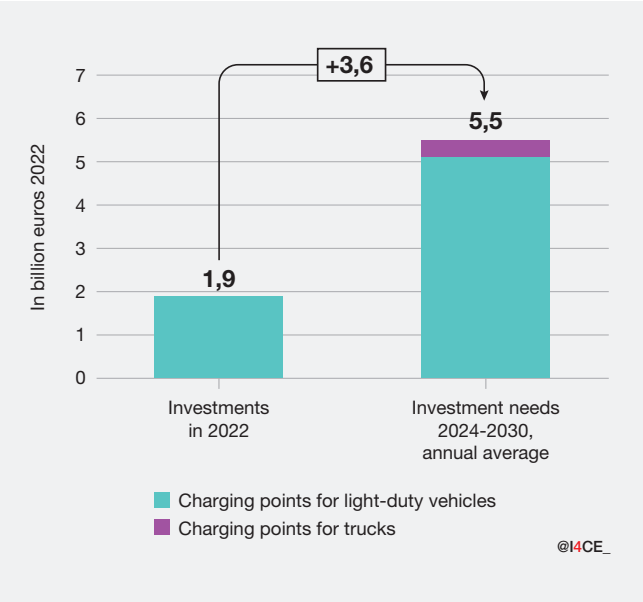
4.2. To support the electrification of road transport, an annual increase of 19% of investment in public charging points is needed

To support the uptake of electric vehicles, the European Union has agreed upon targets for public charging points. This study limited the scope to these targets. The Regulation on the deployment of alternative fuels infrastructure (2023) has set a target of a minimal power deployment per electric vehicle. It also sets deployment targets on the main European highways (defined in the Trans-European Transport Network regulation) for light and heavy-duty vehicles.

Alongside the rise in electric vehicles (EV), electric charging points investment needs are accelerating. On average between 2024 and 2030, 5.5 billion euros are required to be invested. In 2030, it increases to 7.7 billion euros. On average, compared to current investments, an additional 3.6 billion euros should be invested for public charging points, with an average increase of 19% per year. On average, light vehicles account for more than 90% of the needs for meeting the targets. But the infrastructures dedicated to heavy-duty vehicles have needs increasing faster, accounting for less than 1% in 2025 to almost 10% of total investments in 2030.

Because of reduced scope and conservative assumptions, these figures are a minimum. The underlying scenario only includes mandatory deployment. It only focuses on public charging points. It does not include the electric charging points required for trucks outside the TEN-T highways. Figures are also based on conservative assumptions about the deployment of EVs. Only a minimal EV uptake, to meet the objective of the regulation monitoring the CO_2 emissions of vehicles, is supposed. Any over-achievement of this regulation would lead to increased investment needs. Finally, investments in the electricity grids are covered in **Section 2**.

FIGURE 23. THE ELECTRIFICATION OF VEHICLES IS LEADING TO A GROWING DEMAND FOR CHARGING POINTS. BETWEEN 2024 AND 2030, AN AVERAGE OF €5,5 BN OF INVESTMENTS PER YEAR WILL BE NEEDED



Source: I4CE. All data are in euros 2022. The 2022 data is based on actual investments. Investment needs are required investments to meet the Alternative Fuels Infrastructure Regulation objectives (2023). Charging points refer to public charging points. Light-duty vehicles include passenger cars and light commercial vehicles.

4.3. Stagnating investments in trans-European railways threaten the modal shift to clean mobility

The Trans European Transport - Network (TEN-T) regulation (2013) aims to develop transport infrastructures at the continental scale. It defines high-priority infrastructures that must be achieved by 2030, called Core TEN-T. For railways, it mainly includes the development of fast and long-distance rail transport and sets European standards. It is currently under revision (European Commission, 2021c), with a view to increasing its ambition.

Building rail infrastructures for long-distance travel requires 47 billion euros annually between 2024 and 2030, *i.e.* 0.3% of EU GDP in 2022. The estimated investments for 2022, of 18 billion euros, represent 39% of the investments needs. An additional 29 billion euros should be invested annually. For comparison, the EU-economy has spent 48 billion euros on all its total railway infrastructure in 2021 (IRG-Rail, 2023). Current levels have stagnated in the last years. We estimate that 20 billion euros were invested for the Core network in 2020 to 18 billions euros in 2022.

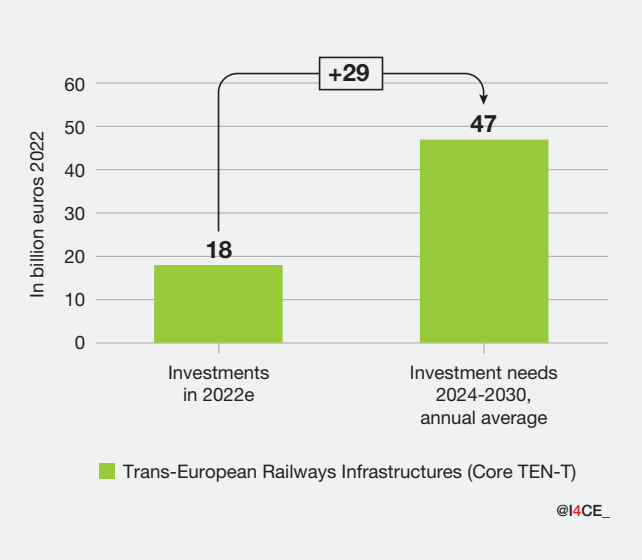
The future revision of the TEN-T[11] accounts for 10 billion euros, representing 22% of the investment needs for the Core network. The remaining 78% of the needs are attributed to the previous regulation. In comparison to the 2016 estimates made by the European Commission (2017), we have adjusted for delayed investments spanning from 2016 to 2022. Between 2024 and 2030, catching up on these investments cost 8 billion euros annually.

Closing the gap will require additional public investment. If the deficit for rail transport can seem small compared to road transports, it should be noted that the investment in railways is largely carried by the public sector, as railway infrastructures is often a natural monopoly. Fixing the climate investment deficit in long-distance railway infrastructures will therefore require additional public funding. This may include additional EU-level funding, given the trans-European nature of many of those infrastructures.

This estimate provides a minimum level, focusing on the investment needs of the Core TEN-T infrastructure before 2030. Investments that are needed to meet the 2040 and 2050 goals, that should start during the 2020 decade, are not included. It also excludes the numerous investments that are needed to develop the network not covered by the TEN-T or just to maintain it. For comparison, France, accounting for only 13% of the European railways network, needs 13 billion euros to be invested in 2030 for all its railways network (I4CE, 2023b).

This study provides figures of needs for European trains before 2030. Dealing with the limited up-to-date accessible data, it's subject to uncertainties (see Methodology Annexes). Our research shows that current EU regulation focuses on a small part of the network. To really understand the need for additional investments, the entire rail network should be considered.

FIGURE 24. THE COMPLETION OF THE 2030 OBJECTIVE FOR TRANS-EUROPEAN RAILWAYS (CORE TEN-T) WILL REQUIRE €47 BN ANNUALLY, LEAVING A CLIMATE INVESTMENT DEFICIT OF €29 BN



Source: I4CE. All data are in euros 2022. 2022 investments in the Core Trans-European Transport Network (TEN-T) are estimated from spending on railway infrastructure provided by IRG-Rail (2023) for 2021. Investment needs are required investments to achieve the 2030 targets of the TEN-T regulation. It includes the future TEN-T revision currently under discussion.

11 Figures were estimated based on the Staff Working Document accompanying the proposal (SWD(2021) 472, page 144) for measures specific to railways objectives for the Core-Network. Even if, the latest trilogue, held in December 2022, has agreed on modifications to the EU Commission proposal, this estimation was the most reliable found.

5. METHODOLOGY

5.1. Measuring past and current climate investments

Defining investments

The report examines:

- gross fixed capital formation (GFCF), *i.e.*, in national accounts, expenditure on the acquisition of tangible and intangible assets (Eurostat, 2013). The notion of assets implies that expenditures will serve to provide goods or services for more than a year, which distinguishes them from consumer goods. The assets covered by the study are physical equipment such as buildings, transport and network infrastructure, boiler houses, power plants, etc., which will be used to produce goods and services for more than one year;
- consumption of goods considered durable, in the sense that they provide services to consumers for more than one year. For example, this includes purchases of new vehicles made by households.

Measuring investments

Investments are measured at the EU-economy scale. It includes all actors, whether they are public or private, transnational or local.

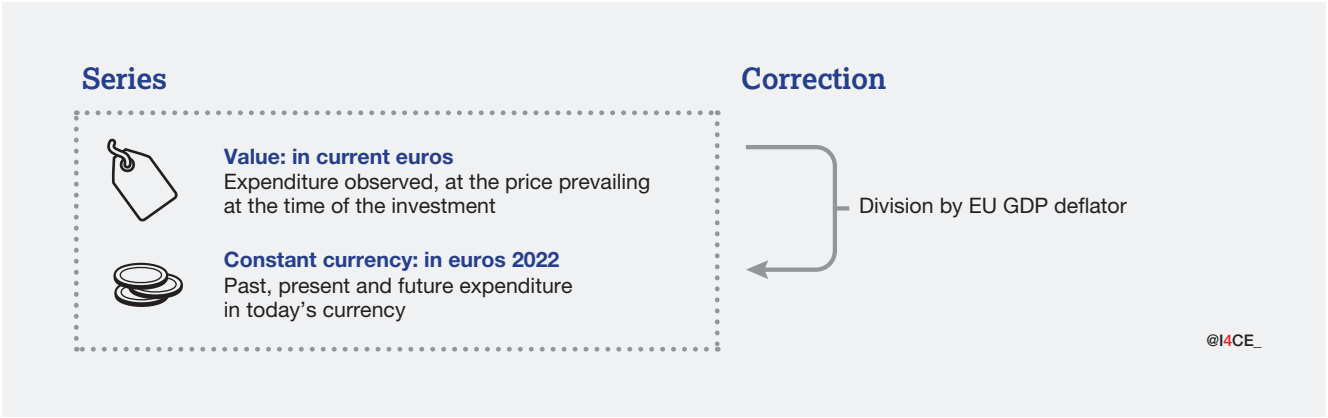
Investment costs are based on the acquisition cost. They correspond to capital expenditure (CAPEX) in company accounting. These costs cover various expenses like studies, authorizations, equipment acquisition, and construction. It is excluding taxes for companies and public authorities but including taxes (VAT) for households. Project financing costs, such as interests paid, are excluded.

Investments are carried on a specific year. Depending on the sector and the national accounting policies, this reference date for costs can be the date of work carried out (the case of construction or energy retrofitting), registration (the case of vehicles), or equipment installation (the case of renewable energies). For the biggest projects, such as transport infrastructure, the costs are spread over several years.

Reporting past and future investments in today's currency

To make it easier to compare past and present climate investment with future needs, and to account for the effects of inflation, we report all investment expenditure in today's currency (euro 2022), in other words in constant currency. Neutralising the effect of inflation makes it easier to measure the real financial effort required to make investments. To calculate this, we divide the current expenditure for the historical period by the chain-linked price index of gross domestic product, also known as the "GDP deflator", provided by the Eurostat [12]. Future investment needs describe the quantities of equipment to be deployed, as well as certain price expectations. These expectations relate to sectoral phenomena specific to energy transition activities. For example, when our sources anticipate that batteries will cost less in the future, what they mean is that their price will fall relative to other products in the economy. Expressed in today's currency, their price will decrease. In other words, price expectations do not comment on the price level of the overall economy, but on the gap between future prices in a sector and overall inflation.

FIGURE 25. METHOD USED TO CORRECT THE INFLATION EFFECT



12 https://ec.europa.eu/eurostat/databrowser/view/nama_10_gdp__custom_9698890/default/table?lang=en

5.2. Measuring climate investments needs

The EU has set itself the objective to reduce its greenhouse gas (GHG) emissions by 55% by 2030 compared to 1990 levels and to achieve carbon neutrality by 2050. To achieve these objectives, the European Union has implemented several legislative measures and presented action plans, as part of the EU Green Deal.

Investment targets in terms of volume

We determine the number and characteristics of the equipment deployed based on the targets set by the European Union. For instance, we consider the number of homes renovated, the installed wind or solar power capacity, and the electric cars or rail transport infrastructure.

In this report, the volumes of chosen technologies that need to be deployed for each technology from 2024 to 2030 have been determined based on legislative documents and action plans from the European Union. When possible, investment targets have been determined based on binding EU objectives concerning volumes. This is, for example, the case for the renovation rate targets and energy efficiency targets for new buildings, which are enshrined in the last Energy Performance of Buildings Directive (EPBD) in 2018 and 2024 recast. The same applies to the targets for the deployment of charging stations within the Alternative Fuels Infrastructure Regulation (AFIR), or the targets for the development of rail within the Trans-European Transport Network (TEN-T) regulation. When volume targets are not explicitly mentioned in EU regulations, we use targets mentioned in EU scenarios, the European Commission's action plans, such as the RepowerEU plans, the Climate Target Plan, or in the European Commission Staff Working Documents. Finally, when the EU does not have any specific targets that can be translated into volume deployment, figures from the industry are used (see **Table 2**).

Future prices

We assign unit prices to equipment. These prices are projected from their most recent observed levels, typically in 2022 or early 2023. Our projections for 2023 and beyond reflect the cost expectations expressed in several recent studies.

Lower investment costs assumptions over the period 2024-2030 have been assumed for certain technologies. This is particularly the case for investment costs in wind energy and solar PV, as well as in the price of batteries for electric vehicles. Renovation and construction costs, on the other hand, are projected to remain stable. The investment costs are expressed in euros 2022.

Cost projections are taken from different sources, including the European Commission Reference Scenario, the IEA, Ipsos and Naviguant, Cravezero, Bloomberg NEF, the ICCT, etc. Details are to be found in the corresponding section of the report and in the Methodology Annexes.

Climate investment needs

The report determines the needs in relation to the levels of investment observed in 2022. The investment target is based on average annual investment over the period 2024-2030. This means that, to achieve its 2030 climate objectives, investment in the EU economy must be at the target level on average over the period 2024-2030. Every year, any unmade investment will contribute to an increase in the climate investment needs of the following year. Conversely, each year, any investment that matches or exceeds the required investment will help to reduce the climate investment deficit.

Understanding the investment deficit

The report defines an investment deficit. It is defined as the difference between: (1) the average investments required every year between 2024 and 2030 for the EU to reach its climate objectives, and (2) 2022 levels of investments in constant euros 2022.

Scope of the study

This report covers climate investment in three systems of the economy:

- the energy system, which includes electricity production, transmission and distribution;
- the building system, which includes energy-efficient investment in the construction, energy renovation of buildings;
- the transport system, which includes investment in transport infrastructures and vehicles.

In these systems, some activities are not yet covered by investment records. The analysis of the energy system only considers investments made in the power system and does not include for instance biomass or geothermal energy. Nuclear energy has not been included as there is no EU objectives for that specific sector. In the transport system, the analysis does not include several investments in rail and public urban transport infrastructure, nor clean aviation or maritime transportation. Agriculture, industry, centralised waste treatment and land use sectors are not covered in this study, as the lack of data makes it difficult to identify investments. Finally, the study does not document investment in research and development, or in climate change adaptation.

For each sector, Climate investments are considered. It is defined as investments that contribute to reducing greenhouse gas (GHG) emissions in the EU.

An overview of the perimeter is given in **Table 2**.

TABLE 2. EUROPEAN REGULATIONS AND TEXTS ASSOCIATED WITH CLIMATE OBJECTIVES BY SECTOR

System	Sector	Climate investments considered	European regulations and texts associated with climate objectives	Technology covered in the scope of climate investments	Noteworthy technologies not covered
Energy	Renewable energy generation	Renewable electricity,	RED, Repower EU plan, EU reference scenario	Wind power, solar power, hydropower, marine	Solar thermal, biomass, waste, geothermal, nuclear
	Networks and flexibility	Electricity grids Battery storage	No EU specific target, except for cross-border infrastructures	Transmission and distribution power grids Utility-scale and residential battery storage	
Residential and non-residential buildings	New buildings construction	Energy performance of construction	EBPD 2018	Building envelop insulation	Non-energy related construction items
	Energy-efficient renovation	Medium and deep renovation[13]	EU Renovation Wave, EPBD 2024	Building envelop renovation	Light renovation, renovation below energy savings threesholds[13], non-energy renovation
	Heating devices	Heat pumps installation	RepowerEU	Heat pumps	Other heating devices (wood heating, biomass, heating networks, …)
Transport	Road transport	Electric vehicles, recharging infrastructures for electric vehicles	Monitoring CO_2 emissions for passenger cars and light commercial vehicles Monitoring CO_2 emissions for Heavy-Duty vehicles Alternatives Fuel Infrastructure Regulation (AFIR)	Passenger cars & Light-commercial vehicles: - Battery electric vehicles, plug-in hybrid vehicles - Battery electric trucks Public electric charging points	Other heavy-duty vehicles (buses, coaches, …) and Plug-in hybrid technology for trucks Private charging points and other refuelling station (hydrogen, gas, …)
	Rail transport	Infrastructure for a modal shift toward railways	Trans-European Transport Network regulation (TEN-T)	Long-distance trans-European railways infrastructures for 2030 (CORE TEN-T Network)	Maintenance and upgrade of existing railways Development of other infrastructures Urban transport

Note: This table presents the systems and sectors considered in the study and the European regulations they are based on. Multiple sectors are not covered in the study and not shown in the table agriculture, industry, centralised waste treatment, land use, adaptation to climate change.

13 See definition in **Section 3.1**

CONCLUSION AND POLICY RECOMMENDATIONS: BETTER ASSESS AND ADDRESS

With its European Green Deal, the EU set itself clear targets to transform its energy, buildings and transport systems in a way that delivers economic, climate, and social benefits. Our research estimates the climate investment deficit, i.e. the difference between the amount of climate investments that are needed for the EU to deliver on its 2030 targets, and the amount of climate investments actually occurring in the EU economy. We find that this climate investment deficit currently sits at 406 billion euros per year, or 2.1% of GDP.

Indeed, the EU economy should invest at least an estimated 813 billion euros every year between now and 2030, or 5.1% of the EU GDP. Looking at the most recent data sources, our research estimates that 407 billion euros, or 2.6% GDP, have been invested in 2022 – the last year for which we gathered sufficiently reliable data.

Our report therefore concludes that, given its significance, **EU policy makers need to better assess and address the EU Climate Investment Deficit, or risk seeing the Green Deal failing** to deliver.

First, EU policymakers must consider investments to be a central piece of the Green Deal future. To better assess the climate investment deficit, EU institutions should build on this report's estimate and deliver their own needs-drive and more accurate, granular, and comprehensive assessment:

- **More accurate:** access to data has been a challenge, especially when it comes to the building sector. Whenever faced with different methodological options, we consistently opted for the most conservative one. This may lead to some under-estimation in some sectors, and over-estimation in others.
- **More granular:** our report relies on EU-27 data. A more granular approach could look at national and regional data that are relevant for national and local public policies. National governments and research organisations may use the methodology I4CE developed for France and the EU, and adapt it to be applied to a specific national or regional economy, as some policy levers are at the national or regional levels (*e.g.* national taxation, regional vocational education).
- **More comprehensive:** our report covers only 22 sectors in the energy, building, and transport systems. It excludes critical sectors such as research and innovation (I4CE, 2023d), cleantech (I4CE, 2023e), industry (I4CE, 2023a), agriculture (I4CE, 2023c), and climate change adaptation (I4CE, 2022), due to lack of access to reliable and up to date data. Solar heating, biogas, district heating or public transport infrastructure were also excluded from this report, due to lack of data. In the forthcoming yearly editions of our climate investment deficit report, the Institute for Climate Economics (I4CE) will plug some of those data gaps.

To better address the climate investment deficit, further EU, national and private sector actions are needed. This requires a comprehensive approach that articulates existing and future regulations, carbon pricing systems, public finance and private finance schemes.

Additional EU public funding is likely required to contribute to reduce the EU Climate Investment Deficit, for two main reasons. **First, EU funding for climate is currently decreasing, as a consequence of the phase-out of Next Generation EU** (Bruegel, 2023a). **Second, the climate investment deficit is high in some sectors that are, by nature, dependant on a degree of EU-level funding**, such as trans-European infrastructures. However, **the quantity, nature, and sectoral targeting of EU funding will depend on the economic sectors and political choices.**

Sector-specific policy actions are vital to close sectoral climate investment deficits. Each sector has its specificities and requires a tailor-made policy mix. Yet, the evidence of deficits in 20 out of the 22 sectors covered in our research points to the need for a cross-cutting investment policy that ensures all economic actors can access the finance they need. To address this, **the EU should debate the creation of an EU long term climate investment plan (I4CE, 2023e) to turn Green Deal objectives into tangible realities for all businesses, workers, and families.**

The 9 June 2024 EU elections constitute a moment for a democratic discussion on the EU's role to support States, local authorities, companies, and families in investing in their own transitions. Such debate would inevitably raise deeply political questions that are for EU citizens and their representatives to answer:

- How much should the EU long-term climate investment plan rely on public and private money? When relying on private sector finance, what tools are used to crowd-it in?
- Regarding public funding instruments, should policy makers make more use of equity, subsidies, loans and/or guarantees?
- How much money is expected to come from the EU, national, regional, and local levels respectively?
- Where should additional public money come from (*e.g.* debt, wealth tax, cuts to fossil fuel subsidies)?
- Which sectors should be prioritised, if any?
- Which policy measures can ensure that all regions and territories, workers and families, can benefit from a just transition?
- How can policy makers build synergies and manage trade-offs between climate investments and other policy priorities, such as energy resilience, job creation, or European sovereignty?

This report does not seek to answer those questions. It provides evidence to support informed decisions by EU citizens and their representatives. Future editions of our annual report will allow to track progress, and therefore estimate to what extent new policies have proven effective in reducing the climate investment deficit and help create an investment pathway for Europe's future.

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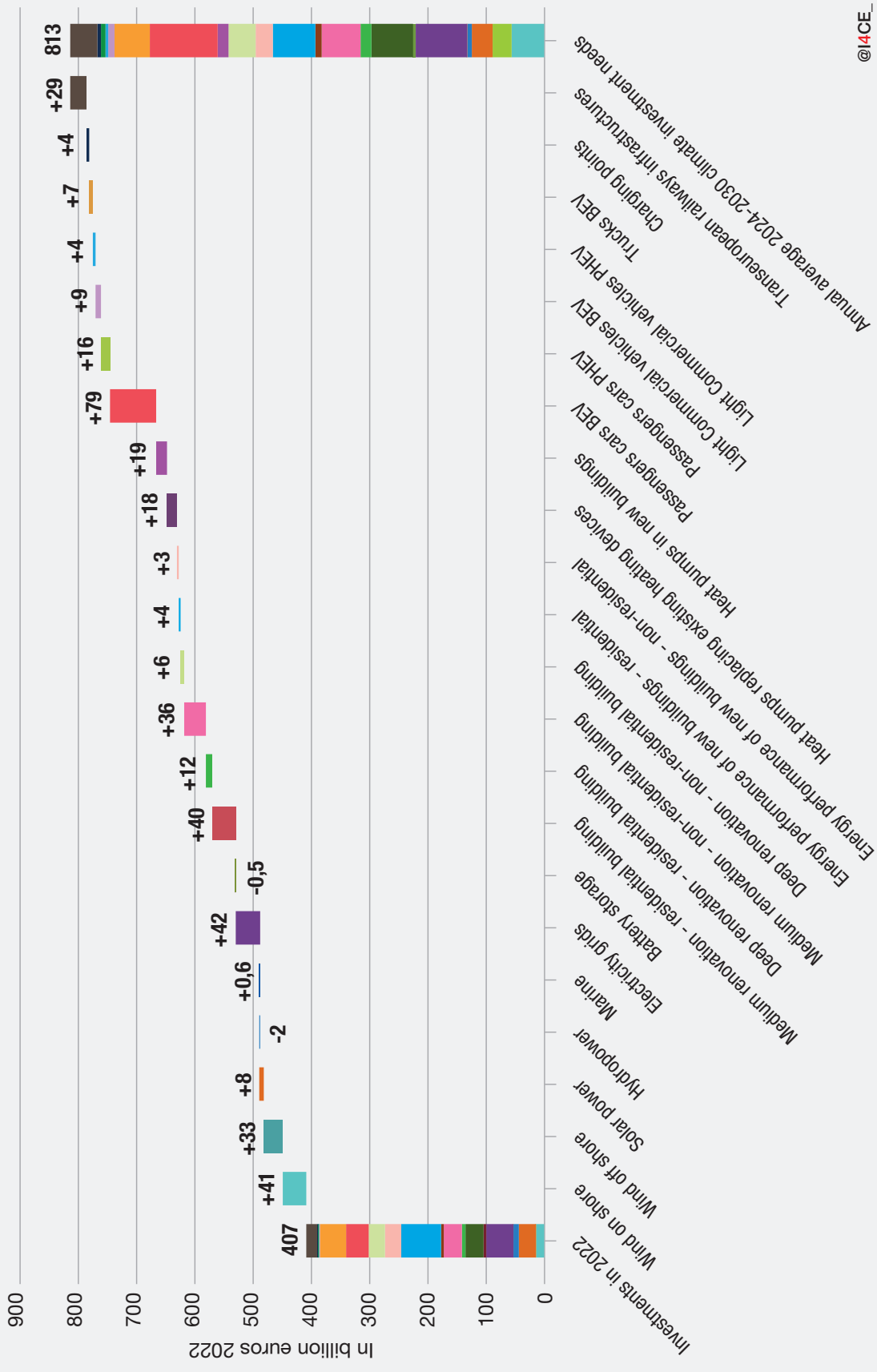
ANNEX

FIGURE 2. THE EU OVERALL CLIMATE INVESTMENT DEFICIT IS THE SUM OF 22 SECTORAL EU CLIMATE INVESTMENT DEFICITS AND SURPLUSES. THE BIGGEST DEFICITS ARE IN WIND POWER, ELECTRICITY GRIDS, ENERGY-RENOVATION OF BUILDINGS, HEAT PUMPS, RAILWAY AND ELECTRIC PASSENGER CARS



Source: I4CE. All data are in euros of 2022. This graph indicates the split of the climate investment deficit by sector. The climate investment deficit corresponds to the difference between the annual average investments that are needed for the EU to reach its 2030 targets and the investments that occurred in 2022. For example, for the onshore wind power sector, the climate investment deficit of 41 billion euros corresponds to the difference between the average investment needs (55 billion euros) and the 2022 investments (14 billion euros).

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