November 2022

Tracking EU CO_2: Emissions and coal use are now falling, after a 16-month rebound

Key findings

EU CO_2 emissions from the energy sector have fallen year-on-year in July to October, after climbing for 16 months straight, based on CREA analysis for Carbon Brief. This ends the rebound in emissions from COVID-19 lows that started in the summer of 2020. From February 2021 until June 2022, emissions increased year-on-year every month, as energy demand recovered. In the power sector, CO_2 emissions increased because of the underperformance of nuclear and hydropower plants, together with increased electricity demand for cooling during this summer's heat waves. These factors led to increased demand for power generation from fossil fuels to cover the shortfall.

Contrary to common perception, the increase in emissions was not the result of the energy crisis. Instead, the data shows that the increase in fossil fuel demand happened due to unrelated reasons at the worst possible time, compounding the supply crunch and worsening the energy crisis.

The increase in CO_2 emissions has now reversed, the main reasons being:

- High fossil fuel prices are affecting the demand for oil, and have suppressed gas demand, particularly in households and the industrial sector. The demand reduction is realized in part through energy saving and energy efficiency measures, and in part through suspension of industrial production which is a drag on the economy.

- Growth in solar power capacity has delivered substantial additional generation.

- The factors that drove emissions increases in the power sector are abating. Hydropower generation is now closer to historical averages, and the fall in nuclear power generation has been arrested. Nuclear generation should recover further as France's EdF brings reactors under maintenance back online. Germany's decision to extend the operation of the three remaining reactors will also ease the situation.

The current reverse in emissions further suggests that EU CO_2 emissions likely have peaked below pre-COVID levels. While this is good news for the climate, much faster emissions reductions are needed for the EU's emissions pathway to align with the Paris Agreement goals.

The effects of the fossil fuel crisis are going to accelerate the EU's emissions reductions trend. EU markets have responded to the energy crisis with a surge in clean energy investments, as well as sales of heat pumps and electrical vehicles. Governments are simultaneously raising their ambitions on the transition to low-carbon energy, boosting these market outcomes further. These events will have lasting effects beyond the current crisis, and contribute to driving fossil fuel use and CO_2 emissions in the EU down over the coming years.

CREA has launched a near-real-time tracker of EU CO_2 emissions that will support evidence-based debate on Europe's energy transition.

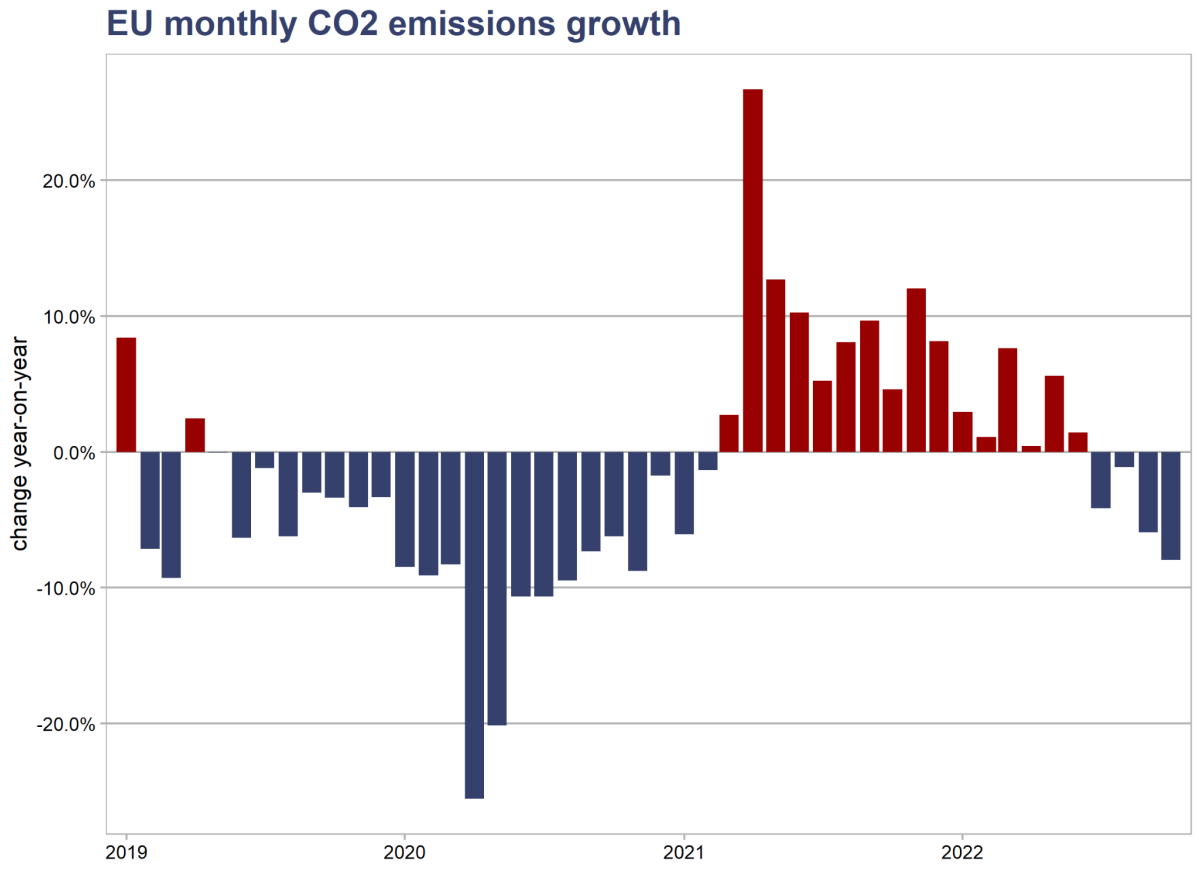

Figure 1: *Year-on-year changes in the EU's monthly CO_2 emissions, showing the falling trend before the onset of the COVID-19 pandemic, the steep drop in 2020 and the rebound lasting from February 2021 until June 2022, with emissions falling since then. Source: CREA real-time tracker.*

Table of contents

November 2022

The causes of the rebound in EU CO_2 emissions and the energy crisis

Why did CO_2 emissions rise

Rising CO_2 emissions in Europe since early 2021 were caused by increasing demand for energy coinciding with a shortage in supply of nuclear and hydropower. Demand was driven by Europe's rebound from low energy consumption during the COVID-19 pandemic, and it increased further with high cooling needs during the heatwaves of summer 2022. Supply of CO_2-free energy was simultaneously low as this summer's heatwave and scarce precipitation caused low levels of hydropower generation at a time when much of France's nuclear fleet was under maintenance. The electricity system responded to the shortfall by temporarily increasing generation of fossil power.

2022 has seen a significant drop in nuclear power generation in Europe compared to 2021. From January to September 2022, Europe produced 84 TWh less than in the same period in 2021. 70% of this reduction is explained by maintenance on 12 out of 56 of France's nuclear plants, while 29% is explained by Germany shutting down three reactors at the end of 2021. French nuclear power generation is expected to decline by 17–22% in 2022 compared to previous years, landing on 280–300 TWh, much less than the 361 TWh generated in 2021. This has dramatic effects on European electricity supply as France, usually Europe's largest exporter of electricity, has become a net importer. This situation is however set to improve, as reactors with a capacity of around 15–20 GW, that are not operational today, are expected back in operation by early January 2023. Germany has further decided to extend the operation of its three remaining reactors to April 2023, which will also ease the situation over the winter.

This decline in nuclear power generation coincided with a 24% fall year-on-year in EU hydropower output in the January-October period. Falling hydropower generation was caused by water scarcity, drought, and heat waves across Europe. In July 2022, Spain saw water reservoir levels down 31% compared to the 10-year average. In Portugal, the levels were just 50% of the average over the last seven years, and the Po River basin in Italy faced the highest level on its scale of drought severity. Falling power generation across Mediterranean Europe was further exacerbated by low reservoir levels and weak hydropower production in other regions of Europe, including Norway, Romania, Montenegro and Bulgaria.

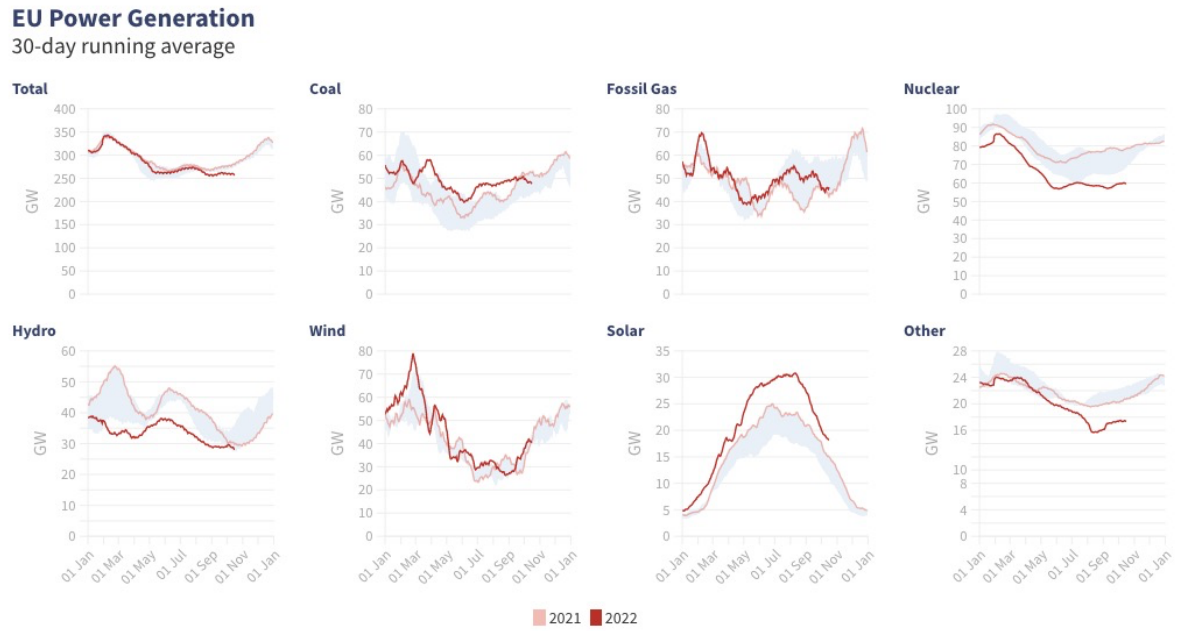

Figure 2: *Development of EU power generation by source in 2022, compared to 2021, with the range of values in 2016–2021 shown in light blue. Source: ENTSO-E Transparency Platform.*

Widespread media narratives linking rising emissions to the fossil fuel crisis are thus false. The increase in coal and gas-fired power generation is a mechanistic result of the weak hydropower and nuclear output at a time when European electricity demand was rising. Skyrocketing fossil fuel costs are dissuading, rather than incentivizing the use of fossil fuels, as seen in reductions in energy demand and increases in investments in clean energy.

Russia's gas blackmail and post-COVID-19 demand rebound caused the current fossil fuel crisis

The current fossil fuel crunch started in the summer of 2021 when Russia began choking the gas supply to Europe, just as demand was rebounding from COVID-19 lows.

In the period of January to September 2021, Russia delivered 67 TWh less gas than the 2016–2020 average for the same months. This contributed to Europe only having 690 TWh of gas in storage per mid-December 2021, which is the level usually seen first in the latter half of January. Gas deliveries from Russia from January to September 2022 were 490 TWh less than in 2021, a reduction of 45%. In addition, the EU started the year with gas storages already partially depleted, with 20% less gas in storage than earlier years, a shortfall of 200 TWh.

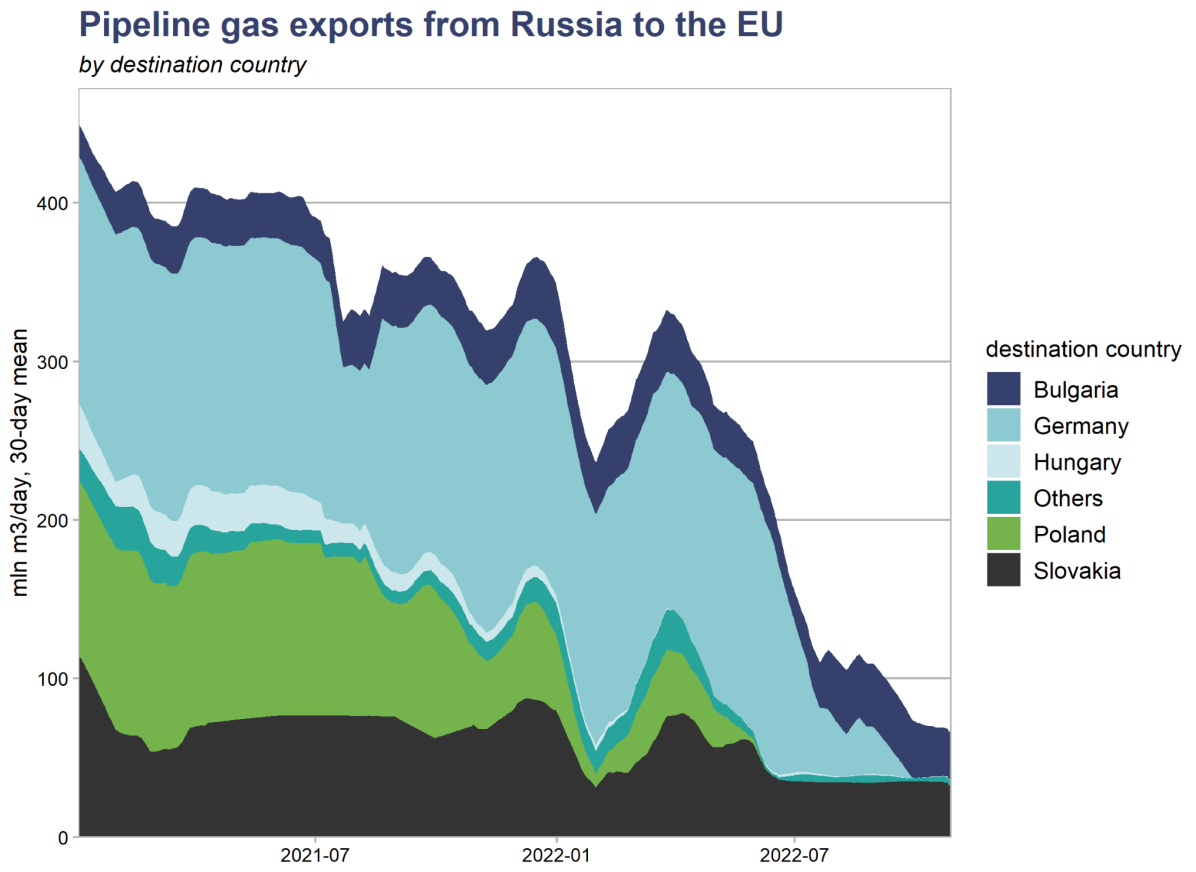

Figure 3: *Russia's yearlong plan to strangle Europe's gas supply. Exports started falling in summer 2021, and even more significantly in January 2022, ahead of the invasion of Ukraine. Source: ENTSOG crossborder flows data.*

Just as Russia was slashing exports to Europe, China experienced a shortfall in domestic coal production, which drove up imports and prices in autumn 2021 and contributed to the onset of the fossil fuel crisis. In September 2021, Chinese imports of coal jumped by 76% while gas imports also rose 22% year-on-year. However, in 2022, China's fossil fuel consumption and imports have been falling precipitously, providing substantial relief to the tight market.

Although the surge in China's coal and gas imports in late 2021 was unrelated to Russia's gas blackmail, it coincided with the cutback in Russian supply and thereby contributed to the fossil fuel price crisis.

Germany's bet on gas and European vulnerability

Many of the reasons for the European Union's vulnerability to Russia's gas blackmail are evident in the energy policy and energy system of Germany, the Union's largest economy and energy consumer. Over the past decade, Germany's energy mix has seen a shift away from coal and

nuclear energy, and a shift towards renewables and gas. The country's Energiewende energy plan counted on gas as a "transition" fuel while coal and nuclear were being phased out. As Russia invaded Ukraine, the country was on the brink of opening up the Nord Stream 2 pipeline, doubling the gas import capacity directly from Russia.

Germany did see a shift away from power generated by nuclear and coal in the 2010 to 2021 period, but it simultaneously saw rising power generation from gas. Power generation from nuclear fell by 51% (72 TWh), coal power fell by 40% (100 TWh), while gas power rose by 46% (28 TWh) and renewable power generation rose by 160% (130 TWh). The choice of moving away from nuclear energy and increasing gas use has contributed to Germany's and — by interconnection of power markets — Europe's vulnerability vis-a-vis Putin's gas blackmail.

Power generation from gas increased because the expansion of renewable energy fell short of filling the gap left by nuclear and coal. Wind power installations, in particular, stalled due to a number of obstacles in the years since 2015. Had Germany followed the European trend in wind power installations after 2015, the country would have been able to generate an additional 87 TWh of power in 2022; enough to reverse the increase in gas-fired generation since 2010, or to substitute three months worth of Nord Stream 1 pipeline gas deliveries. In addition, Germany removed three nuclear power plants from the grid on New Year's Eve 2021, making the country even more reliant on Russian gas.

Recent events have however shaken Germany's perception of gas. The country is therefore planning to boost the electrification of the heating sector to rapidly reduce the use of gas boilers, and is extending the lifetime of three nuclear power plants. These measures will make the energy systems of Germany and Europe less vulnerable to fossil fuel supply disruptions, while also reducing the continent's CO_2 emissions.

Why emissions are now falling

The underlying factors behind the fall in Europe's CO_2 emissions vary from sector to sector.

In the power sector, CO_2 emissions started declining year-on-year since early September, after rising year-on-year for every month between March 2021 and August 2022. The main driver is strong solar and wind power generation, increasing 58 TWh (16%) compared to 2021, thanks to record-breaking solar installation volumes in 2021. In September-October, hydropower generation normalized and good wind conditions provided relief. The fall in nuclear power generation was arrested. These factors have contributed to turning monthly increases in year-on-year power sector CO_2 emissions into decline.

Outside the power sector, demand for gas and oil have also felt pressure due to high prices. Gas demand initially rebounded in the first half of 2021, but as gas prices shot up in the autumn of 2021, gas consumption started falling. In January to September 2022, gas consumption outside the

power sector contracted 360 TWh (15%) year-on-year, while gas use in the power sector increased by 40 TWh (6%). Similarly, oil demand initially continued its rebound from COVID-19 lows with a 220 TWh (7%) increase in consumption year-on-year in the first half of 2022, but has since been tapering as high oil prices put pressure on demand.

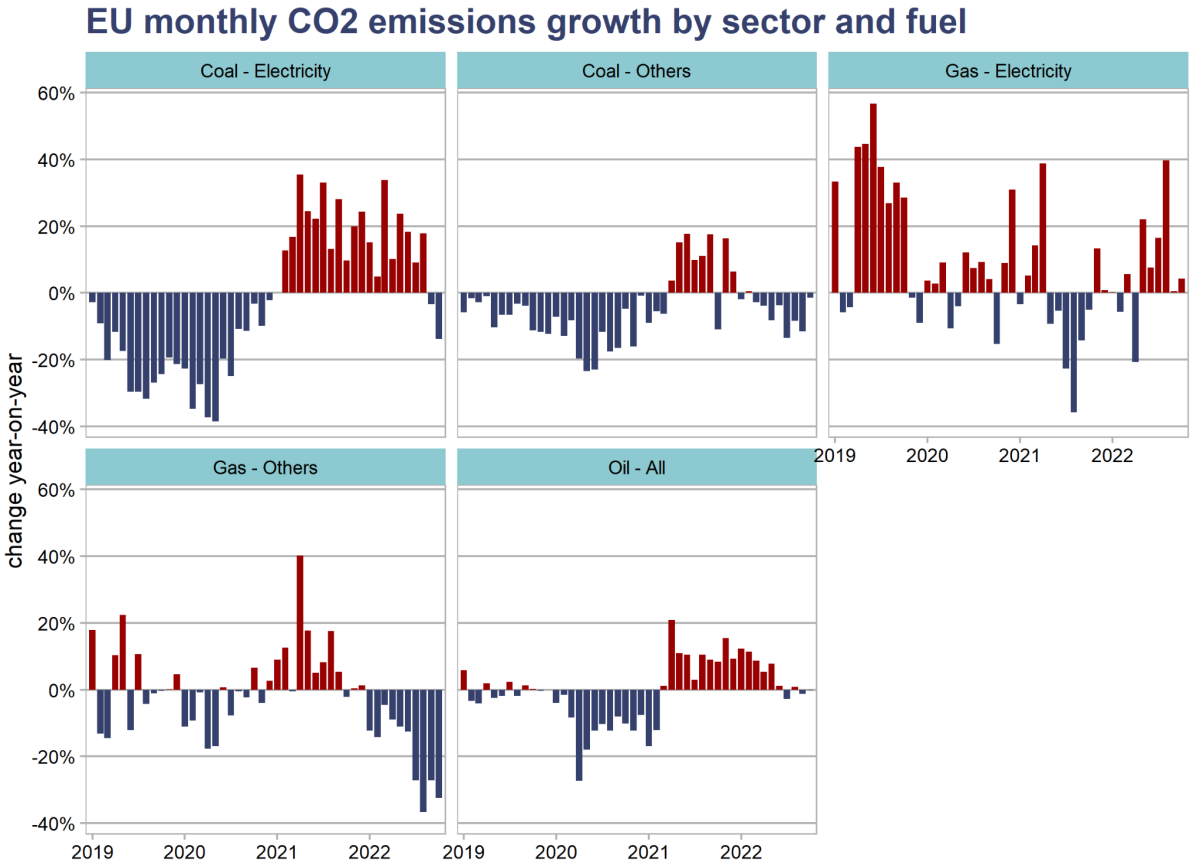

Figure 4: *Year-on-year changes in the EU's monthly CO_2 emissions by sector and fuel, until October 2022. The graphs show the steep fall and rebound in coal, oil and gas consumption, both in the power sector and in other sectors. The rebound in gas use outside the power sector ended in autumn 2021, in oil consumption in summer 2022, and in coal use for power generation only in September 2022. Source: CREA real-time tracker.*

Misconceptions regarding EU CO_2 emission trends

Importantly, neither the fall in power generation from coal or gas, nor the fall in gas consumption by industry and households, can be accounted for by the weather. The fall started in September, when EU total heating needs were higher than in 2021. We measure this using "heating degree-days", the sum of the difference between daily average temperatures and the threshold of

15 degrees Celsius, when temperatures are below this threshold. Cooling degree-days, correspondingly, are days with temperatures above 24 degrees Celsius. The population-weighted heating load for the entire EU is a very good predictor of energy demand: we can account for 80% of the day-to-day variation in gas consumption and 70% of the variation in electricity consumption using the heating and cooling degree days as the predictor.

Neither can the increase in power sector emissions or coal use in 2021 or 2022 be accounted for by policy decisions favorable to coal, such as the extension of the lifetime of coal plants slated to retire. There was no shift in the fuel mix of thermal power generation, even when thermal power generation as a whole was increasing. When more electricity had to be generated using thermal power plants to make up for the shortfall in hydropower and nuclear power, generation from coal and gas increased in the same proportion, with no discernible shift from gas to coal. In September and October, power generation from gas still increased year-on-year, albeit at a lower rate, while power generated from coal dropped, meaning that there was a shift away from coal. If the increase in coal use was driven by policies favoring coal, as has been repeatedly suggested, we should have seen a marked change in the fuel mix.

While steps to prolong the life of coal plants or re-open mothballed plants garnered a lot of attention, the actual impact of energy relief packages introduced by EU countries has been to direct tens of billions of euros to in effect support gas consumption. The most important example are the “gas price caps” for thermal power plants in Spain and Portugal. They involve the government covering the difference between the market price for gas and a guaranteed price ceiling, increasing the ability of utilities to purchase gas, counteracting the economic incentive to shift from gas to coal. These policies help explain why there hasn’t been more of a shift. Many other countries, including Germany, have subsidized gas consumption by households, and are preparing even more aggressive subsidies. These policies are far more impactful than the steps taken to support power generation from coal.

Again, it is clear that increasing CO_2 emissions were not the result of the fossil fuel crisis or political strategies to cope with it. Rather, EU countries saw increased power generation from fossil fuels at the worst possible time as a consequence of factors unrelated to Putin’s war in Ukraine.

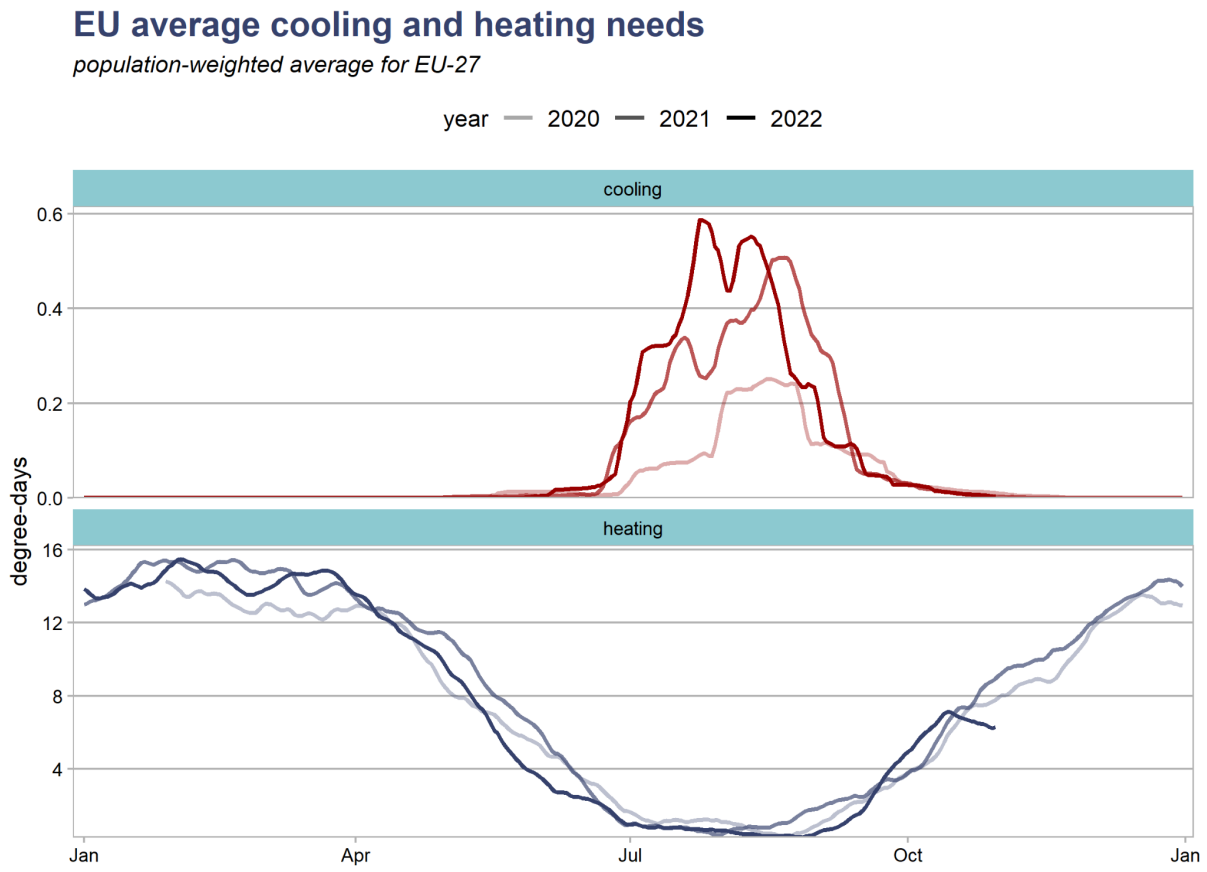

Figure 5: *Cooling and heating needs across Europe, 4-week mean. Heating needs in September 2022 were higher than in 2021, so the reduction in electricity and gas demand cannot be accounted for by temperatures. In October, unseasonally low heating needs have compounded the trend. The graph also shows the dramatic increase in cooling needs this summer, compared with 2021. Heating degrees are degrees below 15°C, and cooling degrees are degrees above 24°C. Gridded daily mean temperatures are taken from the NCEP Climate Forecast System, and population-weighted averages are calculated using the Gridded Population of the World from CIESIN.*

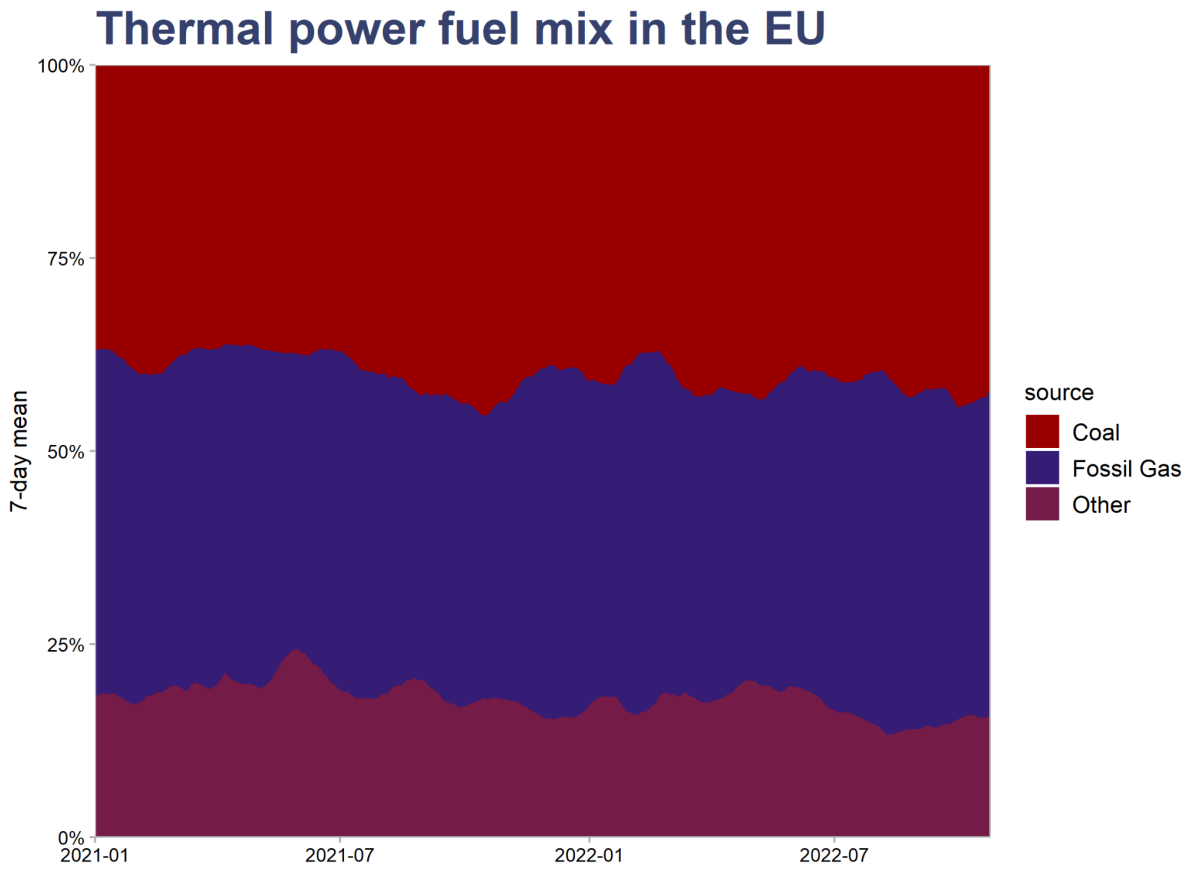

Figure 6: *Thermal power generation by fuel. Contrary to widespread beliefs, there is no discernible shift from gas to coal. Data source: ENTSO-E Transparency Platform.*

The energy crisis is accelerating the energy transition

The market response

The security of supply implications of the fossil fuel crisis and the price implications of the broader energy crisis have resulted in forceful responses, both from energy markets and policymakers. Some of these responses may be observed as the spectacular growth in solar power, heat pump installations, as well as electric vehicle sales.

SolarPower Europe projects that nearly 40 GW of solar PV capacity will be rolled out in Europe in 2022. This would be a 45% gain compared to 2021 which itself broke a decade-long record in capacity installations. Solar is becoming an important source of energy in Europe, generating a record 12% (99.4 TWh) of EU electricity from May to August 2022, up 9% from the 77.7 TWh

generated last summer. Thereby, solar power generation is just 4% points behind coal which currently produces 16% of the EU's electricity.

The boom in solar power generation is widely spread across the Union, with 18 of 27 EU countries breaking their former records in solar power generation as a share of total electricity generation this summer. This is the result of multiple years of investment in solar, like Poland's 26-fold increase in solar power capacity since 2018 and Hungary's and Finland's 5-fold expansions in the same period.

Europe's installed solar power capacity was sufficient to substitute 210 TWh of fossil gas from May through August, the equivalent of 44% of the imports from Russia over that period in 2021. These imports would otherwise have cost the Union EUR 29 billion, and increased its vulnerability to Russian gas cuts. However, while solar is seeing a boom that raises the resilience of the European energy system, wind power is still being held up by restrictions and slow permitting processes in many countries despite the economics of wind power being highly favorable.

Even with high electricity prices, high and volatile prices for gasoline and diesel have made electric vehicles much more competitive and their sales volumes have increased since the beginning of the war. In the second quarter of 2022, which is the first full quarter after the war began, the sales of passenger EVs in Europe increased by 16% year-on-year. This comes on top of a 70% increase in 2021. In some markets, including the Netherlands, Sweden, and Norway, EVs already had a market share exceeding 50%, becoming the default option for new car buyers. In Norway, their share hit 85% of all passenger cars in the second quarter of 2022.

Building owners are also scrambling to install heat pumps to reduce their energy consumption and reliance on gas in heating. This is mirrored in the European Heat Pump Association's projection of a 30% increase in heat pump sales in 2022 compared to 2021 which itself saw a growth of 35%. Some of this growth is already apparent in Germany, where high gas prices have increased heat pump deliveries by 25% in the first half of 2022.

While reduction in gas use has been the main driver behind the recent fall in EU CO_2 emissions, the high prices are also incentivizing the construction of gas supply infrastructure. There is therefore a risk that as more supply becomes available, first through floating LNG terminals and in a few years through onshore terminals, excess supply could be locked in. Current investments in heat pumps, clean energy, energy efficiency in buildings, and a deliberate focus on replacing fossil in the energy mix will however contribute to limiting the scale of any "return of gas". States must be careful in their scramble for LNG contracts in the short term, to avoid getting locked into more supply contracts than needed in a few years' time. The negative prices for gas seen in late October were a prelude for this.

The policy response

Supporting the market reaction is a host of EU and national policies promoting clean energy. The REPowerEU plan launched in May 2022 envisions that 45% of the EU's energy mix in 2030 will consist of renewable energy, up from 40% in the earlier Fit-for-55 plan. This includes all uses of energy spanning from heating, transportation, industry, as well as electricity. Reaching the target will require the EU to install a total capacity of 1,236 GW of wind and solar by 2030, which is 16% higher than the 1,067 GW envisaged in the Fit for 55 strategy.

A report by Ember and CREA shows that the EU's heightened ambition is supported by accelerated decarbonization plans in most EU member states. By June 2022, 19 governments had already announced plans to accelerate the green shift in response to the COVID-19 pandemic and Russia's threat to their energy supply and security. In the power sector, these plans are set to deliver an 82% share of non-fossil energy sources in EU power generation by 2030, which is a substantial increase from the share of 74% projected following plans in place at the end of 2019.

Overcoming bottlenecks that have suppressed wind power expansion in Europe is key to realizing these goals, and EU governments have announced plans to do so. One example is the "Wind-on-Land-Act" launched by the German government which seeks to overcome hurdles that have slowed the expansion of German wind power capacity over the past years. The act will allow wind power installation on 2% of Germany's land area, and seeks to install 10 GW of onshore wind power capacity annually - almost five times more than the average installation over the years 2018-2021. Another example includes the agreement between eight EU countries bordering the Baltic Sea on increasing offshore wind power capacity seven-fold by 2030 to reduce their dependence on Russian energy. Such measures will contribute to a more energy secure Europe with less dependence on CO_2 emitting fuels and their insecure value chains.

Simultaneously, the EU and its member states are boosting their targets for energy efficiency and energy savings to directly cut the need for Russian gas. On the EU level, this includes heightening its energy consumption reduction target from 9% to 13%, meaning that the EU will cut its energy use by an additional 4% points by 2030 compared to the reference scenario. This target is complemented by several measures, including increasing the energy efficiency of buildings and installing 10 million new heat pumps in European households within the next five years. The German government has already embraced this approach, and has called upon the heat pump industry to ramp up production capacity to aid Germany to install 500,000 new units yearly from 2024.

As these policies bear fruit in the future, Europe will become more energy secure than ever and accelerate its journey towards a net-zero future.

Policy Recommendations

- Implement short-term energy-saving measures to balance supply and demand at lower price levels. These measures could include lowering indoor temperatures in public buildings, offering cash incentives to consumers to reduce consumption, and rationing gas to industrial users (rather than using prices to do that).

- To address the cost-of-living crisis, support the incomes of vulnerable groups instead of supporting fossil fuel consumption directly through subsidies or price caps, which simply drives up prices and creates a risk of physical shortages.

- To address the root cause of the crisis, fossil fuel dependence, governments must accelerate energy-saving measures, particularly targeting oil and gas consumption, and accelerate the deployment of clean energy, heat pumps, electric vehicles, and other technologies that can replace fossil fuels.

About CREA

The Centre for Research on Energy and Clean Air (CREA) is an independent research organisation focused on revealing the trends, causes, and health impacts, as well as the solutions to air pollution. CREA was founded in December 2019 in Helsinki and has staff in several Asian and European countries. The organisation's work is funded through philanthropic grants and revenue from commissioned research.

www.energyandcleanair.org

Methodology

The analysis of the EU's CO_2 emissions trends is based on CREA's near-real-time emissions tracker.

We track daily power generation data from the transparency platform of ENTSO-E, the European power grid operator. Emissions are estimated from power output based on average emissions from coal and gas-fired generation by country. These are derived by aligning the daily power generation data with earlier Eurostat monthly data on hard coal, lignite and gas use for power generation.

Gas consumption is obtained from daily data on gas flows from ENTSOG, the European gas network operator. We calculate "apparent consumption", which is the residual of imports from outside the EU, domestic production and flows into and out of storage.

For total oil consumption and for coal consumption outside the power sector, we extend the latest monthly data for each country, based on the average deviation from the 2019–2021 average in the past three months. For oil, consumption is based on observed gross inland deliveries, a measure of implied oil consumption based on refinery output, imports, exports and stock changes, as well as deliveries of crude oil and natural gas liquids to non-refinery users, along with several smaller flows (see full definition). For coal, usage is based on final consumption reported by (industrial) users and sales to residential and commercial consumers reported by sellers. Currently, data is available for most countries until the end of August 2022.

CO_2 emissions are estimated from data on fuel consumption, using the Intergovernmental Panel on Climate Change (IPCC) default emissions factors.