IAEA
International Atomic Energy Agency

Nuclear Energy and Climate Change

QUESTIONS AND ANSWERS ON PROGRESS, CHALLENGES AND OPPORTUNITIES

A synthesis of the IAEA submission to the first Global Stocktake under the Paris Agreement

Nuclear energy is contributing significantly to climate change mitigation and adaptation while supporting sustainable development. Nuclear energy is the second largest source of low carbon electricity and the nuclear power sector is well prepared to adapt to a changing climate. Many countries include nuclear energy in their national climate change strategies.

Further action is needed to fully capitalize on nuclear energy's potential to support climate change mitigation and resilience, including coherent policy, regulatory, infrastructure and other measures to mobilize and direct finance flows, in conjunction with continuing efforts to integrate advances in climate science and forecasting in power plant design, siting and operations.

The IAEA plays a leading role in assisting its Member States as they respond to climate change with nuclear energy by supporting existing and new nuclear programmes around the world, catalysing innovation and building capacity in sustainable energy planning. The IAEA also works with Member States to increase the robustness and climate resilience of nuclear power plants.

<2°C

All low carbon energy technologies, including nuclear power, are needed to meet the Paris Agreement goal of limiting the rise of global temperatures to below 2°C.

In March 2023 at the invitation of the Chairs of the UN Framework Convention on Climate Change's Subsidiary Body for Implementation and Subsidiary Body for Scientific and Technological Advice, the IAEA provided input to the first Global Stocktake under the Paris Agreement on climate change. The Global Stocktake aims to: "[enable] countries and other stakeholders to see where they're collectively making progress toward meeting the goals of the Paris Agreement – and where they're not. It's like taking inventory. It means looking at everything related to where the world stands on climate action and support, identifying the gaps, and working together to agree on solutions pathways (to 2030 and beyond)" [1].

This publication presents a synthesis of the IAEA's submission to the Global Stocktake in the form of a series of questions and answers addressing the contribution of nuclear energy to climate change mitigation, adaptation, finance and technology, along with economic aspects and cross-cutting issues. These topics are elaborated further in recent IAEA publications, including Nuclear Energy for a Net Zero World [2] and Climate Change and Nuclear Power 2022 [3].

"As the first Global Stocktake under the Paris Agreement draws to a close at COP28, we are reminded of the key role nuclear science and technology play in responding to the climate crisis. Nuclear power provides a quarter of the world's low carbon power. As nuclear increases the amount of power it provides worldwide while expanding further into decarbonizing other areas of the economy, nuclear energy will be part of what gets us to a net-zero carbon world."

Rafael Mariano Grossi
IAEA DIRECTOR GENERAL

MITIGATION

1. How does nuclear energy already contribute to climate change mitigation actions and ambition under the Paris Agreement, including the goals of holding the temperature increase well below 2°C (and pursuing efforts to limit warming to 1.5°C)[1] and reaching net zero emissions[2]?

Nuclear energy remains the second largest source of low carbon electricity globally and has historically avoided around 70 billion tonnes of carbon dioxide (CO_2) [4]. With over 400 nuclear power reactors in operation and more than 50 under construction [5], nuclear power is continuing its proven role in climate change mitigation, underpinning the decarbonization of the electricity sector by operating reliably on demand and supporting increased shares of other low carbon generation, in particular variable renewable sources, such as solar and wind power [4,6].

In addition to the continued operation and new construction of nuclear power plants, important progress has been made around the world in extending the operating lifetimes of existing plants, maintaining "a solid foundation on which to build clean energy transitions" [4]. From 2019 to 2022, policy and regulatory decisions have granted lifetime extensions to over 50 gigawatts of nuclear capacity, with decisions pending for close to 60 gigawatts more [4].

These and other developments are reflected in the IAEA's latest projections of nuclear power deployment up to 2050 [7]. The high case projections, which consider country policies on climate change and the expressed intentions of countries for expanding the use of nuclear power, see a doubling of world nuclear capacity by 2050, to 873 gigawatts. On the other hand, the low case projections see nuclear capacity in 2050 at around 400 gigawatts (essentially the same as today) assuming "current market, technology and resource trends continue and there are few additional changes in explicit laws, policies and regulations affecting nuclear power" [7].

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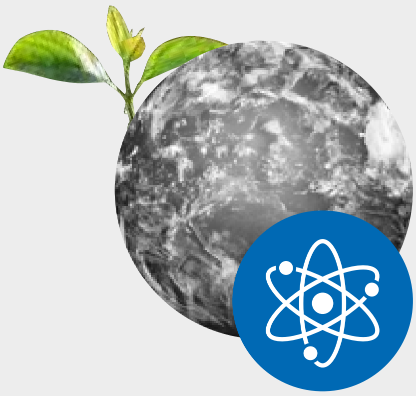


[1] Article 2.1(a) of the Paris Agreement: "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."

[2] Article 4.1 of the Paris Agreement: "In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty."

2. Are current national commitments to reduce greenhouse gas emissions (including nationally determined contributions) sufficient to meet the goals of the Paris Agreement? How much additional abatement is still needed?

According to the Intergovernmental Panel on Climate Change (IPCC) [8], the International Energy Agency (IEA) [9] and United Nations Environment Programme [10] nationally determined contributions (NDCs) submitted by countries under the Paris Agreement remain inadequate to hold global warming well below 2°C. With the full implementation of unconditional NDCs, the United Nations Environment Programme estimates that annual emissions would be 15 and 23 gigatonnes of CO_2 equivalent above the level required in 2030 for 2°C and 1.5° degrees, respectively, and 24 and 36 gigatonnes of CO_2 equivalent above in 2050 [10].

Assuming net zero commitments of the members of the Group of Twenty (G-20) members plus nine other large emitters[3] are achieved — acknowledging that some of these commitments are extremely ambitious — warming would be limited to below 2°C, with a gap of around 12 gigatonnes of CO_2 equivalent for 1.5°C in 2050 [10].

[3] Chile, Colombia, Kazakhstan, Malaysia, Nigeria, Thailand, Ukraine, United Arab Emirates, Viet Nam.

3. What efforts are being taken to plan, implement and accelerate mitigation action using nuclear energy?

According to NDCs and long term strategies submitted under the Paris Agreement [11,12], around 30 countries are planning, implementing and/or accelerating action capitalizing on the substantial mitigation potential of nuclear energy (see Table 1). This includes 14 countries that have assigned an important role to nuclear energy in their latest NDCs and close to 20 countries including nuclear energy in their long term strategies.

Together the countries in the yellow shaded areas in Table 1 account for over 70% of global energy related emissions [14]. Across these NDCs, the commitments include quantitative and project oriented targets to expand nuclear energy capacity, measures to develop and utilize new nuclear energy technologies (including small modular reactors and the production of low carbon heat and hydrogen), general statements of intent to develop, deploy and use nuclear energy to reach mitigation goals, and targets to support developing countries and nuclear industry workforce diversity.

Beyond NDCs and long term strategies, an additional 50 or so countries are pursuing nuclear energy, ranging from countries that have expressed an interest to those currently constructing their first power plants.

The IAEA is also supporting countries to enhance NDC ambition by assisting Member States in assessing the option of nuclear for their decarbonization strategies, including by supporting countries build capacity in energy planning and conduct research on this topic [15].

	USING NUCLEAR POWER TODAY	CONSTRUCTING FIRST NUCLEAR POWER PLANT	OTHER COUNTRIES
Nuclear energy in NDC and long term strategies	Canada, China, Ukraine, United Kingdom, United States of America		
Nuclear energy in NDC only	Argentina, Armenia, India, Islamic Republic of Iran, Russian Federation, United Arab Emirates	Türkiye	Democratic People's Republic of Korea, Ghana
Nuclear energy in long term strategies only	Czech Republic, Finland, France, Hungary, Japan, Mexico, Netherlands, Slovakia, Slovenia, Sweden		Australia, Colombia, Morocco, Singapore
Nuclear energy not included in NDC or long term strategies (or mentioned in the context of moratoria or phase-outs)	Belarus, Belgium, Brazil, Bulgaria, Germany, Republic of Korea, Pakistan, Romania, Switzerland, South Africa, Spain	Bangladesh, Egypt	Rest of the world

Note: Republic of Korea recently announced plans to revise its NDC and long term strategies to increase the role of nuclear power [13].

Table 1: Nuclear energy in national commitments and strategies, as at mid-2022 [11,12].

~30 countries are planning, implementing and/or accelerating action capitalizing on the substantial mitigation potential of nuclear energy.

4. Are current mitigation efforts around nuclear energy, including policies and other means of support, sufficient to reach the goals of the Paris Agreement?

Global mitigation pathways presented in the IPCC Sixth Assessment Report [8,16] consistently highlight an important role for nuclear energy in transition scenarios compatible with achieving the goals of the Paris Agreement — the majority of low carbon pathways in the Sixth Assessment Report project at least a doubling of global nuclear electricity generation by 2050 [17].

While nuclear power continues to provide the second largest source of low carbon electricity worldwide, in many regions and countries policies, efforts and support provided for mitigation action utilizing nuclear energy are not aligned with the IPCC mitigation pathways. That is, even with important progress and ambition (see questions 1 and 3), support for deployment of new nuclear power plants and lifetime extension of existing plants remains inadequate, and in some cases, inconsistent with the goals of the Paris Agreement.

14 countries have assigned an important role to nuclear energy.

Nuclear power provides the second largest source of low carbon electricity worldwide.

5. What further action is required to overcome barriers and challenges to mitigation (facing nuclear and other low carbon energy sources) at national, regional and international levels?

To accelerate and scale up mitigation in the energy sector in line with the goals of the Paris Agreement and address barriers and challenges at different levels, a coherent set of policy, regulatory, infrastructure and other measures is required [2,3,9] to address:

- **Markets and regulation:** Policy makers and regulators can seek to reduce existing energy and investment market barriers and distortions, such as those related to electricity market design and regulation, poorly targeted subsidies, insufficient carbon prices and the absence of mechanisms to value and remunerate system services (including flexibility and reliability) provided by energy producers, including nuclear power plants. Approval processes for low carbon energy projects could also be more closely aligned with the need for urgent action on both climate and energy security.

- **Guiding investment:** The definitions of ESG (environmental, social and governance) criteria aimed at directing public and private investment towards low carbon options, including in taxonomies developed by governments, should have a strong scientific basis and avoid arbitrary barriers. By adopting objective and transparent technology neutral criteria, investment can be mobilized and guided to maximize the likelihood of achieving net zero emissions while responding to other aspects of sustainable development.

- **Management of clean energy project risks:** Decision makers can adopt coherent targeted policy measures to help mitigate the risks confronting investors in relation to capital intensive, long lived, low carbon energy projects. Such measures can support projects that face long lead times, complex regulatory processes and political uncertainty, as well as those providing substantial non-market benefits, such as enhanced long term energy security. Policy makers can facilitate and leverage private investment through measures to manage and share risks during construction (such as via direct public financing or guarantees to debt and equity providers, including regulated asset based approaches) and schemes to share revenue and pricing risks, such as contracts for difference or power purchase agreements.

- **Coordination and cooperation:** Policy makers will need to coordinate, and potentially finance, the development of hard infrastructure (e.g. energy grids and secure supply chains for critical commodities) and soft infrastructure (e.g. human capital, institutions and legal frameworks) to support the energy transition, enhance international financial cooperation and expand technology neutral financing from multilateral development banks and climate finance institutions — particularly to facilitate flows for energy projects in developing countries — and support local capital market development.

- **Supporting new technologies:** Continued public and private investment in research and development and demonstration projects to support technology innovation will be critical to reach net zero, given that substantial emission reductions are expected to come from emerging technologies, including advanced nuclear energy systems [18].

In addition to the above, temporary targeted measures may be warranted to avoid premature retirement of low carbon energy capacity, such as existing nuclear power plants, and to discourage investment that would lead to the lock-in of long lived energy supply infrastructure that is incompatible with the goals of the Paris Agreement.

By adopting objective and transparent technology neutral criteria, investment can be mobilized and guided to maximize the likelihood of achieving net zero emissions.

GOOD PRACTICES, LESSONS LEARNED AND SUCCESS STORIES IN MITIGATION

UNITED ARAB EMIRATES

The successful rapid deployment of large scale low carbon nuclear generation by the United Arab Emirates provides an illustration of good practices and opportunities for enhanced and accelerated mitigation. The Barakah Nuclear Energy Plant alone is expected to produce around 25% of the United Arab Emirates' electricity by 2025, largely replacing natural gas generation, nearly halving power sector emissions in the Emirate of Abu Dhabi [3,19]. With construction starting in 2012, this represents a rapid decarbonization, similar to experiences in France, Sweden and other countries which successfully and rapidly decarbonized their electricity sectors with nuclear energy in earlier decades.

CHINA

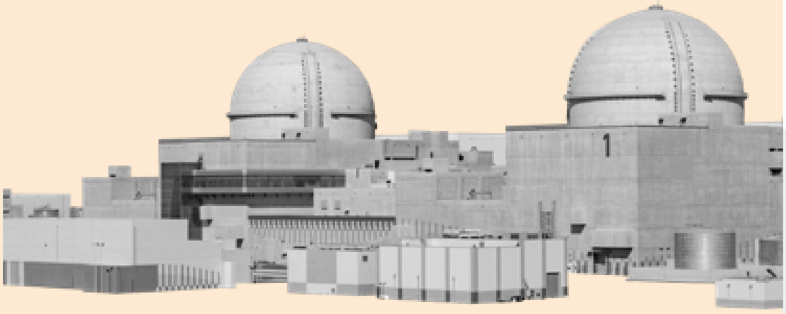
The success of China in deploying new nuclear technologies to decarbonize the country's heat supply provides additional lessons, demonstrating the potential of nuclear energy to not only decarbonize electricity production, but also its capacity to provide low carbon heat to reach mitigation goals in non-electric applications and hard-to-abate sectors [20]. Examples include the Haiyang Nuclear Power Plant (delivering commercial scale district heating since 2020 and now expanding to meet the heating needs of 1 million residents [21]), the Qinshan Nuclear Power Plant (providing industrial heat), a project to supply steam from the Tianwan Nuclear Power Plant to the petrochemical industry by the end of 2023, and plans for dedicated reactors for clean district heating in the city of Liaoyuan [22].

UNITED KINGDOM

On the policy front, the United Kingdom provides an example of good practices, having implemented an integrated package of policies and measures to support investment in low carbon options, including nuclear energy, in line with ambitious climate goals. Complemented by a comprehensive strategy for the nuclear industry [23], measures that have been implemented or are under consideration include:

- Contracts for difference to provide stable revenues for investors in clean electricity projects [24];
- A capacity market for dispatchable generation to ensure a reliable and affordable electricity supply [25];
- A final investment decision process to accelerate energy investment;
- Loan guarantees to support project finance and investment [26];
- Government financing during project construction;
- Regulated asset base models that provide a regulated return to investors [27].

The United Kingdom recognized the potential of low carbon nuclear energy to also support broader social and economic development objectives in the recovery measures in its Ten Point Plan for a Green Industrial Revolution, providing over UK £400 million for small modular nuclear reactors (and mobilizing private funding), research and development of advanced modular reactors, developing regulatory frameworks and supporting supply chains [28].



ADAPTATION

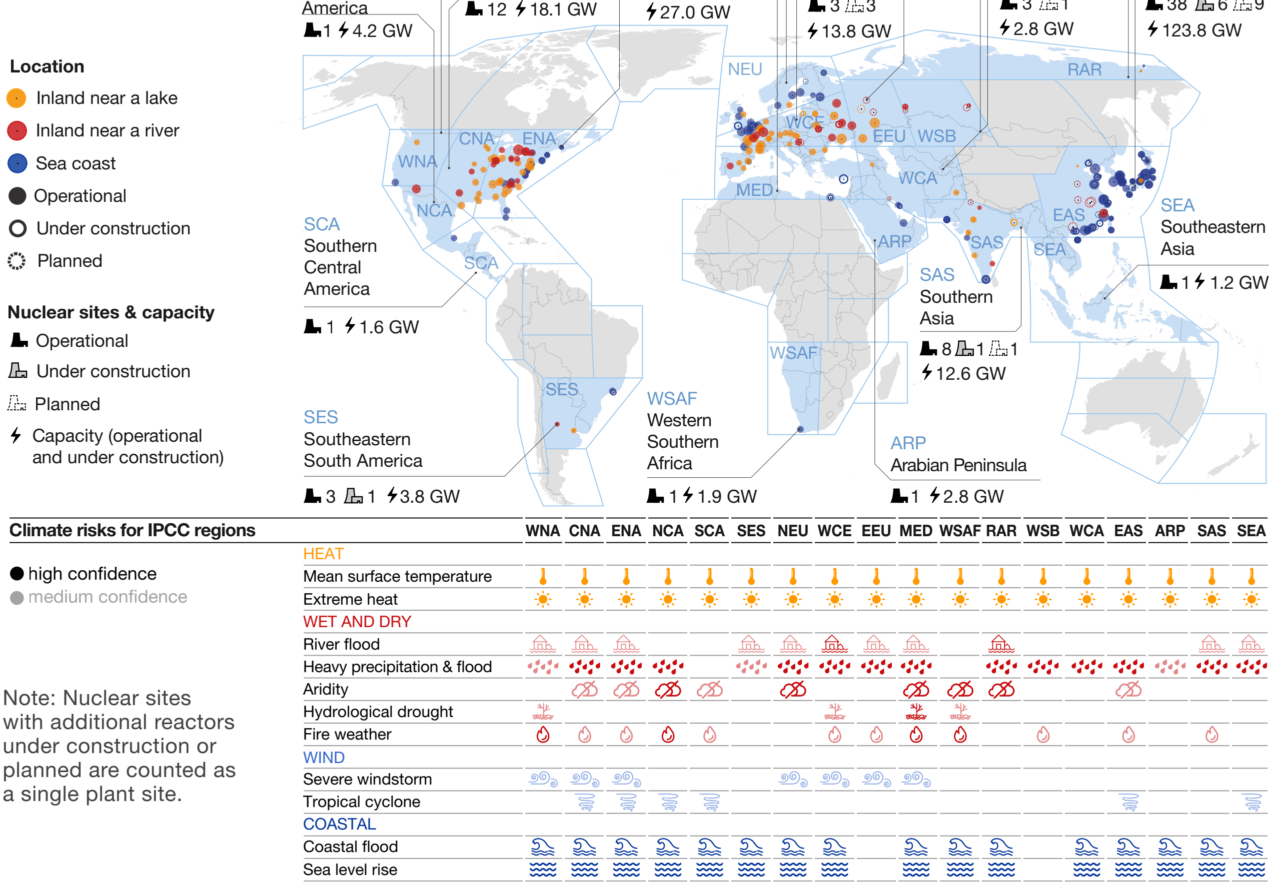
6. What are the main climate change adaptation challenges facing the nuclear energy sector around the world? How adequate and effective are current adaptation efforts?

Global energy infrastructures are increasingly exposed to frequent and severe climate hazards [29] and the nuclear energy sector is facing and responding to multiple climate impacts (see Fig. 1).

While reported nuclear power production losses attributed to adverse climatic and weather conditions remain modest (<0.5% of total plant output), they account for an increasing share of total production losses. In 2022, the share of weather related losses was 11.5 percentage points higher than in the preceding decade [5,31]. The majority of reported climate-related disruptions occurred at plants located by rivers or lakes, where continuity in production directly depends on strictly regulated access to water bodies, ensuring minimal impact on ecosystems.

The effectiveness of current adaptation efforts is likely attributable to revisions to regulatory regimes and improved operational experience. On the former, the evolving nature of weather events has led many countries and regulators to revise safety guidelines to maintain or strengthen the overall resilience of nuclear operations [3]. Episodes of extreme heat, lack of cooling water or floods were at the origin of specific adaptation measures [32]. Plant designs have been adapted with a variety of engineering solutions including:
(i) a reduction of the usage and consumption of cooling water; (ii) modification of water intake; (iii) investigation of on-site water production; and (iv) increase and more efficient use of heat exchanger capacity. As a result, the nuclear energy sector is well prepared to face changing environmental conditions in the foreseeable future [3].

Fig. 1: Regional climate risks and climatic impact drivers, based on climate data from IPCC [29,30] and nuclear data from IAEA [5].



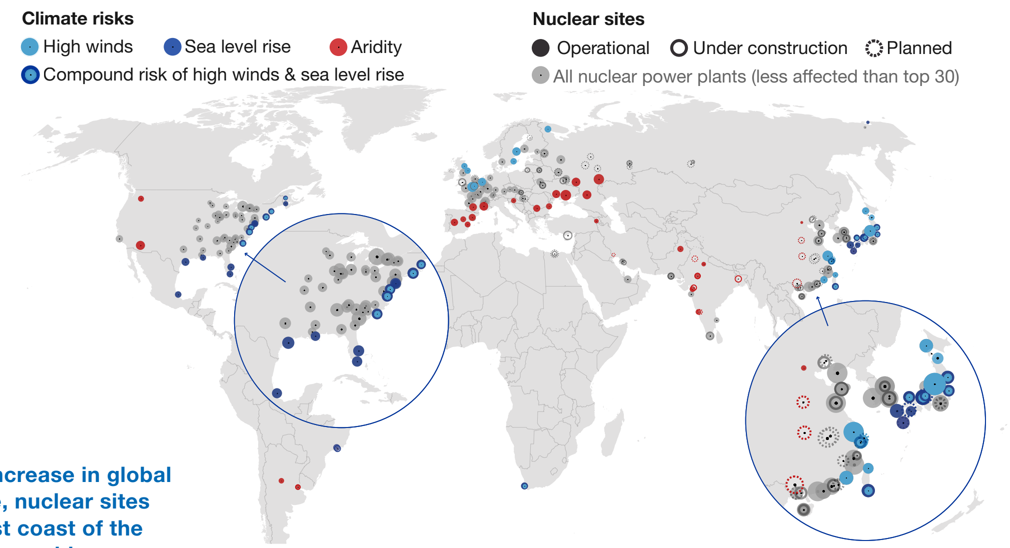
7. What efforts are being taken to adapt the nuclear energy sector? How is the IAEA supporting this?

Beyond continuing successful adaptation approaches (see question 6), adaption efforts can be further enhanced to address climate related hazards (e.g. meteorological, hydrological, fire related) that have the potential to affect all types of nuclear installations worldwide.

Anticipating weather and water related events, for example with seasonal and sub-seasonal forecast models, can help identify priorities, implementation and support needs, and support planning and actions to ensure the availability of individual power infrastructure assets (see Fig. 2) and the design of measures to mitigate the economic and societal impacts of such events.

The IAEA has initiated a technical project that draws on the most recent experience of countries in the application of climate predictive methods for the assessment of site hazards and safety issues related to existing and new nuclear sites [3]. The project combines statistical and numerical methods with meteorological and hydrological approaches to assess time dependent hazards through the lens of sustainability, drawing on special methods to assess the evolution of climate hazards over long time frames. The expected outcomes include identification of safety relevant actions for on-site hazards and the design of new protection measures for both existing installations and new designs. Measures will aim at increasing the robustness and resilience of nuclear power plants in the face of time dependant hazards exacerbated by climate change, combining engineering provisions (e.g. improved barriers) and operational, performance related procedures (e.g. preventive shutdown).

In addition, the IAEA is convening an expert group to develop a publication detailing performance related technical solutions recently selected or under consideration by Member States to reduce production losses caused by environmental changes and climate variability before safety and protection measures are triggered. The publication will provide illustrative examples of modifications to physical assets and operating procedures that maximize plant economics under conditions such as warmer hot seasons, longer dry seasons and more frequent storms and episodes of aquatic organism ingress into cooling water intake structures.



Under a 4°C increase in global mean temperature, nuclear sites located on the east coast of the USA and in Florida would see increases in sea level above 50 cm compared to current levels, exacerbating the impacts of other unpredictable and frequent extreme weather manifestations.

43% of nuclear new build is located in East Asia, where tropical cyclones, floods and droughts have increased significantly over the last decades, with severe and destructive impacts on coastal communities.

Fig. 2: Global overview of the most significant environmental changes around selected nuclear power plant site locations, based on climate data from IPCC [30] and nuclear data from the IAEA [5].

Note: m/s — metres per second, m — metres.

8. What further adaptation action is required in the nuclear energy sector and how can barriers and challenges be addressed?

"New climate hazards, including compounded risks resulting from cascading, low probability, extreme weather events, must be included in the siting and design of new nuclear installations, particularly in countries embarking [on new nuclear power programmes]. Integrating the latest advances in climate science, including the better representation of future climate risks at the local scale, can greatly contribute to strengthening the climate resilience of nuclear infrastructures and reinforce the security of the electricity supply" [3].

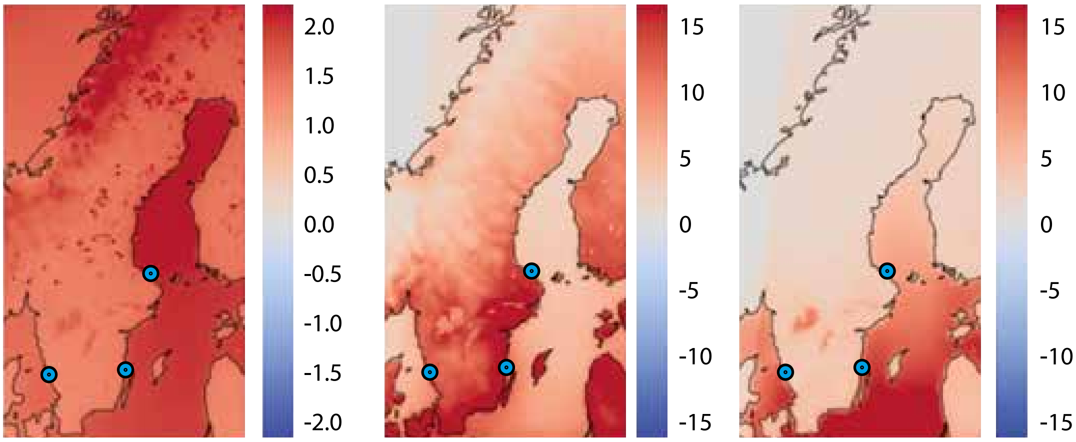
GOOD PRACTICES, LESSONS LEARNED AND SUCCESS STORIES IN ADAPTATION

SWEDEN AND FINLAND

"Nuclear power plants in Sweden and Finland have successfully prepared for a changing climate…well beyond 2050 [33]. Actions initiated in the aftermath of the Fukushima accident and the overall high level of safety in the nuclear sector ensure a robustness to meet extreme events in general, including extreme weather events. Recent investments in independent core cooling in plants in Sweden have further strengthened durability [2].

"Nonetheless, climate and weather related events with the potential to affect the operation of nuclear power plants have occurred historically and are expected to increase in frequency and severity in the future [(see Fig. 3)]. For instance, all Nordic nuclear power plants are situated by the sea, making them potentially vulnerable to rising sea levels, although this effect is partly offset by land uplift at most of the nuclear sites. It is estimated that current safety margins can accommodate the impact of sea level rise caused by climate change and extreme weather conditions for several decades to come — for example, plants in Sweden can cope with a sea level rise of up to 3 metres above the current normal level [2].

"A number of other climate or weather related events may also potentially affect the operation of nuclear power plants in Nordic countries. These include, for example, lightning strikes that may impact the electricity grid at the plant site and externally. Another example is higher seawater temperature, which in extreme cases may lead to power reduction or even require a temporary shutdown. In the summer of 2018, the production in both the Ringhals and Loviisa nuclear power plants was impacted by high cooling water temperatures. A warmer sea also increases the risk of marine organisms obstructing cooling water intakes, as evidenced by jellyfish intrusions at the Oskarshamn nuclear power plant in 2005 and 2013" [2].



Changes in maximum temperature (°C).

Changes in consecutive warm days in June–August (days).

Changes in tropical nights (i.e. days when night time temperatures remain above 20°C).

Fig. 3: Projected changes in climate indices of relevance for high sea water temperatures at +2°C global warming compared to pre-industrial conditions [2].

Note: Blue dots denote operational nuclear power plants.

“The potential impacts of climate change outlined above are not considered threats to plant safety, at least for a foreseeable future, and hence are more relevant for plant economics and electricity supply security” [2]. The effect of high seawater temperatures can be mitigated by increasing the capacity of the heat exchangers, and measures to monitor for, screen and clear marine organisms have also been implemented at some power plants. Similarly, “to protect the facilities from lightning strikes, several different types of protections have been installed, both in the plants and in the grid” [2]. On the other hand, more extensive solutions, such as the installation of deep water inlets (e.g. at Loviisa), are not currently deemed economically viable.

UNITED STATES OF AMERICA

Another important example of opportunities is provided by the Palo Verde Nuclear Generating Station in the Arizona desert in the United States of America. Even under moderate climate change scenarios, it is estimated that this plant could experience around 60 days of extreme temperatures above 40°C per year later this century, increasing to close to 100 days under scenarios with higher warming [30]. In this context, the Palo Verde nuclear power plant provides a unique example of a successful design adapted to withstand and operate under severe environmental conditions, including utilizing wastewater from surrounding sewage stations, cutting freshwater consumption needs drastically [3].

FINANCE FLOWS, TECHNOLOGY DEVELOPMENT AND TRANSFER, AND CAPACITY BUILDING

9. Are current finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development in line with the Paris Agreement[4]? Are current trends in nuclear energy financing sufficient?

To achieve net zero emissions by 2050, the IEA estimates that global electricity sector investment will need to more than double from recent level to over US $2 trillion annually between 2023 and 2030 [9,34]. This includes an almost 2.5 fold increase in annual nuclear energy investment to over US $100 billion by 2030, and more than US $2 trillion by 2050 — primarily in the Asia and Pacific region (especially in China), Europe and North America [9].

Recent trends in nuclear energy investment have been positive, increasing from around US $35 billion between 2017 and 2019 to almost US $50 billion in 2022 [34], driven by construction of new reactors in China, Europe and Pakistan, and refurbishment and lifetime extensions in a number of other countries. Sustaining and accelerating this growth in financial flows will be necessary to meet the 2030 investment needs identified by the IEA. In this context, important progress is being made in terms of initiatives to provide investors with additional guidance on which activities are compatible with long term climate and sustainability goals. For example, governments and the financial sector are adopting sustainable investment taxonomies and similar frameworks to direct and mobilize private financial flows towards sustainable investment, including low carbon nuclear energy. This is elaborated further in question 11.

However, despite these and other positive developments [35], mobilizing the scale of investment needed to achieve the Paris Agreement goals remains challenging in the current market and policy environment. For instance, recent national energy policy responses to the war in Ukraine and the COVID-19 pandemic have continued to direct financial resources towards the production and consumption of fossil fuels: among G-20 countries over 40% of the more than US $1 trillion in public finance committed to energy investment in pandemic recovery packages is allocated to fossil energy [36], threatening the goals of the Paris Agreement. In comparison, around US $12 billion has been committed to nuclear energy investment — mainly in Canada, France, the United Kingdom and the United States of America [2].

[4] Article 2.1(c) of the Paris Agreement: “Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.”

10. How are nuclear energy technology development and transfer and capacity building in developing Member States, contributing to ensuring improving climate resilience and mitigation[5]?

Establishing and maintaining a robust system of institutional, regulatory, legal, industrial and other infrastructure (including human capital) is critical to supporting technology transfer for the low carbon energy transition (as well as research and development for new technologies). Directly addressing this need, the IAEA assists its Member States in using nuclear science and technology for peaceful purposes and facilitates the transfer of such technology and knowledge in a sustainable manner [37]. For instance, the IAEA has developed and implemented a comprehensive Milestones approach to assist Member States considering or planning to utilize nuclear power, incorporating technical education to train the workforce for the energy transition and ensuring a robust scientific basis to regulation, planning and policy, among others.

As an illustration, the development of a nuclear power programme is a key element in the United Arab Emirates' climate change mitigation actions [38]. To this end, the United Arab Emirates is enhancing its technical and vocational education system to support the development of the professional workforce fundamental to accelerating the deployment of nuclear and other clean energy technologies [39,40].

For more than four decades, the IAEA has also provided extensive support to Member States to build capacity through training, technical assistance and technology transfer of tools and methodologies for sustainable energy systems analysis and planning, enabling them to evaluate the role of different technologies in meeting their future energy needs while reducing greenhouse gas emissions. For example, over the last decade the IAEA has provided technical assistance to Member States in Africa to reinforce local energy planning capabilities. This has comprised capacity building and the transfer of tools and methodologies to support the establishment of national planning teams and case studies analysing sub-regional power pools, most recently supporting the development of a Continental Power System Masterplan in cooperation with the International Renewable Energy Agency [41]. These case studies in turn demonstrated the benefits of cooperation and integrated development of local generation options and grids, in terms of increased access to energy services, stronger economic development and improved electricity affordability. This effective model of technology transfer was also applied in Latin America and the Caribbean between 2015 and 2020, with IAEA tools and methodologies transferred to over 200 experts in 15 countries to support sub-regional studies on energy and climate change mitigation.

Hands-on training at the never-used Zwentendorf Nuclear Power Plant in Austria.

[5] Article 10.1 of the Paris Agreement: "Parties share a long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions."

11. What further action is needed to support finance, technology development and transfer and capacity building to achieve the Paris Agreement goals? What are key barriers and challenges as well as opportunities, good practices, lessons learned and success stories?

Given the scale of investment required and the current misallocation of financial resources, providing investors with additional guidance on which activities are compatible with long term climate and sustainability goals is a key element in the framework of policies and measures needed to drive the low carbon energy transition.

Taxonomies and similar frameworks represent one important way in which governments and the financial sector are seeking to mobilize and direct private financial flows towards sustainable investment. Such frameworks should have a strong scientific basis and avoid arbitrary technology barriers. Good practices — that is objective and transparent technology neutral criteria — have been adopted in relation to nuclear energy in several taxonomies (see Table 2), mobilizing and guiding investment consistent with the goals of the Paris Agreement while responding to other aspects of sustainable development.

In addition, further public sector interventions and public–private collaboration will also be critical. For example, public sector coordination and financing of infrastructure development is likely to be necessary to leverage private investments and fully unlock the large potential of financial markets [8]. This includes both hard (e.g. energy grids, critical supply chains, physical adaptation measures) and soft infrastructure (e.g. regulatory and legal frameworks, and human capital). The specific coordinating role of the public sector, and the nature of public–private partnerships, will depend on national circumstances and complementary policy measures.

In addition to national, regional and private sector initiatives and policy support, enhanced international financial cooperation will be essential to realize the low carbon transition, given that many developing countries rely on public resources to finance energy projects. Beyond existing commitments to

	NUCLEAR ENERGY INCLUDED	NUCLEAR ENERGY CURRENTLY EXCLUDED	NUCLEAR ENERGY CLASSIFICATION TO BE DETERMINED
National and regional sustainable finance taxonomies and roadmaps	China, European Union, Japan (implicit), Republic of Korea, Malaysia (implicit), Philippines, Russian Federation	ASEAN, Bangladesh, Canada, Colombia, Kazakhstan, Mongolia, South Africa, Thailand	Chile, Indonesia, Singapore, United Kingdom Under development/ discussion: Dominican Republic, India, Mexico, New Zealand, Sri Lanka, Viet Nam
Private sector initiatives	Green Bond Principles (ICMA) (implicit)	Climate Bonds Standard (CBI)	

The IAEA assists its Member States in assessing the option of nuclear energy for their decarbonization strategies.

Table 2: Examples of sustainable investment taxonomies that include nuclear energy in 2022 [3].

scale up public finance flows to developing countries to US $100 billion under the United Nations Framework Convention on Climate Change, opportunities exist to support local capital market development, expand financing through multilateral development banks and specialized climate finance institutions and leverage private capital by increasing the use of public guarantees. The significant barriers that developing countries face in relation to financing nuclear energy projects can be partly addressed through the adoption of a technology neutral approach in the funding decisions of development and green banks for infrastructure and clean energy funds [2, 42].

Beyond the need for policy interventions to accelerate the deployment of low carbon technologies in the near term (to 2030), securing net zero emissions over the longer term will also necessitate continued public and private investment in research and development to support technology innovation — the IEA expects nearly half of the emission reductions for net zero to come from technologies yet to have reached the market [18] — including for advanced nuclear energy systems. A key complement to inform the design of research and development and broader energy policy is the robust assessment of long term decarbonization pathways, such as those published by the IEA [43] and IPCC [15]. Enhancing the representation of low carbon options in such assessments is critical to identifying key mitigation technologies and lower cost pathways to reach net zero [17].

Enhanced international financial cooperation will be essential to realize the low carbon transition.

Continued public and private investment in research and development will be necessary over the longer term to secure net zero emissions.

ECONOMIC AND SOCIAL ASPECTS, AND LOSS AND DAMAGE

12. How can nuclear energy address the social and economic consequences and impacts of mitigation policies and actions?

According to analysis by the International Monetary Fund, investment in low carbon energy as part of mitigation policies can provide a substantial economic boost [44]. “The spending multiplier — i.e. the change in economic activity (GDP) divided by the change in investment spending — for nuclear energy is estimated to be around six times larger than for fossil energy and around three times larger than the multiplier for renewable energy over the short term, delivering a rapid economic boost [(see Fig. 4)]. Spending on nuclear energy is also estimated to stimulate (or ‘crowd in’) more investment in other parts of the economy and lead to ‘larger employment of both high- and lower-skilled resources’ [44] per unit of spending compared to other low emission energy sources.

“In the near term, investment in projects to extend the operation of existing nuclear power plants can be implemented rapidly and at scale, providing a substantial boost to economic activity and employment, while delivering competitive, low carbon electricity [45]. In quantitative terms, extending the life of nuclear power plants from 40 to 60 years would retain 95 gigawatts (GW) of low carbon generation by 2025 and an additional 90 GW by 2030 [46,47]. At an estimated investment cost of US $650 per kilowatt for extension projects in much of Europe and the USA, this would be realized with a global investment of around US $120 billion over the next decade and create up to 370,000 jobs [6,45,48,49]” [2].

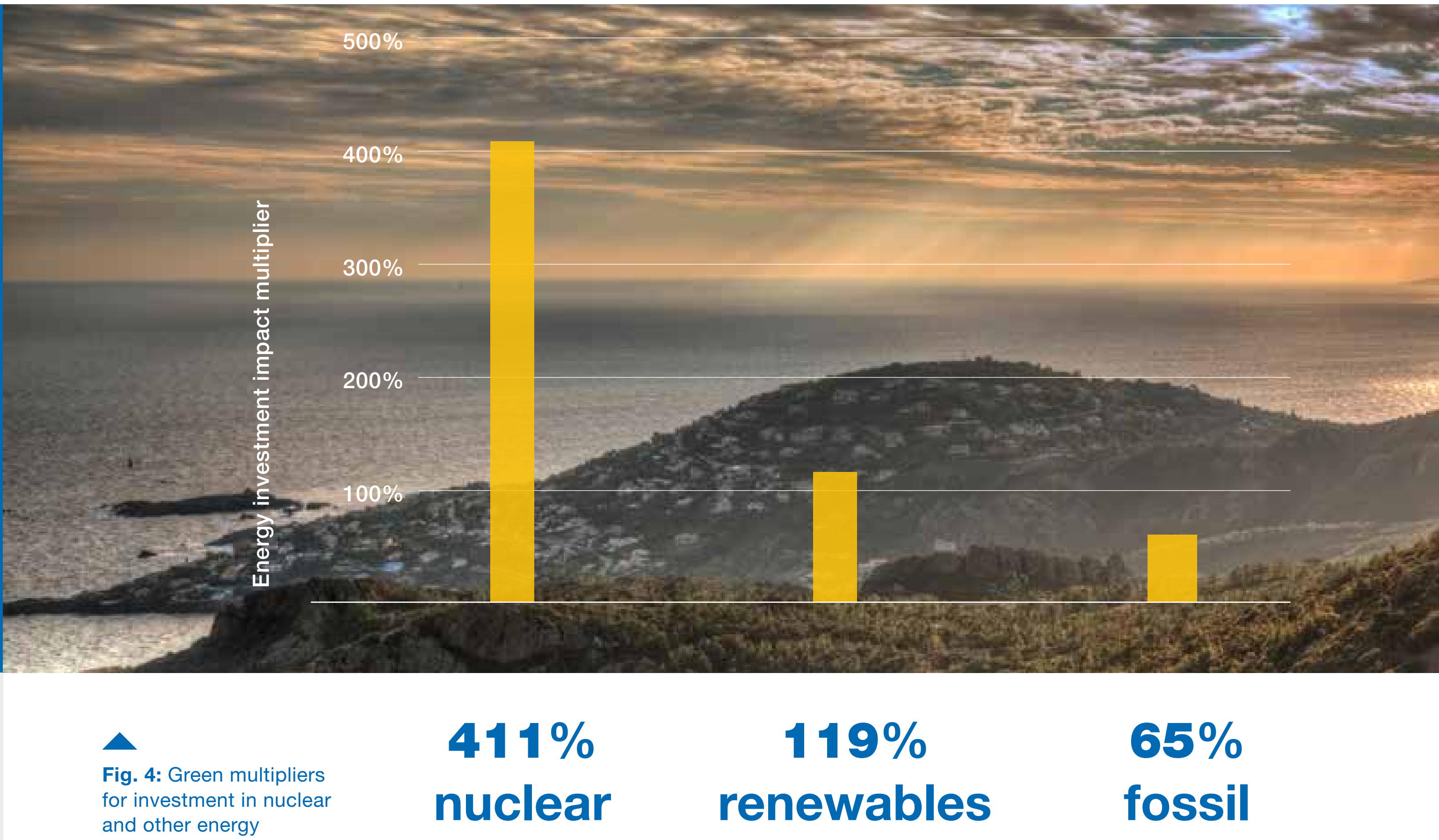
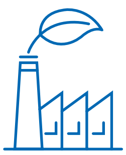


Fig. 4: Green multipliers for investment in nuclear and other energy sources [2, 44].

13. How can nuclear energy also avert and minimize loss and damage associated with the adverse effects of climate change? What further action is required to strengthen these efforts?

Countries are increasingly recognizing the value of nuclear energy to mitigate and enhance resilience against the adverse impacts of climate change, while ensuring a reliable and security energy supply critical for sustainable development. In addition to the 30 countries planning, implementing and/or accelerating action to capitalize on the substantial mitigation potential of nuclear energy in their NDCs and long term strategies (see response to question 3), around 15 least developed countries are actively considering or implementing nuclear power programmes. These efforts can be strengthened with additional capacity building (particularly in energy planning and nuclear infrastructure development), technology transfer and financing.

Countries are increasingly recognizing linkages between climate action and other aspects of sustainable development.



Investment in low carbon energy as part of mitigation policies can provide a substantial economic boost.

CROSS-CUTTING ISSUES

14. How are fairness considerations, including equity, being reflected in NDCs?

The IAEA, in partnership with other United Nations agencies, intergovernmental and non-governmental organizations, and experts, is working with countries to revise and enhance their NDCs, which includes addressing issues of fairness and equity in the context of supporting strategies to ensure a just transition to low carbon energy systems.

15. How are mitigation and adaptation actions with nuclear energy respecting, promoting and considering gender and intergenerational equality and empowering women?

Mitigation action using nuclear energy is proactively enhancing and promoting gender equality and the empowerment of women, who are integral to the nuclear energy sector. Recognizing the benefits that gender diversity brings to workplace, the IAEA, its Member States, industry and non-governmental organizations, are active in promoting interest in nuclear engineering, science and other nuclear related professions among women. For example, in partnership with the European Union, the IAEA Marie Sklodowska-Curie Fellowship Programme seeks to increase the number of women in the nuclear field, supporting an inclusive and diverse workforce to drive global scientific and technological innovation [50]. The United Kingdom also provides a leading example of how countries are explicitly incorporating specific policies and targets to enhance diversity, gender equality and women's participation in the nuclear sector via government–industry partnership agreements [51].

16. To what extent are countries recognizing the need to address other aspects of sustainable development, such as ensuring the integrity of all ecosystems and the protection of biodiversity to achieve the purpose and long term goals of the Paris Agreement?

Countries are increasingly recognizing linkages — both synergies and trade-offs — between climate action and other aspects of sustainable development, including protection of ecosystems (including oceans) (Sustainable Development Goals 14 and 15). This includes linkages affecting mitigation options for clean energy transitions [8]. To account for such interactions and ensure the integrity of all ecosystems, including oceans, and to protect biodiversity, life cycle approaches are increasingly being recognized and applied to develop strategies towards long term energy sector decarbonization [52]. Life cycle assessment can account for impacts from the production, operation and disposal of energy technologies across a wide range of environmental and sustainability indictors (for example, eutrophication, acidification and ecotoxicity, distinguishing between impacts on terrestrial, freshwater and marine environments). This is critical to identify and develop strategies to manage or avert potential negative impacts from clean energy transitions on ecosystems and biodiversity, particularly given the relatively large impacts of several clean energy technologies (see Fig. 5).

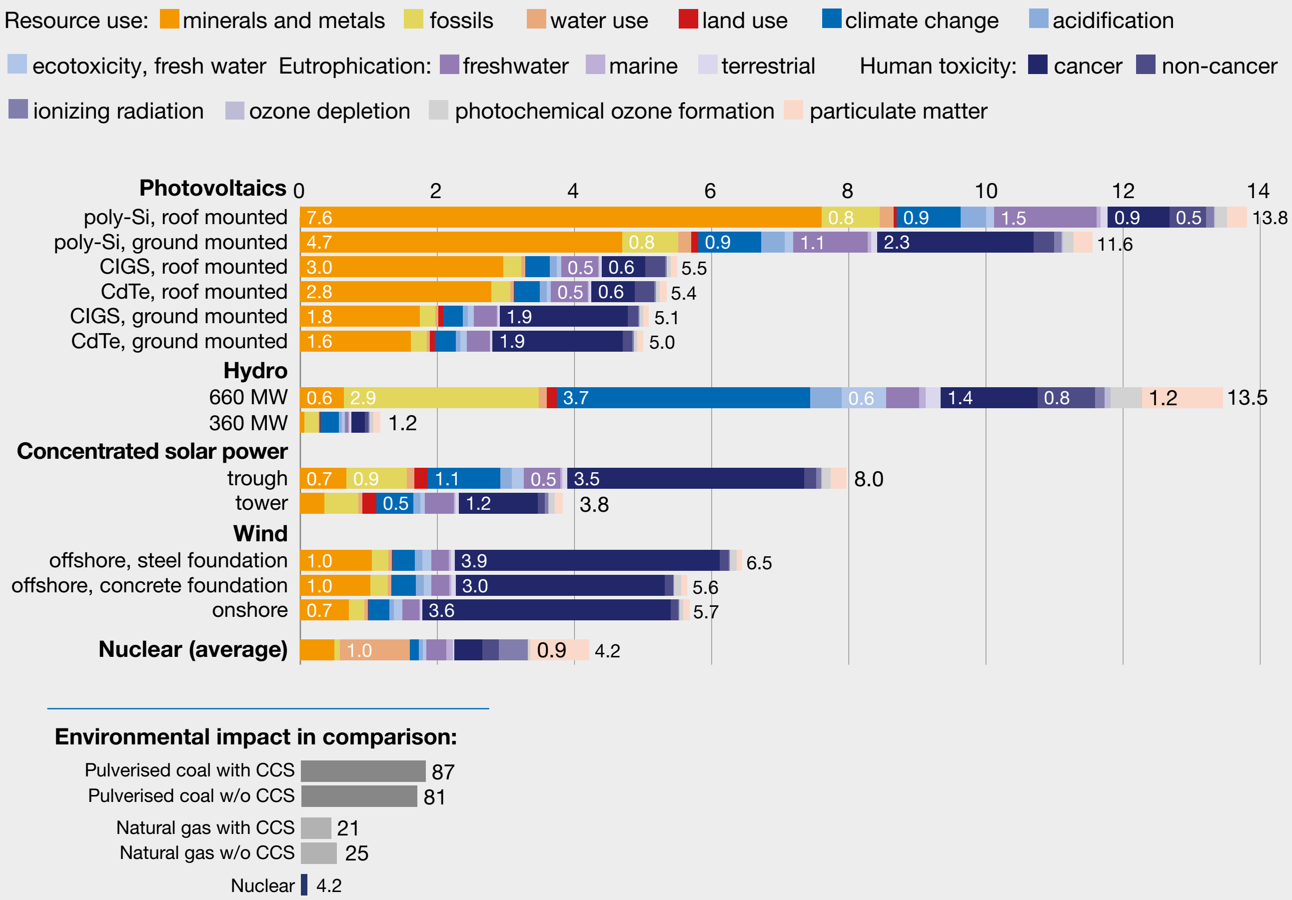


Fig. 5: Normalized and weighted life cycle impacts of renewable and nuclear technologies from the production of 1 kilowatt-hour in Europe in 2020, based on data from Ref. [51].

Note: poly-Si, CIGS and CdTe refer to the type of solar cells.

The IAEA also carries out climate monitoring activities through research in its own laboratories and extended networks of research institutions, academia and reference laboratories.

In Argentina, like in many parts of the world, water is at risk of over exploitation and contamination. To protect it, scientists are studying its most invisible details with the help of nuclear technology.

16. How is the IAEA contributing directly to the purpose and long-term goals of the Paris Agreement?

As a non-Party stakeholder, the IAEA contributes to the purpose and goals of the Paris Agreement by fostering the efficient, safe, secure and sustainable use of nuclear power "by supporting existing and new nuclear programmes around the world, catalysing innovation and building capacity in energy planning, analysis, and nuclear information and knowledge management" [53]. The IAEA also carries out climate adaptation and climate monitoring activities, for example through research in its own laboratories and through extended networks of research institutions, academia and reference laboratories. Once vetted, relevant nuclear technologies and techniques are transferred to countries, especially developing countries, through the IAEA Technical Cooperation programme. The Technical Cooperation programme is the IAEA's primary mechanism for helping countries address key development priorities. Over the past decade, the IAEA has supported almost 500 projects related to climate change adaptation in more than 100 countries around the world, disbursing over €110 million in support [54].

The IAEA has supported almost 500 projects related to climate change adaptation in more than 100 countries around the world

[1] UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, Global Stocktake, Global Stocktake (2023), https://unfccc.int/topics/global-stocktake

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Energy for a Net Zero World (2021), https://www.iaea.org/sites/default/files/21/10/nuclear-energy-for-a-net-zero-world.pdf

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Climate Change and Nuclear Power 2022: Securing clean energy for climate resilience (2022), https://www.iaea.org/sites/default/files/iaea-ccnp2022-body-web.pdf.

[4] INTERNATIONAL ENERGY AGENCY, Nuclear Power and Secure Energy Transitions (2022), https://www.iea.org/reports/nuclear-power-and-secure-energy-transitions

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Power Reactor Information System (2023), https://pris.iaea.org/pris/

[6] INTERNATIONAL ENERGY AGENCY, Nuclear Power in a Clean Energy System (2019), https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Energy, Electricity and Nuclear Power Estimates for the Period up to 2050, Reference Data Series No. 1, IAEA, Vienna (2022).

[8] Intergovernmental Panel on Climate Change, Climate Change 2022: Mitigation of Climate Change, Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (2022), https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

[9] INTERNATIONAL ENERGY AGENCY, World Energy Outlook 2022 (2022), https://www.iea.org/reports/world-energy-outlook-2022

[10] UNITED NATIONS ENVIRONMENT PROGRAMME, Emissions Gap Report 2022 (2022), https://www.unep.org/resources/emissions-gap-report-2022

[11] UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, Communication of long-term strategies (2023), www.unfccc.int/process/the-paris-agreement/long-term-strategies

[12] UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, NDC Registry (2023), www.unfccc.int/NDCREG

[13] REPUBLIC OF KOREA MINISTRY OF ENVIRONMENT, Nuclear power included in 'Korean Green Classification System'... NDC also redesigned (2022), www.gov.kr/portal/ntnadmNews/3088371?srchOrgCd=1480000

[14] INTERNATIONAL ENERGY AGENCY, CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (2022), https://www.oecd-ilibrary.org/energy/data/iea-co2-emissions-from-fuel-combustion-statistics_co2-data-en

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, The Potential Role of Nuclear Energy in National Climate Change Mitigation Strategies, IAEA-TECDOC-1984, IAEA, Vienna (2021).

REFERENCES

[16] RIAHI, K. et al., “Mitigation pathways compatible with long-term goals” Climate Change 2022: Mitigation of Climate Change, Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge (2022).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY 2023, Nuclear Energy in Mitigation Pathways to Net Zero, IAEA, Vienna (2023).

[18] INTERNATIONAL ENERGY AGENCY, Energy Technology Perspectives, International Energy Agency, Paris (2020).

[19] EMIRATES WATER AND ELECTRICITY COMPANY, personal communication, 2022.

[20] WORLD NUCLEAR NEWS, Chinese nuclear plant starts supplying industrial heating (2022), https://world-nuclear-news.org/Articles/Chinese-nuclear-plant-starts-supplying-industrial

[21] WORLD NUCLEAR NEWS 2023, China starts building long-distance nuclear heating pipeline (2023), https://world-nuclear-news.org/Articles/China-starts-building-long-distance-nuclear-heatin

[22] CHINA NATIONAL NUCLEAR CORPORATION, personal communication, 2021.

[23] UK DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY, Nuclear Sector Deal, Department for Business, Energy and Industrial Strategy, London (2018).

[24] UK DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY, Contracts for Difference, Department for Business, Energy and Industrial Strategy, London (2020).

[25] OFFICE OF GAS AND ELECTRICITY MARKETS, Capacity Market (CM) Rules, Office of Gas and Electricity Markets, London (2020).

[26] INFRASTRUCTURE AND PROJECTS AUTHORITY AND HM TREASURY, UK Guarantees Scheme, Infrastructure and Projects Authority and HM Treasury, London (2017).

[27] UK DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY, RAB Model for Nuclear: Government Response to the Consultation on a RAB Model for New Nuclear Projects, Department for Business, Energy and Industrial Strategy, London (2020).

[28] HM GOVERNMENT, The Ten Point Plan for a Green Industrial Revolution, HM Government, London (2020).

[29] Intergovernmental Panel on Climate Change, Climate Change 2022: Impacts, Adaptation, and Vulnerability, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (2022), https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/

[30] GUTIÉRREZ, J.M., et al., IPCC WGI Interactive Atlas, Climate Change 2021: The Physical Science Basis, Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (2021), http://interactive-atlas.ipcc.ch/

[31] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Energy in Climate Resilient Power Systems, IAEA, Vienna (2023).

[32] OECD NUCLEAR ENERGY AGENCY, Climate Change: Assessment of the Vulnerability of Nuclear Power Plants and Approaches for their Adaptation, OECD Nuclear Energy Agency, Paris (2021).

REFERENCES

[33] UNGER, T., KJELLSTRÖM, E., GODE, J., STRANDBERG, G., The Impact of Climate Change on Nuclear Power, Energiforsk, Stockholm (2021).

[34] INTERNATIONAL ENERGY AGENCY, World Energy Investment 2022, International Energy Agency, Paris (2023).

[35] INTERNATIONAL ATOMIC ENERGY AGENCY 2021, Transitions to Low-carbon Electricity Systems: Key Economic and Investment Trends Changing Course in a Post-pandemic World (2021), https://www.iaea.org/sites/default/files/21/06/transitions-to-low-carbon-electricity-systems-changing-course-in-a-post-pandemic-world.pdf

[36] ENERGY POLICY TRACKER, G20 Countries, International Institute for Sustainable Development, Winnipeg (2023).

[37] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Technology and Applications (2023), https://www.iaea.org/topics/nuclear-technology-and-applications

[38] UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, Updated Second Nationally Determined Contribution of the United Arab Emirates (2022), https://unfccc.int/sites/default/files/NDC/2022-06/UAE%20Second%20NDC%20-%20UNFCCC%20Submission%20-%20English%20-%20FINAL.pdf

[39] SECRETARIAT FOR UAE NATIONAL COMMITTEE ON SDGS, UAE and the 2030 Agenda for Sustainable Development: Excellence in Implementation, National Committee on Sustainable Development Goals (2017), https://sustainabledevelopment.un.org/content/documents/20161UAE_SDGs_Report_Full_English.pdf

[40] INTERNATIONAL ATOMIC ENERGY AGENCY 2018, IAEA Reviews UAE's Nuclear Power Infrastructure Development (2018), https://www.iaea.org/newscenter/pressreleases/iaea-reviews-uaes-nuclear-power-infrastructure-development

[41] IRENA AND INTERNATIONAL ATOMIC ENERGY AGENCY, IRENA and IAEA to Help African Union Develop Continental Power Master Plan with EU support (2021), https://www.irena.org/News/articles/2021/Sep/IRENA-and-IAEA-Selected-to-Help-African-Union-Develop-Continental-Power-Master-Plan-with-EU-support

[42] WORLD NUCLEAR NEWS, Viewpoint: Financing nuclear projects in developing countries (2020), www.world-nuclear-news.org/Articles/Viewpoint-Financing-nuclear-projects-in-developing

[43] INTERNATIONAL ENERGY AGENCY, Net Zero in 2050: A Roadmap for the Global Energy Sector, International Energy Agency, Paris (2021).

[44] BATINI, N. et al., Building Back Better: How Big Are Green Spending Multipliers? IMF Working Paper WP/21/87, International Monetary Fund, Washington, DC (2021).

[45] INTERNATIONAL ENERGY AGENCY, Projected Costs of Generating Electricity (2020), https://www.iea.org/reports/projected-costs-of-generating-electricity-2020

[46] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power Reactors in the World, Reference Data Series No. 2, IAEA, Vienna (2021).

[47] INTERNATIONAL ATOMIC ENERGY AGENCY, Climate Change and Nuclear Power 2020 (2020), https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1911_web.pdf

[48] INTERNATIONAL ENERGY AGENCY, Sustainable Recovery, World Energy Outlook Special Report, International Energy Agency, Paris (2020).

[49] INTERNATIONAL ENERGY AGENCY, Nuclear Power and Secure Energy Transitions International Energy Agency, Paris (2022).

[50] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Marie Sklodowska-Curie Fellowship Programme (2023), https://www.iaea.org/services/key-programmes/iaea-marie-sklodowska-curie-fellowship-programme

[51] DEPARTMENT FOR ENERGY SECURITY AND NET ZERO, DEPARTMENT FOR BUSINESS AND TRADE, AND DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY, Nuclear Sector Deal, Department for Energy Security and Net Zero and Department for Business and Trade, Department for Business, Energy and Industrial Strategy, London (2018).

[52] UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE, Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources, UN Economic Commission for Europe, Geneva (2022).

[53] INTERNATIONAL ATOMIC ENERGY AGENCY, Energy (2023), https://www.iaea.org/topics/energy

[54] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Science and Technology for Climate Change Mitigation, Adaptation and Monitoring (2022), https://www.iaea.org/sites/default/files/22/10/nuclear-science-and-technology-for-climate-change-mitigation-adaptation-and-monitoring.pdf

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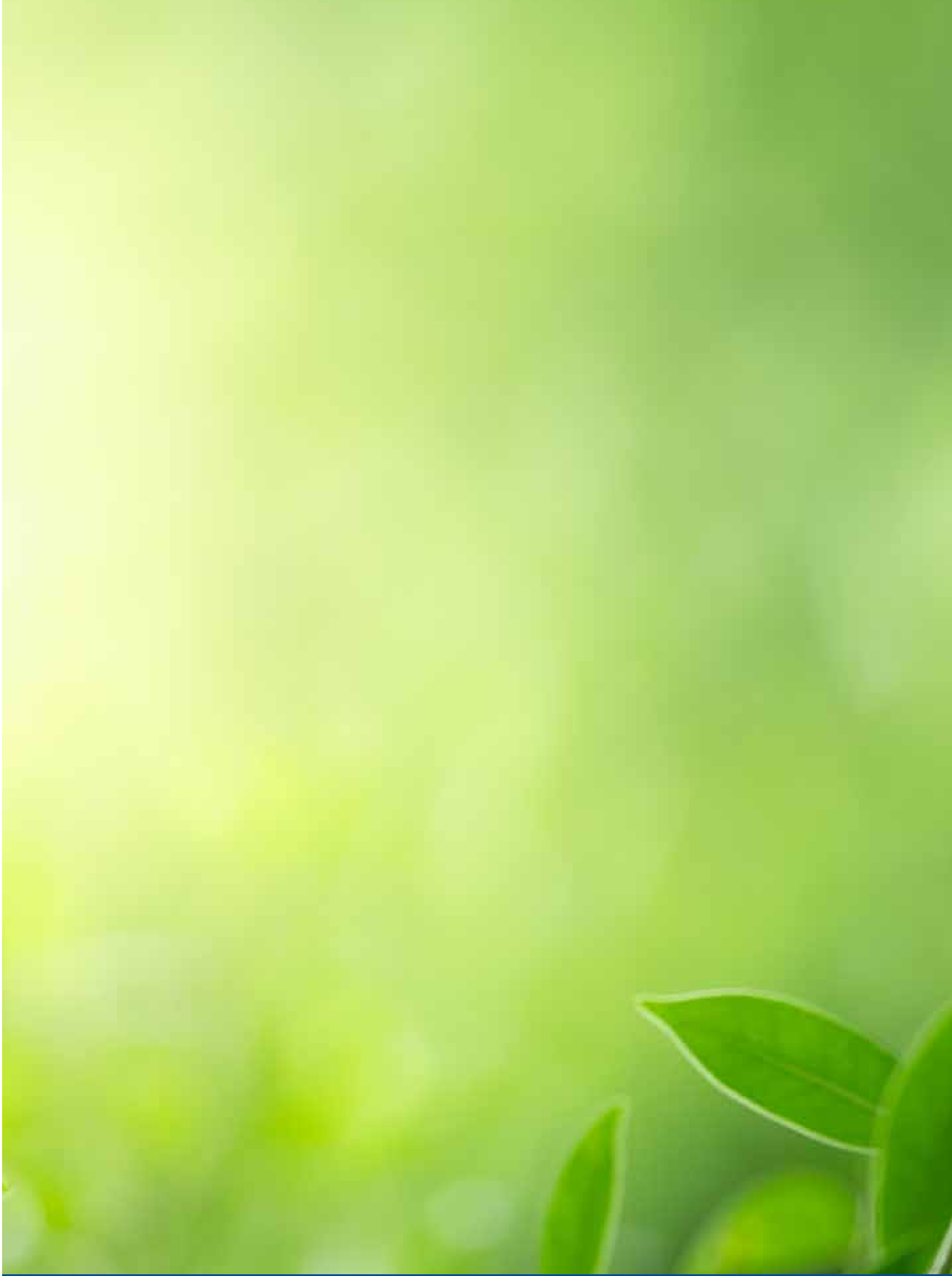

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