# Aligning policy responses to rising energy prices with the long-term climate neutrality objective

European Scientific Advisory Board on Climate Change

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Manuscript completed in February 2023



Luxembourg: Publications Office of the European Union, 2024



PDF ISBN 978-92-9480-661-1 doi: 10.2800/153987 TH-09-24-455-EN-N

# Contents

# About the European Scientific Advisory Board on Climate Change

The European Scientific Advisory Board on Climate Change is an independent scientific advisory body providing the EU with scientific knowledge, expertise and advice relating to climate change. The Advisory Board identifies actions and opportunities to achieve the EU's climate neutrality target by 2050. The Advisory Board was established by the European Climate Law of 2021 with a mandate to serve as a point of reference for the EU on scientific knowledge relating to climate change by virtue of its independence and scientific and technical expertise.

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The Advisory Board is supported in the execution of its tasks by a secretariat, hosted by the European Environment Agency.

# Executive summary

## Context and aim of this advice

**Since mid-2021, the EU and its Member States have been confronted with a severe energy supply crisis that has resulted in record-high energy prices.** The main cause of the crisis is Russian energy supply cuts in the run up to and since its invasion of Ukraine, which exposed the EU's vulnerability due to its high energy import dependency. Throughout 2022, the EU, national and sub-national governments have taken a range of measures to mitigate the adverse impacts of high energy prices. Reduced energy demand and high availability of liquified natural gas (LNG) have allowed the EU to cope better than expected with the Russian supply cuts, and energy prices have decreased since their peak in summer 2022.

**However, the crisis is far from over,** and the winter of 2023-2024 might be even more challenging, as the EU might come out of the 2022-2023 winter with depleted gas reserves, Russian pipeline gas supplies could drop to near zero and LNG demand in other world regions rebounds.

**The energy crisis poses both an opportunity and a risk for the EU's transition towards climate neutrality.** On the one hand, it provides a strong argument to accelerate the transition and become less dependent on imported fossil fuels. On the other hand, there is a risk that efforts to secure supply through the increased use of fossil fuels or soften the high energy prices through subsidies could delay the transition or even lead to long-term emission lock-ins. While some of the measures that have been taken or are still being considered could accelerate the EU's transition towards climate neutrality, others might hamper it.

The crisis came sudden and acute, requiring policy makers to act fast to avert adverse impacts on EU citizens and businesses. With the peak of energy prices behind us, the time is now to shift from crisis-management to structural measures to reduce the EU's overall dependence of (fossil) energy imports.

**To this end, the European Scientific Advisory Board on Climate Change (hereafter 'the Advisory Board') hereby provides advice to the EU and its Member States to support future decision-making in response to the energy crisis, to ensure that decisions support and do not hinder the EU's transition towards climate neutrality.** The Advisory Board's main aim is to provide an overview of measures that can tackle the energy and climate crises simultaneously, and to caution against measures that risk undermining the climate objectives. The advice builds on lessons learned from the energy crisis so far, theoretical considerations and the latest empirical scientific insights.

To develop its advice, the Advisory Board has mapped different types of measures that are being considered or have already been implemented both at the EU level and in different Member States.

**The Advisory Board has then assessed the ability of these measures to increase energy affordability for EU consumers (in the short and long terms), and their expected impact on greenhouse gas (GHG) emissions (in the short and long terms).** Where relevant, other expected impacts (e.g. on energy independence or other environmental impacts) have been included as a third assessment dimension.

## Key recommendations

Based on its assessment, the Advisory Board puts forward three types of recommendations to tackle the energy crisis:

**Recommended measures,** which tackle the energy crisis while supporting the transition towards climate neutrality

**Measures that should be considered with caution,** as they could require a trade-off between energy security, energy affordability and the EU's transition towards climate neutrality

**Measures that are not recommended,** as they risk hampering the EU's transition towards climate neutrality.

A more detailed overview of the Advisory Board's recommendations is included in section 4.

**1. Tackle the root causes of the energy crisis: reduce demand and increase low-carbon energy supply**

The energy crisis was caused by an imbalance between energy demand and supply, with historically high prices as a result. The Advisory Board recommends that policy makers focus on reducing energy demand and increasing the supply of secure, domestic and low-carbon energy sources[1] as the principal mechanism by which energy prices can be brought down, rather than ad hoc market interventions such as energy consumption subsidies and price caps.

**2. Save energy through efficiency improvements and behavioural change**

Energy saving is the best approach to both reducing GHG emissions and tackling the current cost-of-living crisis, and its significant potential remains underexploited. The Advisory Board recommends that the EU and its Member States:

- increase ambitions and efforts to reduce energy demand through energy efficiency measures, such as building renovations;
- incentivise energy savings through behavioural changes, using both awareness campaigns and regulations.

Energy-inefficient low-income households should be supported to overcome specific challenges such as upfront investment costs, split incentives and asymmetrical information.

**3. At least double the expansion rate for renewable energy**

Renewable energy is a key lever for ensuring secure, affordable, domestic and low-carbon energy supply. Both the investment and deployment rate of renewable energy sources need to be at least doubled to achieve the proposed 2030 renewable energy objectives. The EU and its Member States should ensure a stable investment framework, shorten permitting procedures while ensuring social and environmental safeguards, and strengthen and expand electricity grids, flexibility and storage. The Advisory Board would favour steering the EU's electricity market reform towards stimulating and facilitating investments in renewable energies while allowing markets to take advantage of low-cost electricity, which supports electrification in end-use sector.

(1) Including most renewable sources as well as nuclear energy but excluding natural gas. See Glossary for a full definition.

**4. Boost electrification to improve efficiency and shift away from fossil fuels**

The roll-out of electrification technologies should be boosted to both reduce overall energy demand and shift away from fossil fuels. Scaling up the deployment of heat pumps would decrease energy bills while reducing the EU's reliance on natural gas. To this end, the Advisory Board recommends aligning price signals with electrification goals. It welcomes the provisional agreement on strengthening the EU Emissions Trading System (EU ETS) and the introduction of a similar system for buildings and road transport. This should be complemented by a revision of energy taxation frameworks at both the EU (the Energy Taxation Directive) and the national levels to shift the tax burden from electricity to fossil fuel energy carriers.

**5. Provide direct income support for vulnerable consumers**

Targeted support can mitigate the worst social and economic impacts of the crisis while prices remain high. Member States should target support measures at vulnerable consumers, including low-income households and economic sectors struggling with high energy costs. Direct income support is preferred over price-distorting interventions, as it maintains the price signal for energy savings and investments in renewables. Targeted price reductions such as social tariffs or block tariffs could be considered as a second-best solution, as they distort the marginal price signal to only a limited degree. The Advisory Board recommends that the EU and its Member States refrain from non-targeted, distortive price interventions, such as general tax reductions and energy subsidies, as such measures are costly, ineffective, as they undermine the incentive to reduce demand and could potentially trigger a subsidy-driven price spiral, and could lead to hard-to-reverse fossil fuel lock-ins with adverse implications for the climate.

**6. Ensure that efforts to diversify gas supply are compatible with the long-term transition towards climate neutrality**

When considering new investments in gas infrastructure or committing to long-term gas supply contracts, a careful balance should be made between security-of-supply objectives in the short to medium term and avoiding the risk of lock-ins to future gas consumption, which could undermine the transition towards climate neutrality in the longer term. Preference should be given to sources with the lowest upstream climate impacts.

**7. Ensure a sustainable supply of biomass while minimising pressure on food production and biodiversity**

Biomass fuels can provide an alternative to fossil fuel energy sources, but their climate benefits depend on their origin and whether or not they compete with other biomass purposes, such as food and feedstocks. Therefore, the Advisory Board calls on increased biomass fuel use to be limited to sustainable biomass that has limited added value (based on the cascading principle) and to be prioritised for sectors with limited alternatives to fossil fuel replacement, such as certain industrial processes and bunker fuels.

**8. Do not invest in new coal and oil infrastructure**

The Advisory Board urges EU Member States to stop investing in coal and oil infrastructure — including in the exploration and extraction of new deposits — to avoid emission lock-ins. The increased use of these fuels to compensate for reductions in natural gas supplies in the short term should be strictly limited in time and ramped down as soon as possible.

# 1 Introduction

**Since the second half of 2021, the EU and its Member States have been confronted with a severe energy supply crisis that has resulted in record-high energy prices.** Reduced Russian gas supply from the summer of 2021 coinciding with the post-COVID-19 recovery of energy demand resulted in a supply shortage and price escalation for natural gas and petroleum products, as well as for electricity for which gas power plants have become the marginal supplier. The situation worsened with Russia's attack on Ukraine in March 2022 and the ensuing Western sanctions on the Russian economy. A drought affecting hydropower and reduced output by nuclear power plants further added to scarcity of supply. Escalating energy and food prices have been causing a cost-of-living crisis for many European households and undermining the competitiveness of many companies, especially in energy-intensive sectors.

**National and European policy makers reacted swiftly, starting in the winter of 2021-2022, with a range of different policies and measures** that address price pressures and supply shortages, mobilising significant financial resources. The EU has so far coped better than initially expected with the supply crisis and managed to fill its gas storage capacity to near full before winter 2022-2023. It was able to do so using moderate levels of Russian pipeline gas supply in the first months of 2022, and because of high availability of liquified natural gas (LNG) and lower-than-expected demand due to mild weather, behavioural changes and reduced industrial production. Energy prices have declined since their peak in summer 2022, although they are still significantly above pre-crisis levels.

**However, the crisis is far from over and the winter of 2023-2024 might be even more challenging,** as the EU will have to refill its gas stocks after winter 2022-2023, Russian pipeline gas supplies might drop to near zero and the global LNG market is expected to tighten as demand from China rebounds (IEA, 2022c).

**The crisis — and the way in which the EU and its Member States deal with its impacts — can be both a risk and an opportunity for the EU's transition towards climate neutrality.** On the one hand, Russia's invasion of Ukraine provides a new, urgent rationale for lessening Europe's dependency on fossil fuel imports from third countries and to accelerate the transition towards climate neutrality. Record-high energy prices have made efforts to expand renewables and increase energy savings more necessary than ever. On the other hand, there is a risk that efforts to secure supply or soften high energy prices can delay the transition towards climate neutrality or even lead to long-term emission lock-ins. The policy responses in the context of the crisis will determine whether Europe's long-term decarbonisation pathway derails or whether the crisis will be used as leverage to accelerate the transition towards climate neutrality.

**The Advisory Board has identified the current energy crisis as a critical test for the EU, where measures to tackle rising energy prices may have important consequences for the EU's long-term transition towards climate neutrality.** The main aim of this advice is to provide an overview of measures that can tackle both the energy crisis and the climate crisis and to caution against measures that risk undermining the transition towards climate neutrality. The advice builds on lessons learned from the energy crisis so far, theoretical considerations and the latest empirical scientific insights.

The advice is structured as follows. Section 2 contains a detailed overview of the context, providing an overview of the main causes and consequences of the energy crisis. Section 3 covers the main assessment underpinning this advice, and provides an overview of the different types of measures that have been taken or (could be) considered in context of the energy crisis and assesses their performance on three dimensions. Section 4 then builds on this assessment to provide recommendations.

# 2 Context: causes and consequences of the energy crisis

This section describes the causes and impacts of the energy supply crisis and its consequences for European citizens and businesses. This will be used as a point of departure for the analysis in section 3.

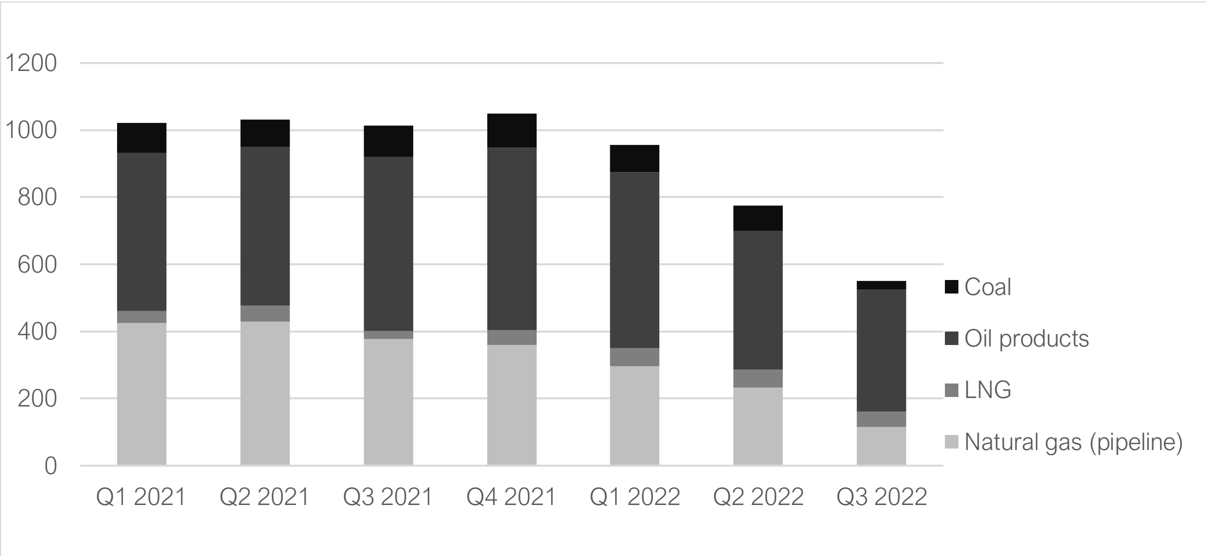
## 2.1 Cause: Russian energy supply cuts

**The EU is highly dependent on the import of (fossil) energy to meet its energy demand. Imports from Russia — its main energy supplier — have been gradually reduced in the run-up to and since the Russian invasion of Ukraine.**

The EU is highly dependent on the import of fossil fuels, with an import dependency (i.e. the share of the total available supply of energy accounted for by energy imports) of between 55% and 60% over the last 15 years (Eurostat, 2022a). Russia has traditionally been the EU's main supplier, accounting for 44% of all natural gas imports, 54% of all solid fossil fuels imports (mainly coal) and 29% of all oil product imports into the EU in 2020. In addition, Finland and the Baltic countries imported 5% and 15% of their electricity from Russia, respectively (Eurostat, 2022b).

However, in mid-2021, Russia already started to structurally reduce natural gas exports via pipeline to the EU, and gas flows have fallen to below 20% of historical levels since its invasion of Ukraine in February 2022. Similarly, EU-imposed sanctions have led to a decrease in solid fuels and oil product exports to the EU, and a suspension of electricity exports to Finland and the Baltic countries. The gap in Russian piped gas supply has been largely compensated for by increased LNG imports from other trade partners, mainly the USA, but also Russia (EC, 2023).

***Figure 1 Evolution of Russian energy imports into the EU since January 2021 (in TWh / quarter)***




**Sources:** Natural gas imports taken from https://www.bruegel.org/dataset/european-natural-gas-imports, which is based on ENTSO-G data. Oil imports based on Eurostat database (NRG_TI_OILM). Coal imports taken from www.statista.com.

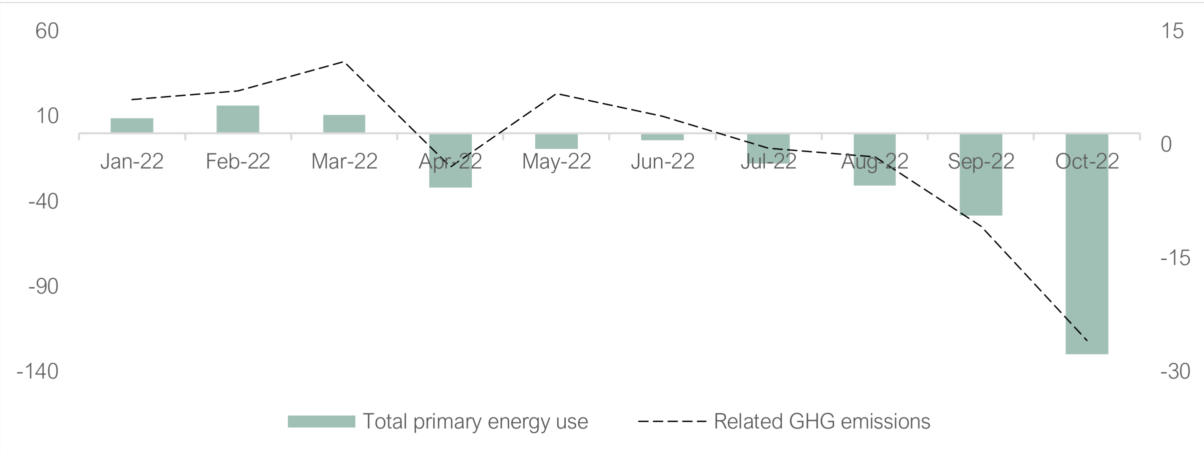
## 2.2 Consequences: changes in EU energy use and related emissions

Between 2005 and 2020, the EU reduced its primary energy consumption by 17.5%, increased the share of renewables from 10% to 22%, and reduced its greenhouse gas (GHG) emissions by 27%. Despite a limited post-COVID-19 rebound in energy use and GHG emissions in 2021, total energy consumption and emissions were still below 2019 levels (EEA, 2022).

There have been concerns that the current energy crisis would have reverted the decreasing trend in energy use and related GHG emissions, as initial signals suggested a rebound in coal and oil use to replace the drop in Russian natural gas supplies. However, data show that this concern is only partially justified:

- Overall, energy consumption was 236 TWh (or 2%) lower in the period January-October 2022 than in the same period in 2021. This overall decrease occurred despite a year-on-year rebound in transport fuel use (+160 TWh) linked to the COVID-19 pandemic and related low transport activity in the first half of 2021. As of July 2022 — when the effect of this rebound disappeared — primary energy consumption dropped considerably on a year-to-year basis.
- Similarly, energy-related $CO_2$ emissions increased on a year-to-year basis in the first half of 2022, but the trend was reversed as of July 2022.

***Figure 2 Year-on-year evolution of primary energy use (left axis, in TWh) and related $CO_2$ emissions (right axis, in Mt $CO_2$)***




**Sources:** Calculations by the Advisory Board based on Eurostat data on monthly energy supplies (Eurostat, 2022b) and standard emission factors from the IPCC 2006 Guidelines (IPCC, 2006).

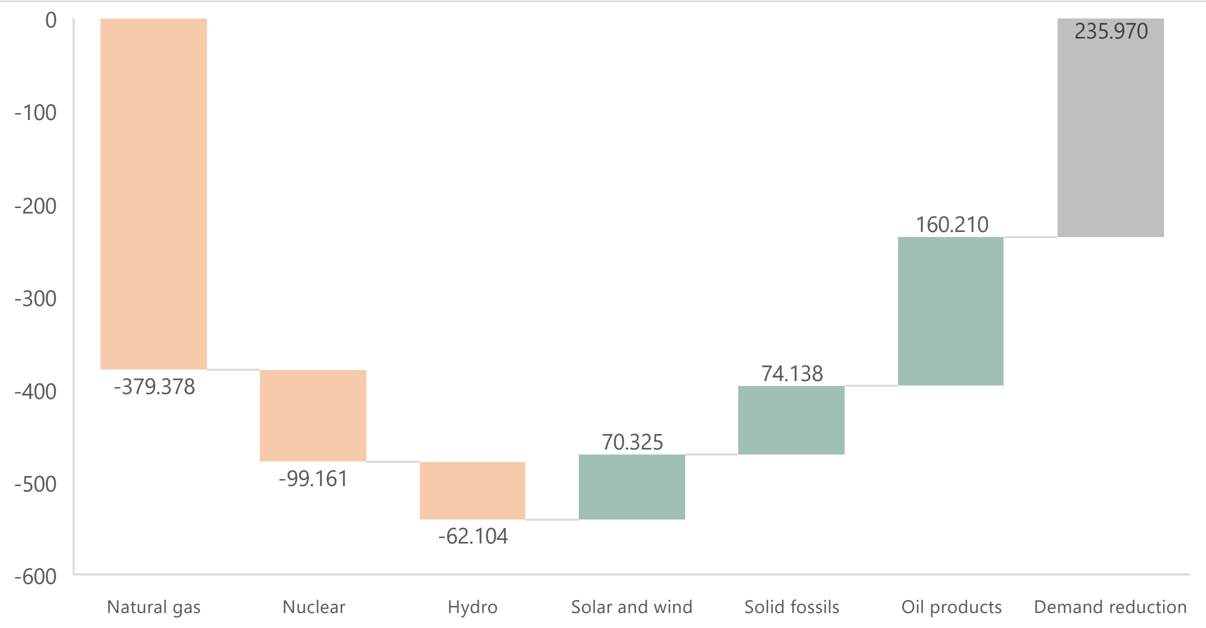
Importantly, while reduced energy demand has helped the EU to cope with reduced energy supply, reduced demand might be caused by undesirable socio-economic drivers such as increased energy poverty and relocation of industrial activities.

When looking at the use of specific energy carriers and the energy mix, the following trends can be observed:

- Natural gas use dropped considerably in 2022 compared with 2021 (-379 TWh or -11% over the period January-October). Reductions have been strongest in the industrial and residential sectors (-15% difference between the averages for the period January-November 2022 and the same period in 2019-2021) due to a combination of milder weather, and energy savings and production curtailments triggered by high energy prices and policies. Natural gas consumption in the power sector has remained relatively stable (a -1% difference between the same periods) despite high natural gas prices; this was most likely due to limited alternatives to compensate for the decreased outputs from nuclear- and hydro-based power plants (McWilliams and Zachmann, 2022)

- The decrease in available energy supply was worsened by lower outputs from nuclear plants (-99 TWh or -17%) — primarily driven by temporary shutdowns in the French nuclear parc[2] (-69 TWh) and nuclear phase-outs in Germany (-27 TWh) — as well as decreased hydro-based power plant outputs (-62 TWh or -20%) linked to unusually low rainfall (Toreti et al., 2022).
- The reduction in available energy supply has been partially mitigated by a strong growth in solar and wind energy (+70 TWh or +16%); however, this growth has not been sufficient to fully compensate for reductions in nuclear and hydro outputs.
- The use of solid fossil fuels has increased on a year-to-year basis (+74 TWh or +4%), mainly in the power sector, to compensate for the drop in nuclear and hydro outputs.
- There was a strong year-on-year increase in the demand for transport fuels (+160 TWh or +4%). The bulk of this increase (+154 TWh) is related to increased kerosene demand, following a rebound in aviation activity post COVID-19.

***Figure 3 Year-on-year change in primary energy use per source (January-October 2022, TWh)***




**Sources:** Calculations by the Advisory Board based on Eurostat data on monthly energy supplies (Eurostat, 2022b).

At the time of writing this advice, official Eurostat data were available until October 2022. Latest available data on natural gas use show that the year-on-year decrease continued into November 2022 (McWilliams and Zachmann, 2022), and projections from the International Energy Agency suggest that both overall energy demand and GHG emissions continued to be lower in the last months of 2022 than in 2021, as demand reductions and an increase in renewable production capacity outpaced the (temporary) increase in coal use (IEA, 2022a, 2022b).

([2]) Owing to a combination of scheduled maintenance shutdowns and unscheduled shutdowns due to corrosion issues and a lack of cooling water during summer 2022 (Reuters, 2022; RFI, 2022).

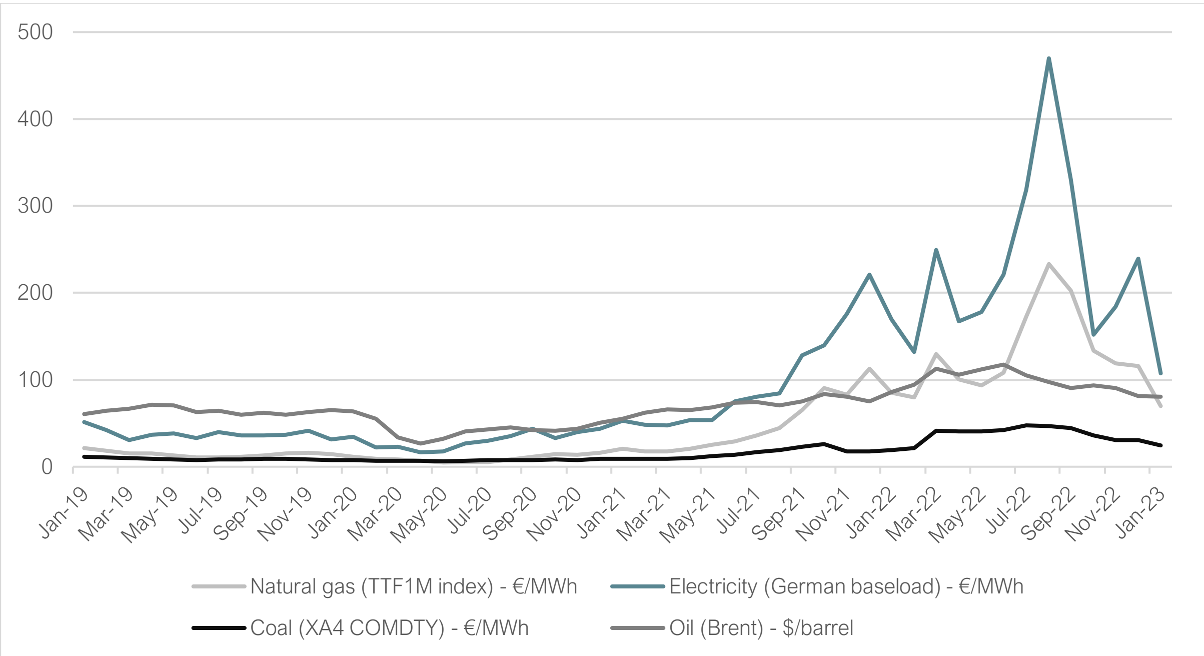
## 2.3 Consequences: high energy prices, increasing the risks of energy poverty and a loss of competitiveness

**Energy prices started increasing in mid-2021 and peaked in summer 2022. Since then, prices have cooled down again but are still significantly above pre-crisis levels.**

Energy prices were relatively stable between the financial crisis in 2009 and 2021. In 2020, prices dropped because of the COVID-19 pandemic, but rebounded quickly when the global economy started recovering in 2021.

However, in the lead up to and, even more so, since Russia's invasion of Ukraine, wholesale energy prices have increased considerably. Natural gas prices rose to a peak of over €300/MWh in August 2022 (a 15-fold increase compared with the €20/MWh average for 2012-2019). Similarly, the electricity price — which is linked to the gas price — had also increased 10-fold by August 2022, compared with the 2012-2019 average. The increase in coal prices (4.5-fold) and crude oil prices (1.5-fold) were less pronounced but still significant. Since the price peaks in summer 2022, prices have cooled down significantly, but are still considerably above pre-crisis levels.

***Figure 4 Evolution of wholesale energy prices since 2019 — monthly averages (units in legend)***




**Sources:** Based on Bloomberg data, price data up to 9 January 2023 is included.

**Low-income and southern and eastern European households are most affected by high energy prices.**

Overall, energy expenditure as a share of total income declined between 2012 and 2021. Nevertheless, energy poverty — where a household is unable to access energy services at a socially and materially necessary level (Bouzarovski et al., 2012) — is still a significant challenge, affecting over 30 million EU citizens even before the crisis (Manjon et al., 2022). Within the EU, energy poverty is concentrated in eastern and southern Europe, with the highest levels in Lithuania, Bulgaria, Greece and Portugal (EC, 2022c).

There is genuine concern that the observed high energy prices will increase energy poverty across the EU. An analysis by the International Monetary Fund suggests that high energy prices will increase the overall cost of living by 7%, with low-income households and eastern European countries experiencing higher inflation than western parts of Europe because of their high reliance on Russian supplies and energy spending accounting for higher shares of overall expenditure (Ari et al., 2022).

**Energy-intensive industries and small businesses have reported lower production levels, and some might close permanently.**

High energy prices also pose a challenge for the competitiveness of energy-intensive industries in that they are unable to pass on increased energy costs because of foreign competition or disappearing demand. Several sources indicate that these sectors may be curtailing or even shutting down production because of the high energy prices (Trading Economics, 2022; International Aluminium, 2022; SMM News, 2022). In the long run, if demand remains unchanged, a concern is that the energy-intensive production of metals, fertilisers and chemicals will permanently move to other continents, which could result in increased import dependency and vulnerability to supply disruptions, carbon leakage and lost European income (Beck et al., 2023).

## 2.4 The interlinkages between the energy and the food crises

The energy crisis is interlinked with high food prices and the resulting food crisis, which has been observed globally, in two ways, as outlined below.

First, the crises share a common cause, as Russia's invasion of Ukraine has directly affected the available food supply on the market and has reduced grain exports from Russia and Ukraine (which together accounted for one third of global grain exports and 80% of global sunflower exports in 2021). In parallel, fertiliser prices have also increased because of the double effect of increased energy prices and disrupted Russian exports (with Russia producing 15%, 14% and 17% of globally traded nitrogen, phosphorus and potassium fertilisers, respectively) (FAO, 2022). These dynamics have contributed to the observed increases in food prices worldwide.

Second, there is a risk that responses to the energy crisis will worsen the food crisis, as the EU might turn to biomass fuels to replace reduced fossil fuel energy supplies and to achieve its climate and renewable energy objectives. The use of biomass for energy purposes has contributed to an increase in the share of the European energy mix accounted for by renewables in the past decade, with biomass accounting for over 60% of the EU's renewable energy use in 2019 (EC, 2019). Policy makers are aiming to achieve a further increase in the production and consumption of certain types of biomass fuels, for example through accelerated development of biogas under the REPowerEU plan. Data also show that the use of solid biomass is increasing, particularly for heating purposes. However, in certain cases, biomass production is competing with food production. First-generation biofuels are crop products that could be used for human consumption and have long been criticised for causing direct and indirect land use changes. Other biomass fuels, including biogas and second-generation (or third-generation) biofuels, do not directly compete with food if they rely on waste streams and lignocellulosic biomass. Nevertheless, to some extent, the land used for producing second-generation biofuels could also be used for feed production, putting indirect pressure on the food system. In addition to increasing pressure on the food system — and in some cases on water resources — energetic biomass use could also have a counterproductive negative impact on climate change, as biomass production reduces the carbon stored above and below ground, and might increase albedo, contributing — at least temporarily — to climate change.

Increased food prices increase food insecurity in vulnerable households in both Europe and globally. In these circumstances, reducing biofuel imports and increasing food production in Europe at the expense of bioenergy generation could alleviate food insecurity (Enciso et al., 2016).

These interlinkages between the energy and food crises require a certain trade-off between using biomass for food purposes and for energy purposes. In this complex trade-off, the actual source of biomass, its potential alternative use and the energy decarbonisation options play a key role in determining the extent of food and energy price impacts.

## 2.5 Implications of the crisis for the EU's transition towards net-zero GHG emissions

The crisis, caused by Russia's invasion of Ukraine — and worsened by a drop in nuclear power output and a compound event in the shape of a heatwave and a drought — is causing hardship in the EU and beyond. Changes in the availability and prices of different energy sources are already causing a shift in both energy demand and the energy mix. However, it will be the measures taken in response to the crisis that will determine if the crisis becomes a catalyst or a stumbling block for the EU's trajectory towards climate neutrality by 2050. These measures and their respective impacts are assessed in section 3.

# 3 Assessment of EU and national measures for tackling the energy crisis

## 3.1 Assessment methodology

Since the start of the energy crisis, several measures have been taken at the EU, national and sub-national levels to mitigate the worst adverse impacts. Rather than assessing each of these measures individually, the Advisory Board has identified different types of measures, based on common characteristics, objectives and expected impacts. Overall, these types of measures have been classified in the following four categories:

(1) measures seeking to redress the market imbalance by **securing energy supply**;
(2) measures seeking to redress the market imbalance by **reducing energy demand**;
(3) measures seeking to **address the distributive impact** by directly influencing energy prices or providing income support to exposed households and businesses;
(4) measures aiming to **generate government revenues** to finance any of the previous measures.

For each category, a further distinction was made using sub-categories. Various combinations of these types of policies and measures have been adopted in different Member States and some are being coordinated at the EU level.

The different types of measures were then assessed on two main dimensions, for which both the short and the longer terms were considered:

1. **To what extent are the measures effective at ensuring the affordability of energy for EU consumers**, particularly the most vulnerable consumers? On what timescale would this effect materialise (short term and/or long term)?
2. **What are the expected impacts of the measures on GHG emissions** (which could be either positive or negative), and are these impacts expected to be temporary (short term) or more structural (long term)?

**Where relevant, impacts on other dimensions[3] were included as a third assessment dimension**, although at a lower level of detail.

To underpin the assessment, the Advisory Board reviewed current and proposed EU and national policies. The expected impacts of the different types of measures on the selected assessment dimensions were investigated by referring to scientific literature on these types of policies and measures, as well as economic theory of market processes, as described in literature on policy evaluation and transition studies. The most important findings were identified through this detailed review and are summarised below.

## 3.2 Assessment of supply-side measures

### 3.2.1 Overview

The EU and its Member States have implemented numerous measures to shift the energy supply to cope with the reduced supplies from Russia. Overall, these measures can be grouped into four sub-categories:

(3) That is, relevant side effects of the measure on other dimensions that are not fully captured under the energy affordability or GHG emission dimensions, such as energy independence and other environmental impacts.

(1) diversifying the supply of natural gas, (2) switching to other fossil fuels, (3) switching to non-fossil fuel energy sources (particularly renewable energy), and (4) reinforcing the energy grid and energy storage. Some of these measures can be and have been implemented in the short term, using existing infrastructure, whereas other measures require the building of new infrastructure and take more time to implement. An overview of the different measure types and their impacts is included in Table 1, followed by a more detailed assessment.

***Table 1 Overview of possible supply-side measures and their impacts***

| | Energy affordability* | | Impact on GHG emissions | | Other dimensions |
|---|---|---|---|---|---|
| | Short term | Long term | Short term | Long term | |
| **Supply-side measures** | | | | | |
| **Diversify gas supply** | | | | | |
| Existing infrastructure | + | + | - | +- | N/A |
| New infrastructure | + | + | - | - | - |
| **Switch to other fossil fuels** | | | | | |
| Existing infrastructure | + | +- | -- | - | - |
| New infrastructure | N/A | +- | N/A | -- | -- |
| **Switch to non-fossil fuel sources** | | | | | |
| Renewable energy (excluding biomass) | + | ++ | + | ++ | +- |
| Delayed nuclear plant closures | + | N/A | + | N/A | ? |
| New nuclear plants | N/A | +- | N/A | ++ | ? |
| Electrification of end-use sectors | +- | + | + | ++ | ? |
| Solid biomass | + | +- | +- | +- | - |
| Biogas | + | +- | N/A | + | ? |
| Green hydrogen | N/A | +- | N/A | + | ? |
| **Reinforce the energy grid and system** | | | | | |
| Interconnectivity and storage — electricity | N/A | + | N/A | ++ | ? |
| Interconnectivity and storage — gas | N/A | +- | N/A | - | ? |

*Legend*

| | |
|---|---|
| ++ | *Considerable positive impact expected* |
| + | *Moderate positive impact expected* |
| +- | *Impact is uncertain, for example because of opposing dynamics* |
| - | *Moderate negative impact expected* |
| -- | *Considerable negative impact expected* |
| *N/A* | *Not applicable, for example because of timing constraints, or not relevant for this assessment* |
| *?* | *Not considered for this assessment* |

**Energy affordability should be interpreted here as affordability for the end consumer. The potential impact on public finances — e.g. because of subsidy costs or reduced tax revenues — is considered under 'Other dimensions'.*

### 3.2.2 Diversifying gas supply: necessary in the short to medium term, but runs the risk of long-term lock-ins

**Overview of measures:** The EU and its Member States have been seeking to replace Russian gas imports with imports from other trading partners. Alternative supply has been mainly delivered through greater use of existing import infrastructure (mainly LNG infrastructure, but also, to a lesser extent, existing natural gas pipelines). However, several Member States are also planning to increase their LNG import infrastructure, through either onshore terminals or more flexible floating storage and regasification units (FSRUs) (Aitken et al., 2022; EC, 2023; IEA, 2022b; Sgaravatti et al., 2022a). The underlying reason is that, although the EU as a whole might have sufficient import capacity, Russian supply cuts have affected gas availability in eastern Europe whereas excess LNG import capacity is concentrated on the Iberian Peninsula and there is insufficient intra-European infrastructure to transport gas between both regions (Di Bella et al., 2022).

At the EU level, efforts to diversify gas supplies have been facilitated through setting up the EU Energy Platform, which aims to pool demand and coordinate infrastructure use (EC, 2022d). The EU has also set minimum targets for Member States to fill their gas storage capacities to at least 80% before winter 2022-2023 (and to at least 90% in subsequent winters) (EU, 2022b).

**Energy affordability:** The increased gas supply from other trading partners has made an important contribution to the crisis response. It allowed the EU to almost completely fill its gas storage capacity prior to the winter of 2022-2023 (Council of the EU, 2022b) and therefore avoid even higher energy prices. Looking forward, the future impact on energy affordability will depend heavily on the evolution of gas (and in particular LNG) prices, which will depend strongly on global demand but could remain at the high levels observed today (IEA, 2022e).

**Impact on GHG emissions:** In the short term, alternative gas supplies have reduced the need to use other, more polluting energy sources such as coal. There is also, however, an increased impact on emissions outside EU borders, as LNG has a higher upstream carbon footprint than pipeline gas (McGrath, 2022). However, an even bigger concern is the risk of long-term lock-ins: on aggregate, the planned investments in new LNG terminals would increase the EU's total import capacity significantly beyond the projected gas demand under different climate-neutral scenarios (Aitken et al., 2022). As infrastructure investors commonly require long-term contracts with minimum demand commitments, there is a genuine risk that the EU could become locked into future gas consumption that is incompatible with its climate objectives. Efforts to ensure the security of supply should therefore be carefully balanced with climate objectives when considering new gas infrastructure and long-term supply contracts.

**Other dimensions:** The diversification of gas supply does little to reduce the EU's dependency on energy imports, compared with many of the other possible measures included in this assessment. New infrastructure could lock in such dependencies if they are coupled with long-term contracts with guaranteed minimum demand volumes.

### 3.2.3 Switching from gas to other fossil fuels: an emergency measure that should be ramped down as soon as possible

**Overview of measures:** The reduction in Russian gas supply has also been partially compensated for by increased use of other fossil fuels, primarily coal. The increase in coal use has been highest in the power sector as a result of a large excess in coal-fired capacity following steep output reductions in previous years (Sgaravatti et al., 2022a). Despite this short-term increase, no Member State has planned new investments in coal-fired power generation or backtracked on previous coal phase-out commitments (Brown, 2022).

**Energy affordability:** Coal and oil are dispatchable fuels that are available to the EU as alternatives to natural gas, both in a short time frame and on a large scale. Coal in particular has been used to bridge part of the supply gap left by Russian supply cuts and by reduced nuclear and hydro outputs. A continued increase in the use of coal in power generation over the next few years could allow the EU to alleviate supply constraints in electricity generation but would also increase GHG emissions, which would drive up the price of the EU Emissions Trading System (EU ETS) allowances for other industries. Investments in a new fossil fuel infrastructure would work directly against the required transition away from fossil fuels and would increase the ultimate cost of reaching the EU's climate goals

**Impact on GHG emissions:** In all of the European Commission's decarbonisation scenarios, coal use is predicted to decline by 50% by 2030 and be near to being phased out by 2050 (EC, 2018, 2020d). Any increase in coal use to tackle the energy crisis should therefore be strictly limited in time and ramped down as soon as possible. Any investments in new or existing coal-fired plants are incompatible with the EU's climate ambitions and should be avoided.

**Other dimensions:** In addition to increasing GHG emissions, increased coal use would also have a negative impact on air quality, and thereby cause substantial environmental and human health externalities.

### 3.2.4 Switching to other non-fossil fuel energy sources and energy carriers: structural solutions to tackling both the energy and the climate crises

**Overview of measures:** The EU and its Member States have taken a range of measures to increase supply from other non-fossil fuel sources, including through boosting renewable energy production, accelerating the electrification of end-use sectors and prolonging nuclear energy production.

With its REPowerEU plan, the Commission has proposed to increase the EU's renewable energy share objective for 2030 from 40% to 45%, and has set specific targets on heat pumps, biomethane and green hydrogen (EC, 2022b). It has also made temporary changes to state aid rules to allow further support for renewable energy production (EC, 2022a) and has proposed a temporary simplification of permitting procedures to boost the deployment of renewable energy sources in the short term (EC, 2022h). In December 2022, the Council approved the proposal to temporarily simplify permitting procedures, but did not support the proposed increase to the renewable energy share objective (Council of the EU, 2022c). Member States have complemented these efforts through a range of measures, from eased regulations and financial incentives to direct public investments. In addition to renewables, Belgium and Germany have postponed the closure of nuclear reactors. There is evidence that these measures are having an effect. For example, European consumers have been installing solar panels and heat pumps at an accelerated rate since the start of the invasion (Sgaravatti et al., 2022a). Similarly, the use of biomass as an alternative heating fuel is increasing (USDA and GAIN, 2022).

**Energy affordability:** Investments in **renewables** are likely to bring down energy prices and costs in the medium term, as renewable energy technologies are often the most cost-effective option for electricity production (IEA, 2022e). On-site renewable energy production can be an effective option for prosumers to bring down energy bills in the short term, but low-income households might need support to overcome upfront investment costs. Larger scale renewable power plants can be installed quickly once permits have been obtained. Upscaling renewables will have to be combined with investments in sufficient transmission and storage capacities to ensure intermittent renewable energy sources can lower energy costs throughout the year (Reichenberg et al., 2018; Jafari et al., 2020).

Similarly, **electrification** can bring down energy costs, as electricity-based technologies such as heat pumps and electric vehicles are generally more efficient than the fossil fuel-based technologies (IEA, 2022d; Liu et al., 2021). Electricity-based technologies can also increase energy security when combined with renewable electricity production. The overall cost impact depends on retail price structures, which are driven by the market and the energy taxation framework. Although the total cost of ownership of such technologies might be lower, low-income households might need support to overcome higher upfront investment costs if they are to implement them (IEA, 2022d).

Delaying the closure of **existing nuclear reactors** can be a supportive tool to ensure additional low-carbon energy supply in the short term, if it is cost-effective and if safety can be sufficiently guaranteed. The construction of **new nuclear plants** is currently not a profitable investment in Europe (MIT, 2018), and recent experiences with the construction of new reactors in Europe have shown cost escalations and delays (IEA and NEA, 2020). These issues may be tied to first-of-a-kind learning effects (IEA and NEA, 2020), and further improvements in technology, design and construction management may bring down costs in the future (MIT, 2018). Nevertheless, given the long lead times of new nuclear power plants (10 to 15 years), a further expansion of this technology cannot be expected to contribute to alleviating the current supply challenges in the short to medium term. Furthermore, social acceptability remains an issue in some countries.

Increased production and use of **biogas** and **green hydrogen** can also become part of the solution in the medium term and at a cost that is lower than today's fossil fuel energy products (IEA, 2020; BloombergNEF, 2020); however, as their total aggregate supply potential is limited, their use should be prioritised with consideration, such as for sectors that have limited potential for direct electrification.

**Impact on GHG emissions:** Upscaling renewable energy production and phasing out fossil fuels is — together with reducing energy demand — can be used as a key lever for reducing GHG emissions and achieving the climate objectives for 2030 and 2050. The EU had already made significant progress prior to the crisis, with the share of renewables in the total energy mix roughly doubling from 10.2% in 2005 to 22.1% in 2020. However, the pace needs to more than double to achieve the proposed 40% objective for 2030 and even triple to achieve the higher 45% objective proposed under the REPowerEU plan (EEA, 2022). The energy crisis provides a clear additional argument to accelerate the roll-out of renewables and reduce the EU's dependency on fossil fuels.

**Other dimensions:** Increased renewable energy production can reduce the EU's energy **import dependency**. However, there is a certain risk that new dependencies are created in relation to raw materials, with China currently dominating supply chains for renewable technology sources (Kratz et al., 2022). Therefore, it is crucial to develop robust supply chains for fuels, equipment and raw materials. The EU is also dependent on uranium imports to fuel its nuclear power plants. In 2020, one fifth of the EU uranium supply came from Russia (Statista, 2022). Russia produces less than 7% of global uranium supply and holds 8% of global resources (World Nuclear Association, 2022).

The EU's future energy security will also be affected by climate change. In 2022, a wide and persistent lack of precipitation in combination with heatwaves caused a severe drought, affecting several regions in Europe. This in turn has led to historically low hydropower outputs, as well as reduced generation by thermal power stations — including nuclear reactors — due to a lack of cooling water (Toreti et al., 2022). In addition, low water levels in some of the EU's main waterways have disrupted fuel supplies to coal-fired power plants (Gillespie and Sorge, 2022). These events show that climate change — which is projected to make extreme weather events such as drought more frequent and intense — can undermine the EU's energy security, even for technologies that have been considered highly reliable, such as nuclear power. Similarly, climate change could also reduce the future availability of biomass (Xu et al., 2022), and the output ratio for photovoltaic solar cells (Hou et al., 2021) and wind turbines (Zeng et al., 2019).

Negative **externalities regarding environmental, health and social impacts** exist for all energy technologies. Specific impacts and risks need to be weighed carefully against benefits, both regarding defining policy targets as a whole and for specific implementations of technology.

The increased use of **biomass** can provide alternative fossil feedstocks and energy sources. However, not all biomass use is beneficial for the climate, the aggregate availability of sustainable biomass is limited and biomass burning also has negative impacts on local air quality (EC, 2022f; Tomlin, 2021). The use of solid biomass as an energy source should therefore be limited to sustainable biomass that does not have a higher added value (following the cascade principle) and be prioritised for processes that have limited alternative decarbonisation options available. Sustainable sourcing needs to be rigorously monitored to avoid the risk of the unsustainable harvesting of woody biomass and the depletion of soil carbon stocks, and to address concerns of direct and indirect land use change outside Europe. Furthermore, the negative impact on biodiversity due to competition for land use and potential depletion of water resources are issues to consider.

### 3.2.5 Reinforcing the energy grid and system: a prerequisite for integrating high levels of renewables and a secure supply

**Overview of measures:** The EU has heavily invested in the development of the interconnectors' infrastructure (e.g. via the Trans-European Networks for Energy and funding from the Connecting Europe Facility), which contributes to both supply and demand optimisation. The Commission's REPowerEU plan aims to accelerate investments in the EU's energy infrastructure as a means to build an integrated energy market that secures supply in a spirit of solidarity. The plan considers the needs for limited additional investments in gas and oil infrastructure, and more significant additional investments in the power grid (EC, 2022b).

**Energy affordability:** A further reinforcement of the **electricity grid** can help to further bring down energy prices in the medium to long term. Increased interconnection and storage capacities can further integrate the EU electricity market, facilitate the integration and balancing of intermittent renewable energy sources, and reduce the need for flexible back-up capacities, reducing overall energy costs (Berrill et al., 2016). Some investments in **gas infrastructure** can alleviate supply shortages, but there is a danger of potentially expensive overcapacities towards the end of this decade as fossil fuels are replaced by renewables (Di Bella et al., 2022; Aitken et al., 2022). Oversupply may also result from long-term contracts with guaranteed purchasing volumes, which may be required to ensure supply in the coming years (Simon, 2022).

**Impact on GHG emissions:** Reinforcing the electricity grid and storage capacities is a necessary condition for facilitating the uptake of high levels of renewable, intermittent energy sources and is therefore a key lever in decarbonising the energy system. Investments in gas infrastructure risk lock-ins for future gas consumption and related GHG emissions, and should therefore be considered with caution.

**Other dimensions:** Transmission lines, cables and substations require considerable space. Their use of land area and creation of long corridors can shape landscapes and biospheres in a negative way. Affected citizens often contest the building of new grid infrastructure for a variety of reasons (Koelman et al., 2022). Transmission lines above ground can have a negative impact on landscape aesthetics, which may result in welfare loss (Oehlmann et al., 2021). This obviously must be weighed against other types of externalities.

## 3.3 Assessment of demand-side measures

### 3.3.1 Overview

In parallel to securing additional supply, the EU and its Member States are also looking to accelerate reductions in energy demand to ensure security of supply and to reduce energy prices. Overall, energy savings have been pursued both through technical (e.g. energy efficiency) and non-technical (e.g. behavioural changes) solutions.

Overall, the EU has a proven track record of improving energy efficiency and reducing energy demand. In 2020, the EU has surpassed its 20% energy efficiency target by reaching over 25% improvement. The target for 2030 was initially set at 32.5% efficiency (EU, 2018), and is currently being revised with a proposed 36-39% objective as part of 'Fit for 55' package (EC, 2021a). In response to the crisis, the European Commission has since proposed to increase the objective to 40% as part of its 'REPowerEU plan' (EC, 2022b). Additional efforts will be required to achieve this increased ambition. In 2020, the European Commission's assessment showed that the cumulative impact of the national energy efficiency plan would provide a saving of only 29.4-29.7% (EC, 2020c).

An overview of the different measure types and their impacts is included in Table 2, followed by a more detailed assessment.

***Table 2 Overview of possible demand-side measures and their impacts***

| | Energy affordability* | | Impact on GHG emissions | | Other dimensions |
|---|---|---|---|---|---|
| | Short term | Long term | Short term | Long term | |
| **Demand-side measures** | | | | | |
| **Technical (energy efficiency)** | | | | | |
| Building renovations | + | ++ | + | ++ | + |
| Energy efficiency in other sectors | + | + | + | + | + |
| **Non-technical (behavioural changes)** | | | | | |
| Incentivise rational energy use | ++ | ++ | ++ | ++ | +- |
| Demand-side management | + | + | + | + | ? |
| Reduce demand for energy-intensive products and services | N/A | ++ | N/A | ++ | + |

*Legend*

| | |
|---|---|
| ++ | *Considerable positive impact expected* |
| + | *Moderate positive impact expected* |
| +- | *Impact is uncertain, for example because of opposing dynamics* |
| - | *Moderate negative impact expected* |
| -- | *Considerable negative impact expected* |
| *N/A* | *Not applicable, for example because of timing constraints, or not relevant for this assessment* |
| *?* | *Not considered for this assessment* |

**Energy affordability should be interpreted here as affordability for the end consumer. The potential impact on public finances — e.g. because of subsidy costs or reduced tax revenues — is considered under 'Other dimensions'.*

### 3.3.2 Building renovations: renovation rate needs to be increased

**Overview of measures:** Buildings account for 40% of the EU's total energy consumption (EC, 2020b), with 35% of the EU's natural gas consumption used directly for space heating (Eurostat, 2022c). A full, deep renovation of the building stock could technically reduce the EU's energy demand by 57% (EC, 2020a). Even before the crisis, the EU and its Member States had been aiming to boost the rate of building renovations. In 2020, the Commission published its 'Renovation Wave' strategy, with the aim of doubling the annual energy renovation rate of buildings by 2030 and to foster deep energetic renovations (EC, 2020b). To achieve this ambition — and as part of the 'Fit for 55' package — the Commission has proposed specific obligations for energy savings in public buildings under the revised Energy Efficiency Directive (EC, 2021d), as well as a revision of the Energy Performance of Buildings Directive (EC, 2021e). Under the latter, Member States have prepared national long-term renovation strategies, which they should now be implementing. In October 2021, as energy prices started rising, the European Commission published a 'toolbox', which called on EU Member States to invest in buildings' energy performance, facilitating its financing via the revised Energy and Environmental State Aid Guidelines and the Recovery and Resilience Facility (EC, 2021b). Since then, many Member States have taken a range of measures to accelerate building renovation and broader efficiency improvements, including by accelerating the implementation of recovery and resilience plans (Sgaravatti et al., 2022a).

**Energy affordability:** Building renovation measures are highly effective at reducing energy bills. They require high upfront investments, but can be profitable in the longer run when considering both reduced energy bills and increased real estate value (Farsater et al., 2015). Nevertheless, several studies show that energy renovations, even when profitable, are not being implemented at their full potential. There are several reasons for this, such as lack of investment capacity, split incentives and asymmetric information (Ástmarsson et al., 2013; D'Oca et al., 2018; Azizi et al., 2019). Increasing both the renovation rate (i.e. the percentage of building stock that is renovated) and the renovation depth (i.e. the level of efficiency improvement achieved by renovation) would allow significant reductions in energy bills. The impact would increase over time, as long investment cycles and limits to supply chains mean that there is a limit to the percentage of buildings that can be renovated each year.

**Impact on GHG emissions:** Reducing energy demand through energy efficiency improvements is one of the key levers for reducing the EU's GHG emissions and achieving climate neutrality by 2050. Given the long lifetime of buildings and long investment cycles, the rate of deep energy renovations needs to be increased now to keep the EU on track to achieve its 2030 and 2050 climate objectives (EC, 2020d, 2020b; IPCC, 2022; EC, 2020a). The renovation of the building stock will require construction materials that also cause GHG emissions during the production phase. However, this climate impact would be largely compensated for by reductions during the use phase and, in most cases, building renovation causes less GHG emissions than building replacement (Berrill et al., 2022).

**Other dimensions:** Building renovation can contribute to improved comfort and public health, provided that renovation practices look beyond energy efficiency and take into account other criteria such as indoor air quality (Dovjak and Kukec, 2019). Furthermore, the Commission expects that the Renovation Wave strategy would create 160,000 additional jobs in the EU by 2030 (EC, 2020b).

### 3.3.3 Energy efficiency in other sectors: some potential remains, including for waste heat recovery

**Overview of measures:** The EU has been heavily investing in research and development for energy efficiency through several funding programmes (EC, 2022e), including the Intelligent Energy Europe Programme, European Structural and Investment Funds, Horizon 2020, cohesion policy funds, modernisation funds, InvestEU, Horizon Europe, Built4People, the Climate-neutral and Smart Cities EU mission, the Innovation Fund and LIFE Clean Energy Transition sub-programme. Furthermore, EU policies have also pushed for energy-efficient vehicles through increasingly stringent vehicle standards and for energy-efficient products through energy labelling (c.f. section 3.3.6 on circular economy).

**Energy affordability:** Continuous energy efficiency improvements can help EU industries to maintain their energy costs and increase their competitiveness; however, the potential in the industry sector is considered lower than in, for example, the building sector. Nevertheless, there is some potential in the recovery and valorisation of waste heat (EC, 2020d). In addition, energy-efficient products, including vehicles, can help to reduce costs for consumers.

**Impact on GHG emissions:** Increasing the energy efficiency of industrial processes, vehicles and other products contributes to reducing GHG emissions. The incentive for efficiency improvements and fuel switches emanating from the EU ETS can be further reinforced by making free EU ETS allocations subject to installations' commitments to reduce emissions. It should be noted that energy efficiency investments in fossil fuel-based processes and installations may lock in future, albeit lower, emissions, rather than accelerate the transition to zero emissions.

### 3.3.4 Incentivise rational energy use: room for expanding best practices

**Overview of measures:** Both the EU and its Member States have aimed to incentivise rational energy use to cut energy demand within a short time frame. For winter 2022-2023, EU Member States agreed on a short-term, voluntary reduction in both natural gas demand (-15%) (EC, 2022j) and electricity (-10%) (EC, 2022i). At the national level, several Member States have taken concrete measures — both voluntary and mandatory — to reduce energy demand. Several countries have introduced heating and cooling restrictions in public buildings, and prohibited doors from being kept open to commercial spaces that are heated or cooled. Similarly, some countries have reduced electricity consumption from lighting, by switching off public lighting and imposing requirements on commercial operators to turn off lights at night-time. Countries have also considered mandatory speed limits to reduce energy consumption, but so far no such measure has been implemented. In addition to mandatory reductions, some EU Member States have launched awareness-raising campaigns to encourage citizens to lower thermostat temperatures, have shorter hot showers, switch off lights, reduce car use, and turn off appliances or replace appliances (Sgaravatti et al., 2022a). Other Member States, including Germany or Spain, have subsidised rail transport. However, so far, eight Member States have not yet introduced any measure to reduce gas or electricity consumption, and only 12 countries have adopted mandatory measures, signalling room for improvement (EEB, 2022).

**Energy affordability:** Rational energy use can reduce overall energy demand, thereby lowering energy prices and bills. Long-term effects will depend on whether or not measures remain in place and/or if they induce long-lasting behavioural change and the broad adoption of new habits.

**Impact on GHG emissions:** Systematic demand reductions can significantly reduce GHG emissions. Price signals alone might be insufficient because of non-market barriers, which provides a rationale for complementary voluntary and mandatory measures. There are opportunities to learn from best practices across the EU and implement them on a larger scale. There might be some challenges in controlling the application of restrictions. Whether or not rational energy use has a long-term effect on GHG emissions depends on how long measures remain in place and whether or not the measures lead to long-term behavioural change or preferences.

**Other dimensions:** Measures to boost rational energy use can have both positive (e.g. improved air quality, reduced congestion, noise reduction) and negative (e.g. reduced comfort, increased transportation time, reduced productivity) externalities.

### 3.3.5 Demand-side flexibility: further investment is needed to accelerate digitalisation and the roll-out of an automated demand response

**Overview of measures:** In addition to lowering overall energy demand, policy makers have also aimed to shave off peak electricity demand. In addition to a voluntary overall 10% reduction objective, EU Member States also agreed to a mandatory reduction in peak electricity demand of 5% during winter 2022-2023 (EC, 2022i). Even before the crisis, EU Member States had been adjusting the demand in the short term by shifting the consumption of some industrial customers to off-peak hours, and in the long term by investing in the development of smart grids. The roll-out of smart metering throughout Europe provides an infrastructure element that allows for demand-side flexibility. An automated demand response, however, also requires appliances to be connected (Blaschke, 2022; Forouli et al., 2021; Söder et al., 2018). In several EU countries, market solutions for demand-side flexibility are limited. If this is to become an important component of reducing energy use, further investments are required to upscale the digitalisation of the energy system and accelerate the deployment of smart grids.

**Energy affordability:** Structural measures for demand-side management can contribute to lowering energy prices by creating more flexibility in the energy system, in particular during peak times. However, the connected appliances needed for an automated demand response are lacking, and the financial benefits of demand shifting for residential consumers have historically hardly covered the extra costs.

**Impact on GHG emissions:** Flexibility can help to match demand and supply at lower levels of installed capacity, reduce the need for dispatchable, mostly fossil fuel, energy generation and hence allow for a quicker reduction in the use of fossil fuels.

### 3.3.6 Reduce demand for energy-intensive products and services: underused in EU climate and energy policies

**Overview of measures:** In addition to the measures described above that can directly reduce energy demand, there are ways to reduce energy needs indirectly, for example by reducing the demand for energy-intensive products and services. This can be done through a range of levers, including sufficiency (consuming less) and circular economy measures (to be understood in a broad sense, including material efficiency, sharing economies, products-as-a-service, extended product lifetimes, repair, reuse and upcycling/recycling). Such measures are not commonly considered in the context of responses to the energy crisis, although some Member States like France have included sufficiency measures in their plans to reduce energy demand (Gouvernement de France, 2022). At the EU level, as part of the 2020 European Green Deal, the EU has adopted a circular economy action plan, and on 30 November 2022 the European Commission adopted a proposal for the second circular economy package (EC, 2022k).

**Energy affordability:** Sufficiency and circular economy measures have the potential to reduce consumer expenditure directly and can lead to lower overall energy demand, which would suppress energy prices indirectly.

**Impact on GHG emissions:** Similarly, sufficiency and circular economy measures have the potential to significantly reduce emissions from energy-intensive industries. Focusing on three energy-intensive industries (steel, plastics and cement), a study from Material Economics estimates that circular economy measures can reduce industrial emissions by 56% by 2050 (Material Economics, 2018). The potentially beneficial impact of circularity on GHG emissions has also been confirmed in other studies (Gorman et al., 2022; Pauliuk et al., 2021; Masanet et al., 2021).

**Other dimensions:** In addition to lowering energy demand and GHG emissions, sufficiency and circular economy measures can have multiple co-benefits in terms of reductions in resource use, import dependencies and waste (Pauliuk et al., 2021).

## 3.4 Assessment of market and price interventions

### 3.4.1 Overview

There are different ways in which the EU and its Member States have been intervening (or plan to intervene) in energy markets and price formations to mitigate the impact of high energy prices on households and businesses. To support Member States, the Commission has published several guidelines on possible national measures (EC, 2021b) and has provided a temporary adjustment of EU state aid guidelines (EC, 2022a).

Overall, three different sub-categories can be identified:

1. measures that aim to affect wholesale prices
2. measures that aim to affect retail prices
3. direct income support that does not affect prices but provides direct financial support to energy consumers to help them cope with high energy prices.

These measures can be either temporary in nature or more structural and hence long term. Retail price and income support interventions can be either broad based/non-discriminatory or targeted at specific vulnerable energy consumers. An overview of the assessment of different measure types and their impacts is included in Table 3, followed by a more detailed assessment.

***Table 3 Overview of possible market and price interventions and their impacts***

| | **Energy affordability*** | | **Impact on GHG emissions** | | **Other dimensions** |
|---|---|---|---|---|---|
| | Short term | Long term | Short term | Long term | |
| **Market and price interventions** | | | | | |
| **Interventions in/reform of the wholesale market** | | | | | |
| Temporary price caps | +- | - | - | +- | - |
| Structural market reform | N/A | + | N/A | + | ? |
| **Interventions in the retail market/prices** | | | | | |
| Non-targeted | +- | +- | - | +- | -- |
| Targeted | + | +- | +- | +- | - |
| Energy taxation reform | +- | +- | +- | ++ | +- |
| **Direct income support** | | | | | |
| Non-targeted | +- | +- | + | + | -- |
| Targeted | ++ | + | + | + | - |

*Legend*

| | |
|---|---|
| ++ | *Considerable positive impact expected* |
| + | *Moderate positive impact expected* |
| +- | *Impact is uncertain, for example because of opposing dynamics* |
| - | *Moderate negative impact expected* |
| -- | *Considerable negative impact expected* |
| *N/A* | *Not applicable, for example because of timing constraints, or not relevant for this assessment* |
| *?* | *Not considered for this assessment* |

**Energy affordability should be interpreted here as affordability for the end consumer. The potential impact on public finances — e.g. because of subsidy costs or reduced tax revenues — is considered under 'Other dimensions'.*

### 3.4.2 Measures affecting wholesale prices

**Overview of measures:** Overall, policy makers have been aiming to bring down wholesale energy prices through either temporary price caps (i.e. market intervention) or seeking market reform. In December 2022 — after months of difficult negotiations — the Council approved a €180/MWh cap on wholesale gas prices (subject to certain conditions) (Council of the EU, 2022c).The European Council had previously also asked for a temporary framework to cap the price of gas used for electricity production, inspired by a mechanism put in place by Portugal and Spain in June 2022. The European Commission has been hesitant on both approaches and has instead put forward three alternative measures: joint gas purchases via the EU Energy Platform (with the aim of pooling demand and thereby increasing market power), the development of an alternative price benchmark for LNG in parallel to the Title Transfer Facility (TTF) price benchmark, and a structural reform of the electricity market in 2023. For the structural reform, the Commission is considering a hybrid approach where renewables and other types of inframarginal production technologies (e.g. nuclear) would be renumerated based on their true production costs under long-term contracts, whereas marginal technologies (e.g. gas-fired electricity production) would still be renumerated based on short-term markets, as in place today.

**Energy affordability:** Several economists have warned that a price cap on wholesale gas prices — such as the Market Correction Mechanism, which was agreed at the end of 2022 — risks missing its goal to provide sufficient energy to EU consumers at affordable prices. First, such a cap risks further reducing supply and increasing demand, which would exacerbate the supply-demand imbalance that caused high prices to begin with and could undermine the security of supply. Second, when the cap is triggered, an alternative mechanism would have to be developed to allocate the available supply to the demand, which would be more complex and less efficient than the market. Third — as the mechanism would apply to only the Title Transfer Facility trading hub — it would likely shift trades to other hubs and bilateral over-the-counter exchanges, which would reduce liquidity and the effectiveness of market oversight. Finally, a cap would distort energy companies' hedging strategies, which could lead to financial losses as significant windfall profits (Fulwood, 2022; Balachandar et al., 2022).

A cap on gas-fired electricity generation can be effective at reducing electricity prices, as evidenced in Spain and Portugal. However, a cap also increases gas demand, which increases the gas price for other purposes (e.g. heating) and the need for subsidies, which will eventually need to be financed by EU households and companies somehow. There is also evidence that this approach would increase electricity production for exports to interconnected regions, resulting in subsidy leakage and an overall increased usage of gas (Ari et al., 2022; Eicke et al., 2022; Gros, 2022; Heussaff et al., 2022).

Regarding long-term electricity market reform, both the European Commission and prominent representatives of the scientific community have voiced the expectation that a hybrid approach that combines a marginal pricing wholesale electricity pool (as currently in place in Europe) with mandatory long-term contracts for difference or power purchase contracts for low-marginal electricity production technologies would reduce overall electricity prices (Joskow, 2021; Finon, 2021; EC, 2022g; Grubb et al., 2022). The impact on electricity consumers will, however, be highly dependent on how specific elements are designed and implemented, as well as market developments.

**Impact on GHG emissions:** In the short term, price caps would lower the price signal, increase demand and therefore increase energy consumption levels and related GHG emissions (Ari et al., 2022; Bethuyne et al., 2022; Gros, 2022; Heussaff et al., 2022). A price cap on gas-fired electricity poses a particular risk, as it would incentivise increased gas-fired electricity generation for export to neighbouring countries (Eicke et al., 2022). Furthermore, lower prices can also delay investments in efficiency improvements and/or renewable energy production capacities, which also puts an upwards pressure on long-term GHG trajectories.

The impact of more structural market reforms on long-term GHG emission trends depends on their design and overall market dynamics. A future reform of the electricity market towards a hybrid system could increase investor certainty for renewable energy producers and ensure affordable electricity prices to support the electrification of end-use sectors. However, much will depend on the specific design options. Even the announcement of market reforms can have impacts, as this may deter or accelerate certain business activities, including investment in energy production units and infrastructure.

### 3.4.3 Measures affecting retail prices: non-targeted price interventions should be avoided, targeted price interventions can be considered a second-best solution

**Overview of measures:** Member States have been taking measures to directly reduce energy prices at the retail level (Sgaravatti et al., 2022b). Such measures can be either non-targeted, meaning that they are applied to all energy consumers equally, or targeted, aimed at reducing prices for only the most vulnerable consumers. Non-targeted price **interventions** include general value added tax (VAT) reductions, reductions in or exemptions from existing levies, and subsidised retail prices. Targeted price interventions, in contrast, encompass price caps for specific income groups (e.g. social tariffs). A semi-targeted approach that is considered or applied in some Member States is to provide consumers with a base amount of energy at a capped price, with all consumption above that base amount priced at market prices (hereafter referred to as 'block tariffs'). Changes to the taxation of energy in the context of the crisis could also provide an opportunity to structurally reform the energy taxation framework to phase out fossil fuel subsidies and align energy taxation with the transition towards climate neutrality (e.g. by shifting tax burdens from non-fossil to fossil fuel energy carriers).

As an alternative to price interventions — which inherently distort the price signal — policy makers could also shield consumers without distorting the price signal, e.g. by providing direct income support. These measures are described in section 3.2.4.

**Energy affordability:** Non-targeted price interventions might provide some short-term relief for consumers; however, by distorting the price signal, non-targeted price interventions undermine the incentive for demand reductions, putting upwards pressure on wholesale prices and therefore offsetting at least part of the desired price decrease. Moreover, such measures do not guarantee the efficient use of public resources, which are already constrained because of recent relief measures (in the context of COVID-19) and the economic slowdown. These risks are lower under a more targeted approach, such as social tariffs or direct income support for the most vulnerable (Ari et al., 2022; Bethuyne et al., 2022; OECD, 2022; Peersman and Wauters, 2022). Semi-targeted approaches such as block tariffs also reduce these risks — although to lesser extent than targeted measures — but have the advantage of being less complex and therefore easier to implement (Arregui et al., 2022). The impact of a more structural energy taxation reform on energy affordability is difficult to assess, as it depends to large extent on design elements, market developments and the consumption profile of each consumer.

**Impact on GHG emissions:** Measures that lower overall energy prices lead to higher energy consumption and related GHG emissions. Even if such measures are initially intended to be only temporary, past experience has shown that it is politically difficult to reverse energy subsidies and tax cuts. Despite repeated commitments to phase out environmentally harmful subsidies (G20, 2009; UNFCCC, 2022), Member States' fossil fuel subsidies are still around €55 billion per year and have remained stable over time (ECA, 2022a). Therefore, non-targeted price interventions are not recommended.

In contrast, a structural revision of energy taxation frameworks provides an opportunity to align tax levels with decarbonisation efforts (by differentiating the tax levels of different energy carriers as a function of their GHG intensity) and facilitate further emission reductions. In many Member States, the energy taxation framework does not correctly reflect the externalities of different energy sources, includes implicit fossil fuel subsidies and puts a disproportionate fiscal burden on electricity compared with fossil (heating) fuels, which hampers electrification (ECA, 2022a; Rosenow et al., 2023). The EU Energy Taxation Directive is also not aligned with the European Green Deal (EC, 2021c) and is therefore being revised. The energy crisis provides an opportunity to align energy fiscality with climate ambitions. In the short term, the tax burden on electricity can be reduced to shield consumers from high energy prices. When wholesale energy prices come down, the tax burden on fossil fuels can then be increased, i.e. through the introduction of the proposed EU ETS for buildings and road transport.

**Other dimensions:** Any measure that involves energy subsidies (both direct and indirect, such as tax cuts) implies an additional burden on public finances, which are already constrained by relief measures adopted during the COVID-19 pandemic and the economic slowdown. Overall, the more targeted a measure, the more efficiently public resources will be spent.

### 3.4.4 Direct income support: recommended approach to shielding the most vulnerable households

**Overview of measures:** In parallel with price interventions, many Member States have provided direct income support to energy consumers, including both households and companies. These measures were targeted in some cases, and available to all consumers in other cases. Income support can take the form of energy vouchers, direct rebates on energy bills or lump sum transfers to consumers (Sgaravatti et al., 2022b).

**Energy affordability:** The main advantage of direct income support is that it attains the social benefits of supporting the consumer while maintaining the price signal for demand reduction. That way, direct income support avoids the counterproductive upwards pressure on wholesale prices, which occurs in the case of (untargeted) price-distorting interventions. Again, a targeted approach is recommended, as this can maximise support for vulnerable consumer segments while ensuring the most efficient use of public budgets (Ari et al., 2022; Bethuyne et al., 2022; OECD, 2022; Peersman and Wauters, 2022). Targeted support can be channelled through existing social programmes or by providing broad-based income support that is then recovered from more affluent consumers through income taxes.

**Impact on GHG emissions:** Direct income support is also a preferable approach to price interventions in the context of the transition towards climate neutrality, as it fully maintains the price signal for demand reduction and increased renewable production. A targeted approach has the additional benefit of limiting the risk of potential rebounds effects, which could occur in the case of non-targeted income support.

**Other dimensions:** Similar to tax cuts or other forms of subsidised energy prices, direct income support adds to pressure on public finances. Overall, the more targeted a measure, the more efficiently public resources will be spent.

## 3.5 Assessment of revenue-generating measures

### 3.5.1 Overview

Finally, several measures have been implemented or are being discussed at the EU and national levels to generate revenues that can be used to finance other measures in the context of the energy crisis. Overall, two categories of measures can be distinguished:

1. measures that skim the increased profits (referred to as ‘surplus’ or ‘windfall’ profits) made by some energy producers as a result of the high market prices

2. the use of revenues generated from auctioning allowances under the EU ETS.

An overview of the assessment of different measure types and their impacts is included in Table 4, followed by a more detailed assessment.

***Table 4 Overview of possible revenue-generating measures and their impacts***

| | Energy affordability* | | Impact on GHG emissions | | Other dimensions |
|---|---|---|---|---|---|
| | Short term | Long term | Short term | Long term | |
| **Revenue-generating measures** | | | | | |
| **Taxes on surplus profits** | | | | | |
| Revenue cap on inframarginal electricity production | + | +- | +- | +- | ? |
| Temporary solidarity levy on profits in energy sector | + | +- | +- | +- | ? |
| **EU ETS revenues** | | | | | |
| Market Stability Reserve sales | - | - | - | - | ? |
| Frontloading allowances | - | +- | - | +- | ? |
| Innovation Fund | +- | +- | +- | -- | ? |

*Legend*

| | |
|---|---|
| ++ | *Considerable positive impact expected* |
| + | *Moderate positive impact expected* |
| +- | *Impact is uncertain, for example because of opposing dynamics* |
| - | *Moderate negative impact expected* |
| -- | *Considerable negative impact expected* |
| *N/A* | *Not applicable, for example because of timing constraints, or not relevant for this assessment* |
| *?* | *Not considered for this assessment* |

**Energy affordability should be interpreted here as affordability for the end consumer. The potential impact on public finances — e.g. because of subsidy costs or reduced tax revenues — is considered under 'Other dimensions'.*

### 3.5.2 Taxing surplus profits in the energy sector

**Overview of measures:** On 30 September 2022, the Council approved two measures to redivert some of the surplus profits of the energy sector to the public budget. First, a revenue cap of €180/MWh was agreed for inframarginal electricity producers. The difference between this revenue cap and the wholesale market price would be collected by Member States. Furthermore, Member States agreed to a mandatory temporary solidarity contribution to be levied on the profits of businesses active in the crude petroleum, natural gas, coal and refinery sectors. Revenues from both mechanisms are fully earmarked for mitigating the adverse impacts of the energy crisis (EU, 2022a). Several Member States have implemented additional policies to skim off profits from the energy sector to generate revenues for other crisis-related measures (Sgaravatti et al., 2022b).

**Energy affordability:** The impact of these measures on energy affordability depends on the way in which the revenues are used. In that sense, the Advisory Board welcomes the provisions in the EU measures that earmark 100% of the revenues generated from these measures to be spent on crisis response measures, which are also aligned with the EU's climate objectives (EU, 2022a).

The European Commission estimated that the cap on inframarginal electricity production could generate up to €70 billion in revenues. However, actual revenues will depend on the wholesale electricity price, and could be reduced by other measures such as demand reduction and wholesale price caps.

**Impact on GHG emissions:** There have been concerns that because the cap on inframarginal electricity production reduces profits it will discourage investments in renewable energy production. The level of the cap matters in this regard and should be set at a level where renewable electricity producers can still expect sufficient return on investment. The impact of a solidarity levy on GHG emissions from the energy sector is uncertain. It reduces energy companies' investment capacities, but it is difficult to assess the degree to which higher investment capacities would have been used for investments in renewable or fossil fuel energy sources.

### 3.5.3 Use of EU Emissions Trading System revenues

**Overview of measures:** Implementing the REPowerEU plan would require at least €20 billion of additional investments, and potentially even more (ECA, 2022b). The European Commission proposed raising €20 billion in revenues by selling EU ETS allowances that are held in the Market Stability Reserve (MSR). Eventually, EU institutions reached an agreement to source the required €20 billion from different sources of EU ETS revenues (Council of the EU, 2022a):

- A total of €12 billion would be redirected from the revenues available for the Innovation Fund. To (partially) compensate for this loss of revenue, €2 billion would be raised through sales of allowances currently held in the MSR and added to the total Innovation Fund budget.
- A total of €8 billion would be generated by 'frontloading' national auction volumes, implying an earlier auctioning of volumes that were destined to be auctioned later in the period 2021-2030.

**Energy affordability:** The revenue-generation potential of the different options can be used as a proxy to assess their contribution towards energy affordability. Although total revenue generation is predefined at €20 billion, there are some indirect effects that need to be considered:

- The sale of MSR allowances would increase total supply, decrease carbon prices and consequently lower overall revenues under the system (for the Modernisation Fund, the Innovation Fund and national auctioning revenues). However, the impact might be limited, given the relatively small volume of allowances concerned in the final deal (€2 billion, which would imply 25 million allowances at a current average carbon price of €80/t).
- The impact of frontloading auctioning volumes is less certain: it could put downwards pressure on the carbon price in the short term, but upwards pressure in the longer term. The impact on the carbon price would depend on the extent to which the market would discount future reductions in supply. In the case of high discounting, the carbon price is at risk of following a 'hockey stick' trajectory, which could significantly increase carbon prices in the longer term (Pahle et al., 2022).
- Using revenues from the Innovation Fund would not change overall supply, and therefore would not impact on the carbon price or overall ETS revenues in the short to medium term.

**Impact on GHG emissions:** The use of EU ETS revenues can have an impact on GHG emissions in both the short and long terms, depending on the origin of the revenues:

- The sale of MSR allowances could increase the total carbon budget under the system by approximately 25 Mt $CO_2$eq, assuming an average carbon price of €80/t $CO_2$eq). The net impact will depend on the final design of the MSR (in particular the thresholds), as well as the evolution of the surplus under the system (i.e. the Total Number of Allowances in Circulation or TNAC).
- The frontloading of allowances should not significantly impact on the total carbon budget under the system, although some small impacts may occur because of interactions with the MSR. However, if frontloading leads to a 'hockey stick' price trajectory (see above), it could slow down the deployment of decarbonisation technologies in the short to medium term and undermine the political support for ambitious carbon-pricing instruments in the longer term (Pahle et al., 2022).

- Using revenues from the Innovation Fund would not increase the total carbon budget under the system; however, it would divert funds away from demonstration projects for innovative reduction technologies, which could undermine the EU's transition towards climate neutrality in the longer term. In that sense, it is positive to note that the overall size of the Innovation Fund has been increased to offset the use of the fund's resources to finance measures under the REPowerEU plan.

# 4 Recommendations

Based on the assessment in section 3, the Advisory Board wishes to put forward three types of recommendations:

- 🟩 **Recommended measures,** which should be pursued, as they tackle the energy crisis while supporting the transition towards climate neutrality
- 🟨 **Measures that should be considered with caution,** as they could require a trade-off between energy security, energy affordability and the EU's transition towards climate neutrality
- 🟥 **Measures that are not recommended,** as they risk hampering the EU's transition towards climate neutrality.

## Recommended measures

**1. The principal mechanism to increase the affordability of energy in a situation of crisis is to bring the supply and demand of energy back towards a long-term balance by reducing demand and increasing the supply of secure, domestic and low-carbon energy.** The energy crisis was caused by an imbalance between energy demand and supply, with historically high prices as a result. Measures that target the price — such as subsidies, price caps or market interventions — address the symptoms of the crisis instead of the cause, and therefore do not provide a long-term solution.

**2. Reducing energy demand is the most effective approach for both reducing GHG emissions and tackling the current cost-of-living crisis. Reducing energy demand should therefore be at the forefront of efforts to tackle the energy crisis.**

- **Energy efficiency improvements** should be upscaled and accelerated to structurally reduce energy demand. Significant potential remains in **the buildings sector**, and policies need to be strengthened to accelerate and improve the renovation of the building stock. At the EU level, the different initiatives under the Renovation Wave strategy need to be implemented as soon as possible. At the national level, renovation efforts should be upscaled through a full implementation of national long-term renovation strategies. Low-income households should be supported to overcome specific challenges such as upfront investment costs, split incentives and asymmetrical information. In **industrial sectors**, the incentive for efficiency improvements (and fuel switches) emanating from the EU ETS should be further reinforced by making free EU ETS allocations subject to installations' commitments to reduce energy demand.
- In parallel, **behavioural changes** have the potential to deliver further demand reductions at scale and within a short time frame. Best practices from national approaches — including both awareness-raising campaigns and regulations — should be sustained, expanded and upscaled across the EU to achieve further reductions.
- Although somewhat overlooked**, sufficiency and the transition towards a more circular economy** have the potential to reduce demand for energy-intensive products and services in the longer term, and should receive more consideration in the climate and energy policy frameworks.

**3. Renewable energy production is key to ensuring energy security, improving energy affordability and achieving the EU's climate ambitions.** The EU has made progress over the last decade, but the rate of uptake of renewable energy needs to be at least doubled to achieve the ambitions set out for 2030, and this requires the implementation of a range of measures:

- EU and Member States should ensure a **stable and attractive investment framework** to upscale investments in renewable energy production. The EU's electricity market reform should aim to incentivise investments in renewables while allowing markets to take advantage of low-cost electricity, which supports electrification in end-use sectors.
- **Permitting procedures** should be streamlined and simplified to reduce investment risks and allow for a more rapid deployment of large-scale renewable energy products, while ensuring social and environmental safeguards, taking into account the local environmental carrying capacity.
- **The energy system must be strengthened** to facilitate the integration of high levels of intermittent renewable energy, including through

increased interconnection, flexibility and storage capacities. The Trans-European Networks for Energy (TEN-E) Regulation is an important tool to this end, and should be fully aligned with the EU's climate objectives (see also European Scientific Advisory Board on Climate Change, 2022).
- Small-scale on-site renewables can be deployed in a short time frame and provide direct relief for individual prosumers. Specific measures are recommended at the national level to help vulnerable, low-income households make use of this potential, for example by providing upfront investment support.

**4. The electrification of end-use sectors** is a key lever for both increasing energy efficiency and phasing out the use of fossil fuels in these sectors. In particular, the accelerated deployment of heat pumps is required to reduce (fossil fuel) energy consumption in the buildings and industrial sectors. Both EU and (sub-)national policies should facilitate electrification through the following:

- **Price signals should be aligned** with decarbonisation objectives, including by setting a carbon price directly via emission trading and/or indirectly via energy taxation. In this regard, the Advisory Board welcomes the provisional agreement on strengthening the EU ETS and the introduction of a similar system for buildings and road transport. This should be complemented by a revision of energy taxation frameworks both at the EU level (e.g. the Energy Taxation Directive and an emissions trading scheme for heating fuels) and at the national level, to shift taxes from electricity to fossil fuel energy carriers.
- **The availability of sufficient infrastructure,** such as power grids and charging infrastructure, should be ensured.
- **Low-income households should be supported** with upfront investments.

**5. Where direct electrification is not possible, biogas and green hydrogen are feasible low-carbon alternatives to natural gas.** Their production needs to be further upscaled to ensure sufficient supply in the medium term. Because of high costs and limited supply, the use of biogas and green hydrogen should be prioritised for sectors that have limited alternative mitigation options, such as for the replacement of fossil fuel-based (grey) hydrogen and the production of steel, chemicals and high-temperature heat. Support for the development of the biogas and green hydrogen sectors should be supported at the EU and national levels, for example through investment and infrastructure support, standards and norms (e.g. minimum quota for green hydrogen use in specific sectors or for anaerobic digestion of animal waste treatment).

**6. Vulnerable consumers — including low-income households and economic sectors struggling to survive because of current high energy prices — should be sufficiently supported, to shield them from energy poverty and ensure that they remain competitive:**

- Direct income support is the preferable approach, as it does not distort the price signal and therefore maintains the strongest incentive for energy savings. Such support should be as targeted as possible to ensure that support can be sustained for as long as necessary within a context of constrained public budgets.
- Using (semi-)targeted price reductions — such as social tariffs or a block tariffs — is a second-best solution, as the reductions distort the marginal price to only a limited degree and therefore maintain a certain incentive for energy savings, while limiting the strains on the public budget. Such an approach can provide a second-best alternative if direct income support is considered too complex to implement correctly.
- Non-targeted price interventions such as overall price caps/subsidies distort the price signal and are costly, ineffective and potentially

counterproductive. Therefore, non-targeted price interventions should be avoided.

- Support schemes for non-households should be designed to maintain incentives to limit consumption or to switch to renewables, for example by requiring and rewarding the implementation of energy efficiency measures.
- Overall, support measures should be harmonised at EU level, for example through state aid rules.

## Measures that should be considered with caution

**7. Efforts to diversify gas supply should be compatible with the long-term transition towards climate neutrality.** When considering new investments in gas infrastructure or committing to long-term contracts, a careful balance should be made between security of supply objectives in the short to medium term with climate objectives and avoiding the risk of lock-ins to future gas consumption in the longer term. Preference should be given to sources with the lowest upstream climate impacts.

8. Biomass can replace fossil fuels and reduce GHG emissions provided that it is sourced from sustainable sources and any land use-related emissions from its production are accounted elsewhere. However, the total available amount of sustainable biomass is limited and it will have to be shared among multiple purposes, including construction material and chemical feedstock. **Therefore, the use of biomass as an energy source should be limited to sustainable biomass that does not have a higher added value (following the cascade principle) and prioritised for sectors with limited alternatives to fossil fuel replacement,** such as certain industrial processes and bunker fuels. Sustainable sourcing needs to be rigorously monitored to avoid the risk of unsustainable harvesting of woody biomass and depletion of soil carbon stock.

**Policy makers should not incentivise the production and consumption of biofuels if this implies a risk of competition with food products,** which could therefore exacerbate the observed increase of food prices.

## Measures that are not recommended

9. The shift from natural gas to other fossil fuels such as coal has provided some short-term relief from energy supply constraints. However, **the increased use of coal and oil should be strictly limited in time and phased out as soon as possible.** Investments in new coal or oil infrastructure are incompatible with the EU's climate objectives and should therefore be avoided. This includes any activities to explore or extract new sources of these fuels.

# Glossary

| | |
|---|---|
| Advisory Board | The European Scientific Advisory Board on Climate Change, as established by the EU Climate Law |
| Block tariffs | An approach under which energy consumers pay different prices per 'block' or 'tranche' of energy consumption. In the context of this document, block tariffs refer to an approach where energy consumers can use a base amount of energy to meet their basic needs at a regulated price below the market price, with any consumption above this basic amount priced at the market price |
| First-generation biofuels | Biofuels made from edible energy crops, such as sugar-, starch- or oil-based crops |
| Low-carbon energy | Energy that causes low to zero greenhouse gas (GHG) emissions throughout its life cycle. Low-carbon energy includes renewable and nuclear energy technologies. Fossil fuels are not included unless lifecycle emissions are almost fully abated by carbon capture technology. Biomass and hydrogen-based energy is included if GHG emissions are low to zero throughout its life cycle |
| Second-generation biofuels | Biofuels made from non-edible, lignocellulosic crops |
| Sustainable biomass | Biomass that is produced and consumed in a sustainable manner. This includes compliance with the sustainability criteria set out in the Renewable Energy Directive |
| Third-generation biofuels | Biofuels made from algae, biomass waste streams and other feedstocks listed in part A of Annex IX to the Renewable Energy Directive |

# Abbreviations

| | |
|---|---|
| COVID-19 | coronavirus disease 2019 |
| EU ETS | EU Emissions Trading System |
| GHG | greenhouse gas |
| IEA | International Energy Agency |
| LNG | liquified natural gas |
| MSR | Market Stability Reserve |
| TTF | Title Transfer Facility |
| VAT | value added tax |

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