Renewable energy

EU renewable electricity has reduced environmental pressures; targeted actions help further reduce impacts

We need to invest in a green recovery to restart the economy. The European Green Deal puts climate change mitigation at the core of its efforts to recover sustainably from the COVID-19 crisis. Renewable electricity could increase to 70% of all power generation by 2030 to allow a net 55% reduction in greenhouse gas emissions by 2050. Despite multiple benefits for human health and the environment associated with the reduction in fossil fuel use for energy, increasing renewable power supply is not impact free. Concerns have been raised that renewable electricity could shift environmental burdens in ways that do not always lower overall pressures. This briefing investigates changes in the electricity mix since 2005, and their trade-offs from a life cycle perspective to help policymakers and individuals focus on areas that offer opportunities for improvement.

Key messages

The growth in renewable electricity generation across the EU since 2005 is likely to have decreased global pressures linked to climate change, acidification, eutrophication and particulate matter formation.

Renewable electricity generation has doubled since 2005, but the EU's stepping up of climate ambitions requires its power sector to decarbonise faster.

Targeted actions can help minimise some adverse effects of this transition, in particular those regarding freshwater ecotoxicity and land occupation.

Actions could focus on reducing impacts linked to material sourcing and to production processes across various supply chains (e.g. for solar photovoltaic modules and biomass fuels), along with improvements in energy and resource efficiency.

As renewable electricity projects are set to grow, assessing other potential trade-offs, such as those affecting habitats and ecosystems, will be essential to contain future impacts.

Context

In 2019, the EU-wide share of renewable energy was less than half a percentage point below the binding 20% target for 2020 (EEA, 2020a, 2020d, Eurostat 2021). At 34% of all electricity generation, renewable electricity has almost doubled since 2005, and coal no longer supplies most of the EU's electricity. However, **fossil fuels** still **produce most electricity** altogether (38% of all generation in 2019). With combustion-based installations dominating the power mix, the EU electricity sector gives rise to almost a quarter of all EU greenhouse gas emissions. It also remains an important source of acidification, eutrophication and ground-level ozone formation (EEA, 2020b).

Renewable electricity plays a leading role in Europe’s decarbonisation strategy, but it is **not impact free**

Offering the potential for rapid expansion, renewable electricity plays a leading role in Europe’s decarbonisation strategy (EC, 2020a, 2020b, 2020d). Except for biomass and the biodegradable fraction of waste, renewable power sources have negligible emissions during generation. But, even so, increasing the renewable power supply is not impact free, because constructing renewable power generation components and plants is both material and energy intensive. That leads to specific upstream and downstream emissions and impacts, while new infrastructure can affect vulnerable habitats.

Going beyond climate mitigation, a detailed life cycle analysis was undertaken to calculate global changes in overall environmental impacts associated with the trends in the EU power mix between 2005 and 2018, especially given the shift towards increasing shares of renewable electricity generation. The aim was to estimate how key environmental impacts had changed by 2018, thanks to the increase of renewable sources in the electricity supply across the EU, relative to the benchmark year 2005.

Officially reported annual generation data for 16 main renewable and conventional power technologies in each Member State and at EU level were used to provide insights on six essential environmental impact categories:

1. climate change;
2. freshwater eutrophication;
3. particulate matter formation;
4. terrestrial acidification;
5. freshwater ecotoxicity; and
6. land occupation.

By looking at both upstream and downstream parts of the value chain, life cycle analysis can also highlight interactions between domestic measures and global pressures because of the growing complexity of international trade.

Growth in renewable electricity generation has significantly reduced key environmental pressures, but challenges remain

Unsurprisingly, the results show that, in 2018, annual life cycle **impacts** continued to be **dominated by electricity production from coal** combustion, followed by emissions from natural gas and oil burning (Figure 1). Since combustion-related emissions affect many categories [1], the impact intensity of fossil fuel electricity generation is significantly larger than that of renewable power.

At the EU level, switching from fossil to renewable electricity has resulted in clear **improvements** across most impact categories, except for ecotoxicity- and land occupation-related impacts

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Compared with 2005, the increase in renewable electricity generation by 2018 had significantly decreased life cycle greenhouse gas emissions at the EU level. In fact, for most of the impact categories investigated, the switch from fossil fuel to renewable electricity sources resulted in clear improvements in 2018, compared with 2005: at the EU level, the life cycle impact potentials of eutrophication, particulate matter formation and acidification were all lower in 2018 than in 2005.

For **freshwater ecotoxicity** and for **land occupation**, however, the life cycle impact intensities are more evenly spread across renewable and non-renewable sources, with the exception of clear outliers such as ecotoxic impact intensities associated with electricity generation from municipal solid waste and land occupation intensities associated with electricity produced from solid biomass.

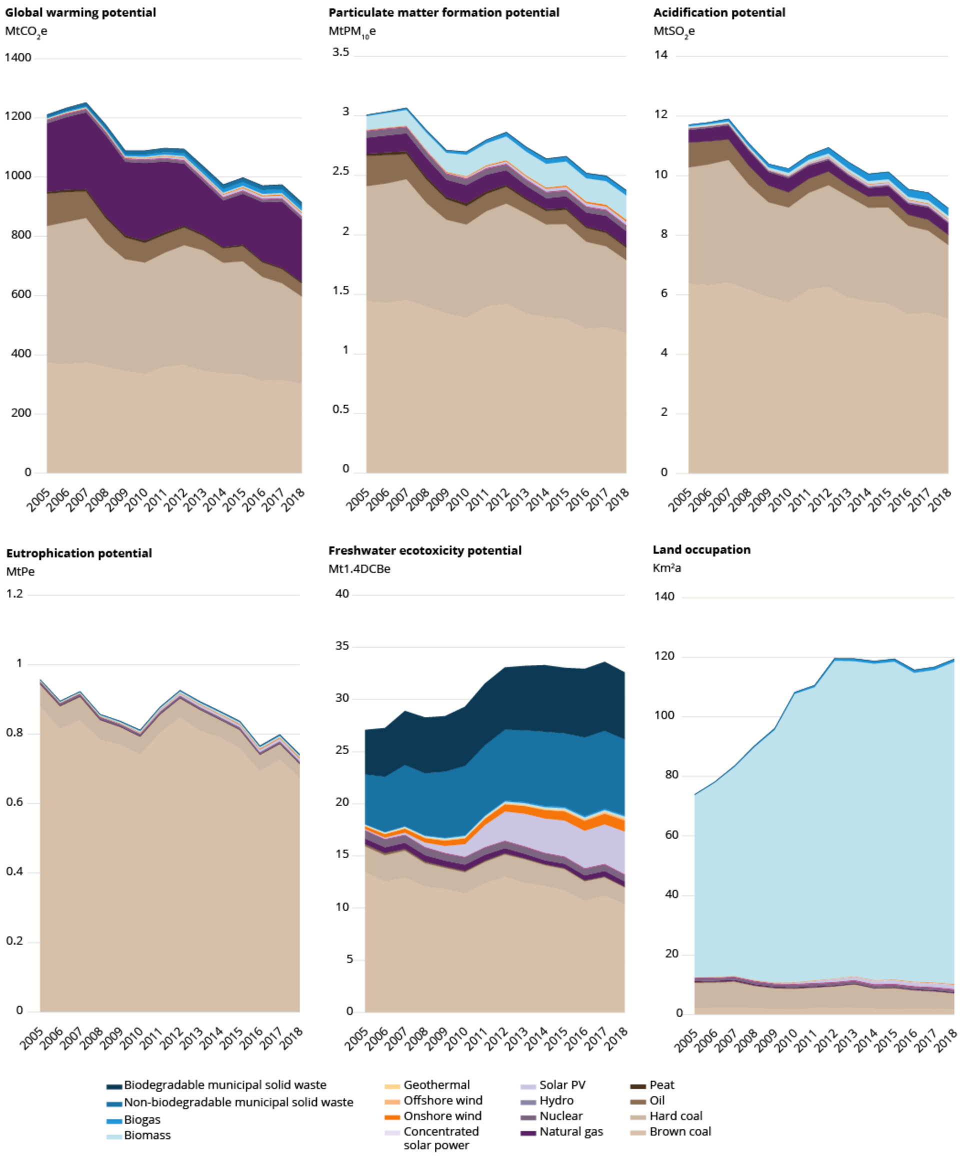
Consequently, the analysis indicates that substituting fossil fuels with a growing share of renewable electricity across the EU has increased impact potentials for freshwater ecotoxicity and land occupation by 2018, compared with 2005.

These findings are in line with the International Resource Panel's landmark study on the benefits, risks and trade-offs of low-carbon technologies for electricity production (UNEP, 2016). That assessment also found that renewable power requires larger amounts of metals and other minerals per unit of electricity generated, while generally having consistently lower environmental impacts than power generated from fossil fuels in nearly all impact categories investigated.

Whereas for freshwater ecotoxicity the potential increase is related to increases in solar photovoltaic (PV) power and in the incineration of biodegradable municipal waste (and to lesser extents to geothermal power), for land occupation the deterioration is associated with increases in biomass use and solar PV power [2]. Small, but noticeable, impacts are also observed for particulate matter formation, related to increased biomass generation. These overall trade-offs are partially compensated for by a simultaneous increase in the contribution of other renewable electricity sources.

Energy

Figure 1. Annual life cycle impacts associated with gross electricity production in the EU



Note: Changes in gross electricity generation are accounted for in the figure (gross electricity generation in 2018 is 1% higher than in 2005). GHG, greenhouse gas.

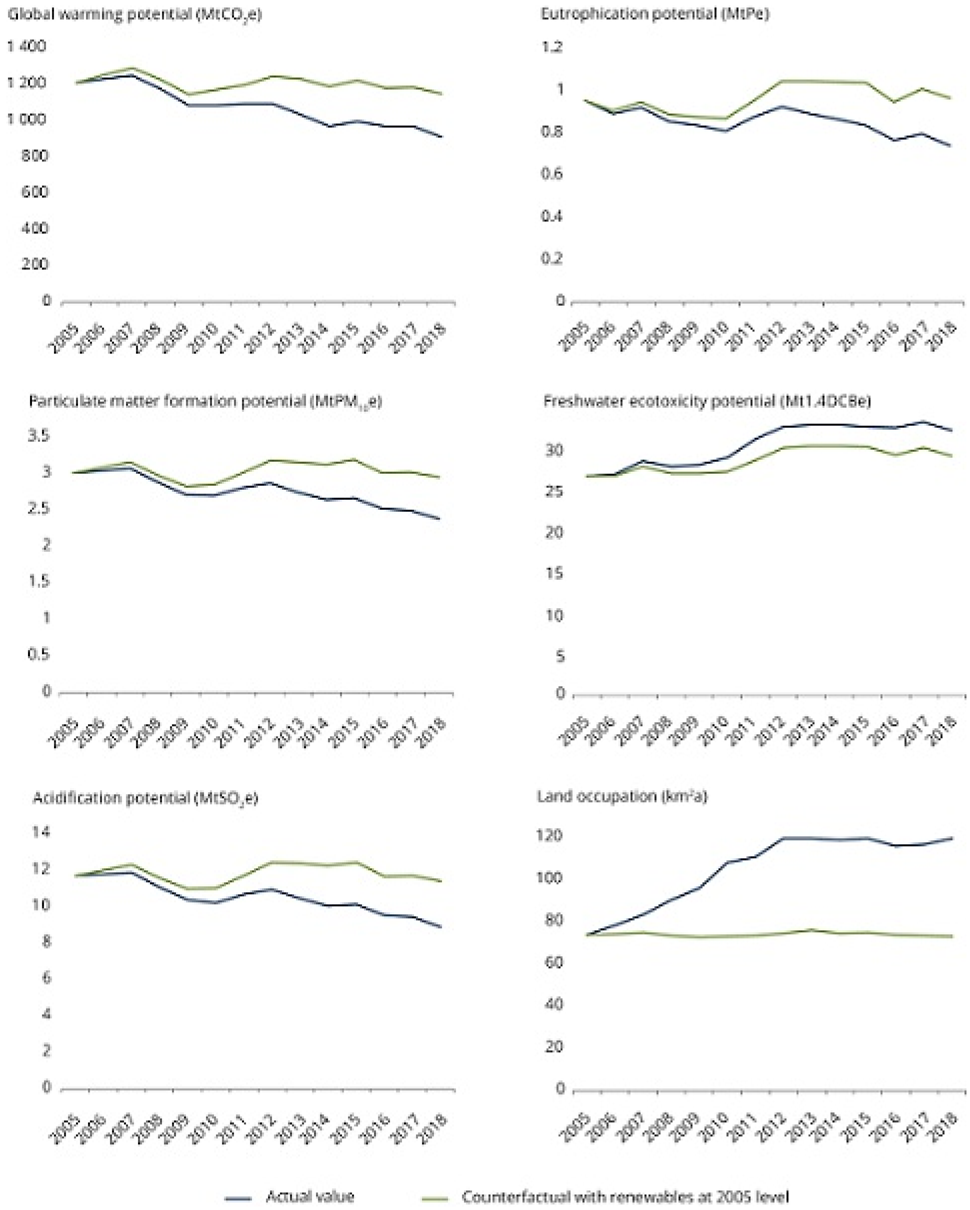
Explore interactive chart

Source: ETC/CME, 2020

These changes came about because of shifts from coal to natural gas and renewables-based generation in most Member States since 2005. Most of the avoided impacts were driven by an increase in electricity generation from onshore wind power and solar PV sources, followed by electricity generation from solid and gaseous biomass fuels. A considerable part of the avoided impacts can be attributed to the **phasing out of hard coal power plants** in favour of renewable and natural gas generation.

The life cycle improvements related to the EU's power supply are especially clear when these estimates are compared with a counterfactual scenario that freezes the share of renewable electricity generation at the 2005 level. In the counterfactual scenario, the growth in renewable power is replaced every year by a mix of conventional sources that changes with the relative annual share of each fossil fuel in the generation mix. The results of this stylised comparison show that the increased use of solar PV and wind power have contributed significantly to reducing life cycle pressures across the impact indicators investigated. One trade-off is that the growth in renewable electricity appears to have increased the potential ecotoxicity- and land occupation-related impacts of Europe's power supply, as shown in Figure 2.

Figure 2. Comparison of trends in key impact categories due to the growth in renewable electricity since 2005



Explore interactive chart
Click here for more information
Source: ETC/CME, 2020

Targeted actions can help minimise some adverse effects of the transition to a renewable power supply

Renewable electricity: good progress for 2020, not enough for 2050

Fully implementing national climate and energy plans for 2030 would allow the EU to overachieve its current climate and renewable energy targets for 2030 (EC, 2020c; EEA, 2020d). Such developments, however, would still be insufficient for the EU to meet a higher target for reducing greenhouse gas emissions, of 55% by 2030, or to achieve climate neutrality by 2050 (EC, 2020d).

To meet these higher pledges, **renewable power should grow** to almost 70% of all EU generation by 2030 and to over 80% by 2050 (EC, 2020a; EEA, 2020c), allowing sectors that are harder to decarbonise to reduce their emissions through electrification. Investments in the renewable electricity supply need to be ramped up to meet those targets and speed up the energy transition. Furthermore, higher carbon prices under the EU Emission Trading Scheme would make renewable power sources more competitive (see also EEA, 2020c).

By substituting more polluting fossil fuels, expanding renewable electricity generation across the EU provides multiple opportunities to improve human health and the environment while mitigating climate change. However, **good monitoring and policy implementation** and potentially other targeted measures will need to accompany these trends to avoid environmental problem shifting, including in areas not addressed by this study. Other critical tools for policymakers will be improvements in cross-sectoral energy and resource efficiency and giving special attention to the planning, design, selection and siting of projects depending on the habitats, species and ecosystems potentially affected.

Identifying key drivers and targeted actions

Several processes and emissions associated with renewable electricity generation lead to high life cycle impacts. However, opportunities to decrease relative and total impact intensities do exist, despite considerable differences in the life cycle impacts of the national electricity supply sectors.

Solar PV has a relatively high impact intensity for ecotoxicity because of the emissions of metal, [3] related to mining and smelting operations, and chlorine from the purification of solar-grade silicon. Reducing the demand for raw materials, e.g. by prioritising better **end-of-life material recovery**, can lower process emissions, bringing down the corresponding life cycle emissions for solar PV power generation. Solar PV power's greenhouse gas impact intensity is also among the highest of all renewable sources across the value chain. Emissions accumulate from a collection of processes, each contributing a little. As the construction of solar PV modules requires both heat and electricity and takes place globally, the cumulative effect leads to relatively high total emissions of greenhouse gases. Increasing the reliance on **renewable energy in manufacturing processes** would help to bring down the emission intensity of solar PV components.

For biodegradable municipal solid waste, almost all ecotoxicity impact potentials arise from the incineration process itself, offering potential opportunities to mitigate impacts by adopting more **advanced abatement technologies**. Similarly, for particulate matter formation linked to biomass fuels, process emission contributions are highest during burning, indicating a potential to install further emission control measures. In addition, focusing efforts on **biomass fuels requiring less land**, such as third-generation biofuels, could considerably reduce the overall high land use intensity associated with the current fuel supply chains.

Generic actions

Demand side management to reduce the need for standby generation during peak consumption, measures to improve **energy and resource efficiency** across end use sectors, and more sustainable, **circular business models** proposed under the circular economy action plan could further reduce some of the potential negative impacts associated with the transition to renewable power supplies, while simultaneously increasing its cost-effectiveness. For non-combustible power sources, measures also include **lifetime extensions** to reduce the emission intensity linked to upstream and downstream processes. Finally, efforts to improve the **design and siting of projects with respect to local conditions and broader ecosystem needs** are essential to reduce adverse trade-offs associated with the energy transition.

Monitoring and further efforts can help avoid environmental **problem shifting.** Efforts should focus on reducing upstream and downstream pressures.

Further research needs

This briefing considers the changes in the EU power sector since 2005 across six key impact categories. Other dimensions that are important to ensure a sustainable transition across the sector were not included in this assessment. Ranging from impacts on terrestrial and aquatic ecosystems (following, for example, changes in land use and in river ecology and morphology) to resource depletion, understanding and addressing these aspects will prove essential to avoid and reduce future impacts, as renewable electricity is set to grow.

Method and data

Life cycle analysis is a quantitative approach for assessing products in terms of their environmental, human health and resource consumption impacts. The method enables a generic assessment of environmental impacts that occur globally across supply chains. The work is based on constant impact factors, leading to impact potentials, which are then compared to identify environmental problem shifting and potential hot spots in value chains. However, the approach should not be confused with assessments based on more detailed estimates of emissions and impacts, e.g. atmospheric dispersion of air pollutant emissions and subsequent impacts on human health. The analysis includes activities related to materials and fuel extraction, transport and refining, the construction of (plant) components and infrastructure, plant operation and end-of-life plant decommissioning.

The briefing draws on the reports:

- A life cycle perspective on the benefits of renewable electricity generation and
- Renewable energy in Europe 2020 — recent growth and knock-on effects.

Information on national renewable energy policies and measures in Europe and on progress to achieving energy targets is also available.

Data on emissions of greenhouse gases and air pollutants are available in dedicated data viewers.

Notes

[1] Combustion processes are a main source of key air pollutant emissions, especially sulphur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide, of particulate matter ($PM_{2.5}$, PM_{10}) and heavy metals (such as mercury, lead and cadmium) and of persistent organic pollutants (in particular hexachlorobenzene and polychlorinated biphenyl). Most of these pollutants are linked to coal combustion.

[2] The contribution of solar PV power to land occupation is due more to indirect and direct land occupation associated with producing polycrystalline silicon and assembling of the PV modules than to the physical space the actual PV modules occupy.

[3] Mainly copper and, to a lesser extent, silver, nickel and zinc.

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