G7 GERMANY
Science 7 Dialogue

Decarbonisation: The Case for Urgent International Action

As part of the 2015 Paris Climate Agreement, 196 countries committed to substantially reduce their greenhouse gas emissions in order to limit global warming. However, announced reduction measures are not at all aligned with the 2°C pathway, much less with the 1.5°C trajectory that is urgently needed to avoid the worst impacts of climate change.[1] The G7 states have contributed to nearly half of global cumulative emissions and currently emit about 25% of annual global carbon dioxide (CO_2) emissions.[2] All main emitters have the obligation to use their economic and technological strength to be the global frontrunners in the effort to achieve the goals of the Paris Agreement.

To accelerate the transition to a world with net zero, even negative, greenhouse gas emissions, immediate action is necessary. Due to relatively long timescales and the profound technological and social change required, it is particularly important to implement and adapt policies now to achieve fossil fuel independence. Energy security and energy system resilience play equally important roles when decarbonising economies and energy systems.

Decarbonisation: Critical Sectors

Electrical Energy

Global efforts to address climate change make it imperative to rapidly electrify many sectors, creating a massive increase in electricity demand. This requires a fundamental transformation of energy systems worldwide and more than ever a focus on renewable energy sources. Moreover, incentives are required in order to retire or retrofit existing facilities. For electricity generation, low and zero carbon technologies are available, such as photovoltaics (PV) and wind energy, which are already cost-competitive in most parts of the world. In the short term, the variable nature of wind and PV may have to be complemented by gas-fired power plants until large scale storage technologies are available in which fossil gas is replaced by CO_2 neutral fuels. Some countries also opt to use nuclear energy in their energy mix as a low carbon technology. Accelerated deployment

1 IPCC, 2022. Summary for Policy Makers. In: *Climate Change 2022: Mitigation of Climate Change. Working Group III Contribution of the IPCC Sixth Assessment Report* [Shukla *et al.* (eds.)], Cambridge University Press.

2 European Commission, Joint Research Centre, Crippa *et al.*, 2020. *Fossil CO_2 and GHG emissions of all world countries: 2020 report.* Publications Office, https://data.europa.eu/doi/10.2760/56420.

of CO_2 neutral power generation facilities across the G7 would allow a phase-out of fossil-fuel technologies. Of utmost priority is the global exit from burning coal in power plants.

As countries vary in terms of their endowment of renewable energy resources, larger-scale power systems across regions and borders are needed. Such broad electric energy markets require large-scale, long-distance energy transport and can operate in tandem with local installations of storage, rooftop and utility scale solar and PV to enhance the penetration of renewable electricity and contribute to sector coupling throughout the system.

Transportation

Near zero carbon technologies are available for many services in the mobility sector. For passenger traffic, battery electric vehicles (BEVs) increasingly enter the market. There is broad expectation that further technological advances will continue with BEVs eventually prevailing in densely populated regions of the world. This will require a substantial expansion of the electricity system and its infrastructure. Alternative solutions are required for less densely populated regions where electrical charging infrastructures could be impractical or too expensive.

For several types of transportation (e.g. aviation, ships, heavy-duty vehicles), battery electricity will likely be more expensive or technically challenging as compared with decarbonisation strategies that rely on e-fuels (from CO_2 and renewable hydrogen), synthetic aviation fuels, ammonia- or hydrogen-powered engines, or hydrogen fuel cells, with supporting infrastructure. Multiple technical and engineering solutions require scaling to the system level within the current and coming decade, including safety issues in the development of hydrogen-based transportation.

Heating and Cooling

Heating and cooling for homes, industry and commercial buildings is one of the major sources of CO_2 emissions as it currently relies mostly on fossil energies. Due to the long lifespan of appliances in buildings and industry, newly added fossil-based heating and cooling systems will lock in emissions for decades.

The combination of efficient insulation and solar and geothermal heating – where geographic location permits – is an alternative which makes direct use of CO_2 neutral energy, in addition to enhanced energy efficiency standards and regulations for the construction of new buildings. Electric heating, preferably by heat pumps, especially where solar thermal heating is not efficient for geographic and economic reasons, is a solution if electricity is generated in a CO_2 neutral manner.

With global warming, increased air conditioning demand for cooling needs to be met. Improved insulation and air conditioners (relying on heat pumps in reverse, driven by renewable electricity) can be used. Most of these technologies are scaled and cost competitive or near-cost competitive.

Industry

A range of decarbonisation challenges exist in heavy industries. Both the metallurgical industries – predominantly steel – and the cement industry are major contributors to greenhouse gas emissions. For steel, hydrogen-based or direct electroreduction processes are alternatives to the blast furnace, but they still have not reached the commercial scale at competitive costs. Metal, glass and concrete recycling is already quite advanced but can still be increased in order to minimise the energy input. Here, quality issues in regaining the essential purities of base materials are limiting factors.

Chemical production is another industrial sector which relies heavily on fossil-based heating energy and raw materials. With higher shares of renewable electricity in the system, electrification and other low carbon heating options can reduce its CO_2 footprint. Plant-based feedstock could replace fossil raw materials. Hydrocarbons produced by Carbon Capture and Utilisation (CCU) technologies could give access to many building blocks of the chemical value chain. However, technological transformations include improvements of and adaptations in chemical production, which require major investments.

Agriculture, Forestry and Land Use

Agriculture, forestry and land use account for just under a quarter of global greenhouse gas emissions.[3] Emissions reductions and sequestration in these sectors are critically important. Livestock and dairy production has a variety of effects on the environment and is a major driver of climate change. Reduced livestock farming, improved fertiliser utilisation as well as technological innovations and regionally adapted farming practices can contribute to sustainable food systems with effects on the climate as well as on soil, water, biodiversity and human health. Moreover, deforestation is the most significant aspect of land use change affecting global warming, turning forests from carbon sinks into carbon sources.

Decarbonisation: Drivers and Obstacles

Where there are low or zero carbon technologies readily available, the main factor inhibiting the transition from greenhouse gas emitting technologies and behaviours has been the economics of adoption in new applications and in retrofitting existing fossil-based infrastructure. However, the calculus is shifting towards renewable energy supply that is increasingly being valued as an essential factor for energy security and independence, local air quality and human health.

Decarbonisation can further be supported through the development and use of energy carriers and synthetic fuels. The use of ‘green' hydrogen[4] based on low carbon and renewable energy sources has the potential to decarbonise sectors which are hard to electrify. Challenges include costs of production, losses during transport and currently low yields in power-to-H_2-to-power scenarios.

3 IPCC, 2022.

4 Green hydrogen has significantly lower carbon emissions than grey hydrogen, which is produced by steam reforming of natural gas.

Across economies, there is no uniform price of CO_2 emissions. The adoption of internationally coordinated minimum carbon prices among the main emitters is needed. This will help adapting institutional and individual behaviours in favour of low carbon production and consumption choices.

Achieving the goals of the Paris Climate Agreement requires negative greenhouse gas emissions. Options include the afforestation and reforestation of depleted land, wetland restoration as well as other nature-based solutions. Further technical approaches are CO_2 capture and use (for long-lived products and in circular energy economies), CO_2 capture and sequestration and direct capture from air and seawater. This emerging toolbox of measures for mitigating climate change will be needed regardless of the progress in the various sectors addressed above.

There still remain fundamental scientific and technological challenges as well as regulatory, scaling and social issues that need to be addressed as we move towards climate neutrality. In all of these endeavours, the G7 states must take a leading role in developing solutions that work both for themselves and for countries in different circumstances around the world.

Recommendations

We call on the G7 governments to provide the following leadership in order to achieve net zero emissions by 2050 or earlier:

(1) Build a carbon neutral and resilient energy system.

- Phase <u>out</u> fossil energy, including especially coal, as well as climate-damaging subsidies.
- Accelerate the complete decarbonisation of the electricity sector.
- Accelerate the electrification of mobility and transportation and associated infrastructure, as well as of heating and cooling.
- Reduce greenhouse gas emissions of hard to abate sectors through:
  - › Energy efficiency, materials efficiency and circularity;
  - › Implementation of alternative fuels, such as e-fuels or ammonia, and hydrogen.
- Develop and deploy negative emission technologies and nature-based solutions.
- Provide mechanisms to deal with intermittency by developing dispatchable electricity solutions for periods of low supply from renewable energy, such as storage or reconversion, demand side management and efficacy, and grid extension across national borders as well as smart grids. Market rules and pricing systems to encourage trade and supply resources are needed.
- Ensure energy security by mitigating potential supply disruptions and diversifying supply to increase system resilience.

(2) Strengthen international cooperation towards a just energy transition worldwide.

- Develop international trading systems for renewable energy as a blueprint for widespread implementation beyond the G7. Start with agreements on standardisation and certification of CO_2 load and provenance of energy carriers.
- Reinforce decarbonisation efforts by establishing a global CO_2 pricing mechanism, complemented by more direct and fast-acting measures.
- Promote climate alliances (such as a global and cooperative climate club) and partnerships to coordinate climate action and deliver on global climate finance promises.
- Ensure appropriate solutions are available globally.

(3) Strengthen climate literacy and citizen involvement.

- Help people around the world to better understand the threats arising from climate change, how it affects their lives and the lives of future generations, and how they need to play a part in mitigation and adaptation.
- Reduce barriers to low carbon consumption and promote behavioural change by encouraging energy efficiency and saving, active travel and dietary change, e.g. reduced meat and dairy products consumption in favour of plant-based products.
- Educate on the co-benefits of renewable and clean energy, such as a reduction in air pollution and noise, improved energy security and stable or decreasing prices.

(4) Promote research as well as technological and social innovation towards climate neutrality.

- Invest in basic research and increase international cooperation to address R&D challenges in climate science and industrial transformation. Improve scaling of climate neutral technologies.
- Support international cooperation in the monitoring of the energy system and its transformation by providing energy and emission data transparently and in near-real time.
- Further develop and standardise methods to report greenhouse gas sources and sinks. Expand research on nature-based solutions, particularly their climate impact and global mitigation potential.
- Promote social and behavioural science in order to support transformative social innovations to increase support for technologies, policies and routines for carbon neutral lifestyles.

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