Nuclear Energy and Climate Change

- The climate crisis is one of the defining challenges of this generation.
- Countries are off-track to limit global warming in line with the IPCC 1.5°C scenario and the window for action is narrowing rapidly.
- NEA analysis concludes that tripling global installed nuclear capacity provides a realistic and practical path to meet net zero goals by 2050.
- The world could avoid 87 gigatonnes of cumulative emissions between 2020 and 2050 with a combination of long-term operation (LTO) of existing reactors, new large-scale reactor builds, and the deployment of small modular reactors (SMRs).
- By 2050, nuclear energy could displace 5 gigatonnes of emissions each year, which is more than the annual emissions of the entire US economy today.

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The world is not on track to meet the decarbonisation objectives of the Paris Agreement

All credible models show that nuclear energy has an important role to play in global climate change mitigation (e.g. IEA, 2021; BNEF, 2023; IIASA, 2021). As highlighted by the Intergovernmental Panel on Climate Change (IPCC) synthesis report, the sustained reductions in greenhouse gas emissions required to meet Paris Agreement emissions reduction targets are not occurring at the required speed. Global emissions are expected to increase by 2030, rather than undergoing the steep reductions needed to avoid the worst climate impacts (IPCC, 2018).

The window for action is rapidly narrowing. Carbon emissions must peak within the next decade and reach net zero by 2050. This will require comprehensive policy changes globally; substantial investments in innovation and infrastructure; and the large-scale deployment of non-emitting energy resources. Electricity grids must be decarbonised; vehicle fleets must be electrified or transitioned to non-emitting fuels; and industries must be transformed across sectors, including off-grid mining, buildings, and the production of chemicals, iron, steel and cement.

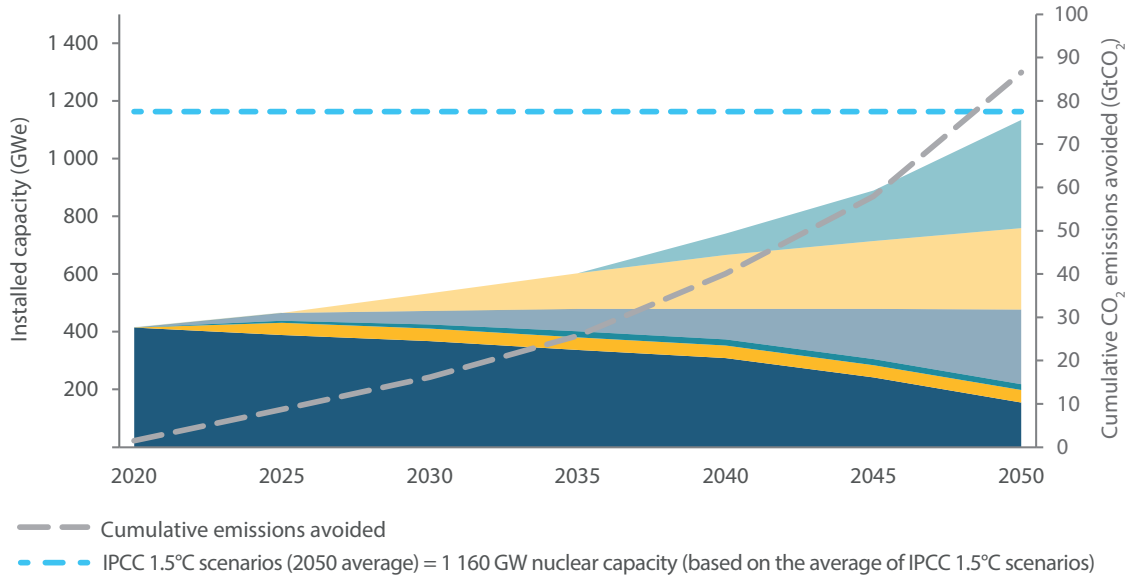
On the current trajectory, emissions are likely to eclipse targets arising from the 1.5°C scenario. A significant shift in direction is required for countries to meet their climate objectives.

Tripling of operational nuclear energy by 2050, to an average of 1 160 GW, compared to 2020 provides a realistic and practical path to enable the world to meet the IPCC 1.5°C scenario

The nuclear sector supports climate change mitigation in many different ways. Existing large-scale global installed nuclear capacity already plays an important role, and the LTO of existing reactors will continue to contribute for decades, displacing 1.6 gigatonnes of carbon dioxide emissions every year – a cumulative 66 gigatonnes of carbon dioxide so far since 1971 (NEA, 2020). Additional measures will be required to meet climate action imperatives. In a special report published in 2018, the IPCC (2018) considered 90 pathways consistent with a 1.5°C scenario, i.e. pathways with emissions reductions sufficient to limit average global warming to less than 1.5°C. The IPCC found that, on average, the pathways for the 1.5°C scenario require nuclear energy to reach 1 160 gigawatts of electricity by 2050, up from 394 gigawatts in 2020 (IPCC, 2018).

This is an ambitious target for nuclear energy, but not beyond reach. It can be achieved through a combination of LTO, largescale new builds and the deployment of SMRs, as shown in Figure 1.

Figure 1. Full potential of nuclear contributions to net-zero



Source: NEA (2022).

How to triple global installed nuclear capacity by 2050

Today around 440 operating nuclear reactors worldwide provide nearly 400 gigawatts of electrical capacity, supplying approximately 10% of the world's electricity. In 2022 nuclear energy was the largest source of non-emitting electricity generation in the countries of the Organisation for Economic Co-operation and Development (OECD) and the second largest source worldwide after hydropower. Approximately 50 new nuclear reactors (accounting for an additional 55 gigawatts of capacity) are under construction, with plans for more than 100 additional reactors. With the development of Generation IV reactors and SMRs, a new wave of nuclear technology innovation stands ready to help provide clean energy baseload power and decarbonise hard-to-abate industrial sectors. These innovations include sector coupling, combined heat and power (cogeneration) for heavy industry and resource extraction, hydrogen and synthetic fuel production, desalination, and off-grid applications.

NEA analysis of the potential contribution of nuclear energy to clean energy capacity and emissions reductions between 2020 and 2050

The full extent of nuclear energy's role in pathways to net zero by 2050 can be seen by estimating its potential contribution for emissions reductions through clean power generation, the supply of industrial heat and production of clean hydrogen.

Reaching the IPCC target of 1 160 gigawatts of electrical capacity from nuclear energy would, in this scenario, avoid 87 gigatonnes of cumulative emissions between 2020 and 2050, preserving 20% of the world's carbon budget consistent with a 1.5°C scenario.

Nuclear power in the hydrogen economy

The Nuclear Energy Agency (NEA) 2022 report on *The Role of Nuclear Power in the Hydrogen Economy* highlights opportunities for the production of low-carbon hydrogen as a solution for the decarbonisation of different industrial processes and transport, as well as longer-term applications to contribute to the flexibility of electricity grids with larger shares of variable renewables. The report provides an overview of the latest developments in the hydrogen economy and offers an in-depth analysis of nuclear competitiveness for hydrogen production and delivery. Building on the NEA's analyses of the system costs of electricity provision, this report investigates the system-level impacts of coupled electricity and hydrogen production. The combination of these complementary economic approaches sheds new light on the hydrogen economy and the role that nuclear technology can play in making it obtainable in the near future. The central conclusion from this study is that nuclear energy can produce low-carbon hydrogen on a large scale and at a competitive cost.

Projected contributions of nuclear energy to cumulative emissions reductions (2020-2050)

Cumulative emissions avoided from…*	…electricity	…heat	…hydrogen	Totals
…long-term operation	38.3	6.7	4.3	49.2
…new builds of large Generation III reactors	16.2	4.2	2.4	22.8
…small modular reactors (SMRs)	9.7	3.6	1.8	15.1
Totals	**64.1**	**14.5**	**8.5**	**87.1**

* All cumulative emissions from 2020 to 2050 are shown in gigatonnes of carbon dioxide ($GtCO_2$).

Addressing the challenges faced by nuclear energy

Both recent and historical experience shows that under the right policy frameworks and with a robust programmatic approach, nuclear power can be a low-carbon technology with rapid delivery times. This was the case historically for countries such as France and jurisdictions such as Ontario in Canada, which decarbonised their electricity mix in less than two decades with nuclear energy and hydropower. Today, countries with established nuclear programmes such as China and Korea have demonstrated construction lead times of 5-6 years or less for large-scale reactor designs with increased safety. Newcomer countries, such as the United Arab Emirates with the Barakah project, have demonstrated the ability to deliver new nuclear energy projects on a timeline and cost consistent with reaching 1 660 gigawatts of installed capacity globally.

While nuclear energy has the potential to contribute much more to global climate change mitigation efforts, challenges remain. The above estimates are not forecasts, but represent what could be achieved with timely enabling decisions. Challenges to realising the contribution of nuclear energy to achieving net zero carbon emissions by 2050 include:

- **Unlocking access to significant amounts of capital at competitive rates**. Realising the contribution of nuclear energy to achieving net zero by 2050 will require unlocking access to significant amounts of capital at competitive rates. The exclusion of nuclear power from financing support at multilateral development banks and international financial institutions works actively against this imperative. The position also places pressure on governments debating the status of nuclear technologies in international taxonomies that define uniform criteria for determining whether an economic activity qualifies as eligible for international developmental finance.
- **Ensuring a healthy and resilient supply chain**. While the nuclear industry benefits from international supply chains built up over seventy years, new nuclear technologies in the energy transition such as SMRs will require changes, for example to manage high-assay low-enriched uranium (HALEU) fuel, transport containers, and factory relocation aspects, compared to former on-site construction methods. Countries will benefit from working together through government-to-government, business-to-business and public-private co-operation to avoid supply chain redundancies and improve cost competitiveness to reach efficiencies of scale for a new industry.
- **Building and maintaining public confidence**. Building trust is central to building public confidence and requires sustained investments in open and transparent engagement, as well as science communication. Effective public engagement strategies often emphasise transparency, open dialogue and education, aiming to inform citizens about the advancements in nuclear technology, safety measures and waste disposal solutions. Revisiting best practices in approaches to public engagement will likely be required to both accelerate projects and deliver new projects for the deployment of nuclear energy at a large scale.

- **Ensuring a skilled workforce**. Although recent nuclear new builds have contributed to revitalising international supply chains, meeting the scale and speed necessary to support a new wave of projects will require a strong industrial foundation and quality workforce. Governments and industry will need to find the right balance between reliance on domestic investments in critical skills and infrastructure, and efficiencies from forming strategic partnerships internationally. Workforce preparedness to sustain the tripling or more of global installed nuclear capacity for net zero by 2050 will require both back-to-basics and creative solutions to re-establish a robust network for nuclear education.

The role of the NEA and the launch of two new initiatives

The NEA continues to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes. This includes a focus on everything from assessments of new supply chain needs and promoting an inclusive new generation of the nuclear workforce, to encouraging adequate regulation that accounts for the safe use of innovative reactor designs, advanced materials and new accident-tolerant fuels.

The NEA is pleased to announce the launch of two major initiatives in 2023: "Roadmaps to New Nuclear" and "Accelerating SMRs for Net Zero."

- **Roadmaps to New Nuclear**. The NEA and the Ministry of Energy Transition of France co-hosted the first government-industry conference on "Roadmaps to New Nuclear" at the OECD Conference Centre in Paris, France, on 28-29 September 2023. The conference convened energy ministers and heads of delegations of 20 countries, as well as over 30 CEOs from industry to pinpoint solutions to deliver new nuclear construction at the scale and pace required for these countries to meet their energy needs. Outcomes of the event included high-level communiqués, from energy ministers and from industry representatives. The NEA plans to build from the momentum of the Ministerial event to deliver work in the areas of the supply chain, financing and workforce skills in the run-up to the second "Roadmaps to New Nuclear Conference" in September 2024.
- **Accelerating SMRs for Net Zero**. The NEA is launching a new "Accelerating SMRs for Net Zero" initiative at the 28th Conference of Parties (COP28) hosted by the United Arab Emirates (UAE) on 30 November - 12 December 2023. "Accelerating SMRs for Net Zero" leverages the NEA network of industry leaders, government officials, researchers and experts to establish a practical, solutions-oriented platform with a defined plan of work for collaboration and knowledge exchange to support decision makers in maximising the full potential of SMRs. As a component of this effort, the NEA will host an annual Summit to bring together senior government officials and private sector executives to address key sector needs.

To engage with "Roadmaps to New Nuclear" or "Accelerating SMRs for Net Zero" please contact roadmapsnewnuclear@oecd-nea.org and SMR4NZ@oecd-nea.org.

References and further reading

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Cover page: Romolo Tavani/Shutterstock.

OECD/NEA, November 2023