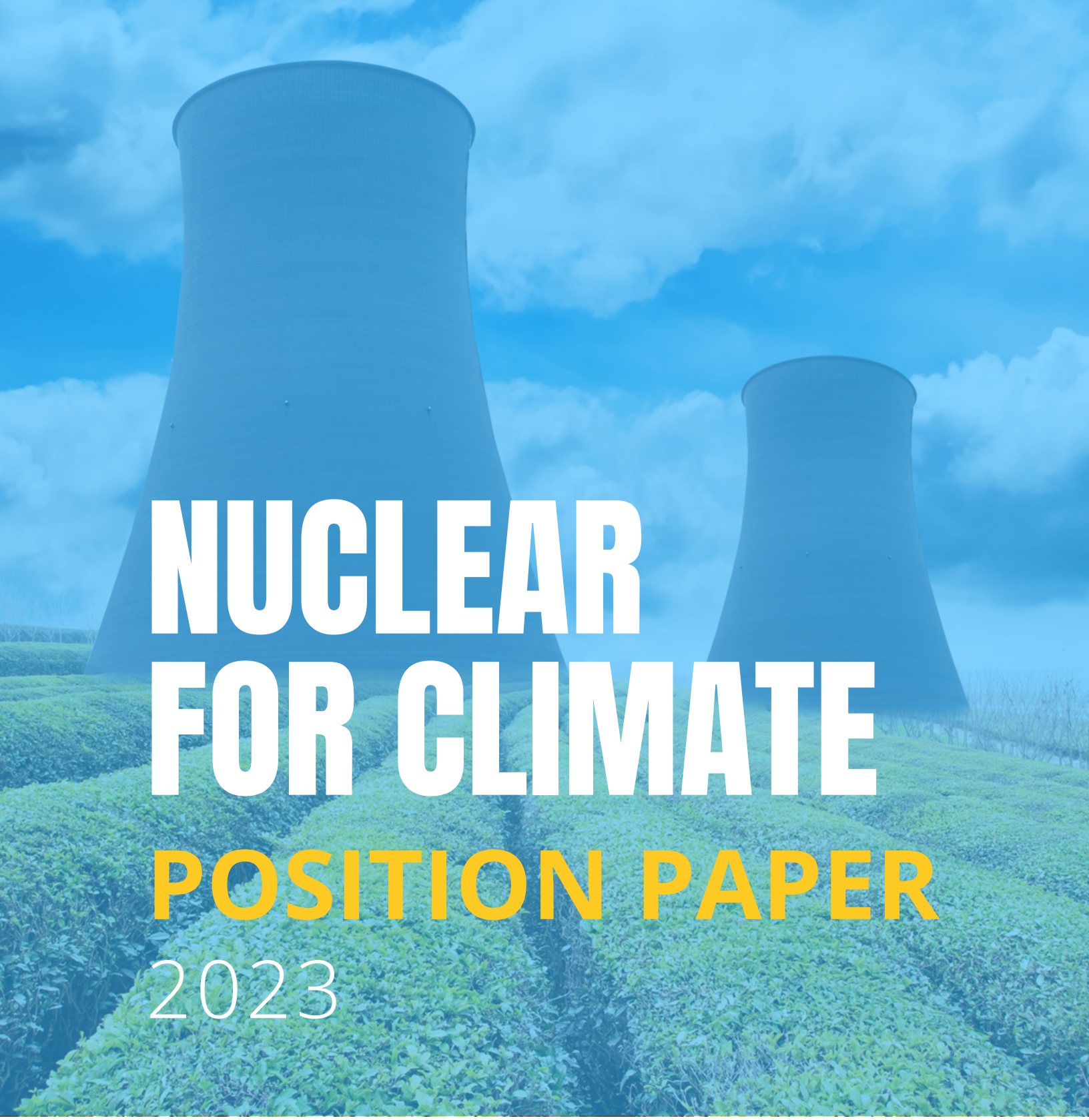


NUCLEAR FOR CLIMATE

POSITION PAPER

2023

Nuclear for CLIMATE

Call to Action

Nuclear for Climate urges policy makers to take decisive and evidence-based action to urgently reduce global greenhouse gas emissions and achieve net zero targets. We emphasise the importance of supporting nuclear energy as a key clean energy source in order to achieve these ambitious goals effectively and efficiently.

Executive Summary

- Nuclear energy has avoided the emission of over 63 gigatonnes of carbon dioxide since 1971.
- The International Energy Agency projects that nuclear energy capacity needs to double by 2050 to achieve net zero carbon emission goals.
- Nearly 30 parties have recognized the potential for mitigation through nuclear energy in their nationally determined contributions and long-term strategies.
- Nuclear energy has a median life cycle emission of 5.1 g of carbon dioxide per kilowatt hour, lower than solar and wind.
- Nuclear energy is the most land-efficient energy source, requiring significantly less space than any other electricity generator.
- Many countries, like France, have successfully integrated nuclear energy into their grids, providing clean and affordable power.
- Nuclear energy plays a role in furthering all United Nation sustainable development goals including: healthcare, food security, access to clean water, industry, and economic growth.
- The global market for nuclear products, services, and fuel is estimated to be worth $500-$740 billion over the next 10 years, stimulating economic development and job creation.

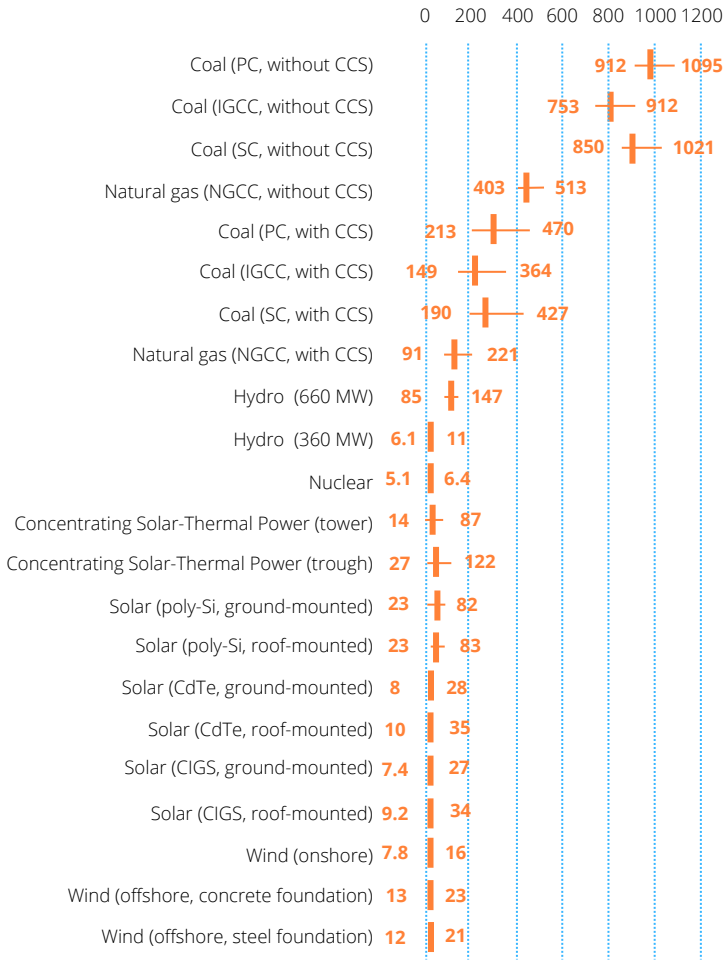
Nuclear in the Global Stocktake

With over 400 nuclear energy reactors already in operation and more than 50 under construction, nuclear energy plays a vital role in climate mitigation efforts (International Atomic Energy Agency, 2023) by preventing the release of over 63 gigatonnes of carbon dioxide since 1971 that would have otherwise come from fossil fuels (International Energy Agency, 2019).

Nuclear energy provides a dependable source of electricity that supports decarbonization strategies, enabling the integration of variable low-carbon energy sources like wind and solar. Nuclear energy is the second-largest source of clean energy globally after hydroelectric energy (World Nuclear Association, 2023).

The International Energy Agency (IEA) projects that to achieve net zero carbon emissions by 2050, nuclear energy capacity will have to double from 413 GW today to 812 GW by 2050 (International Energy Agency, 2022). In order to achieve this, annual nuclear capacity additions would need to reach 27 GW in the 2030s (International Energy Agency, 2022).

Presently, there are 196 parties to the United Nations Framework Convention on Climate Change. These parties have



Lifecycle greenhouse gas emission ranges in g CO2 eq. per kWh, regional variation, 2020 (United Nations Economic Commission for Europe, 2022)

pledged to implement actionable plans toward greenhouse gas emission reduction.

Based on the nationally determined contributions (NDCs) and long-term strategies (LTSs), nearly 30 parties are presently capitalising on the significant potential for mitigation through nuclear energy (United Nations, 2023). This encompasses 14 parties that have recognised the vital role of nuclear energy in their latest NDCs, along with another almost 20 parties that have included nuclear energy in their LTSs (United Nations, 2023). Beyond NDCs and LTSs, an additional 50 parties are pursuing nuclear energy, ranging from countries that have expressed an interest to those currently constructing their first power plants (United Nations, 2023).

	Using Nuclear Power Today	**Constructing First Nuclear Power Plant**	**Other Countries**
Nuclear Energy in NDC and LTS	Canada, China, Ukraine, United Kingdom, United States		
Nuclear energy in NDC only	Argentina, Armenia, India, Iran, Russian Federation, United Arab Emirates	Turkey	Ghana
Nuclear energy in LTs only	Czech Republic, Finland, France, Hungary, Japan, Mexico, Slovakia, Slovenia, Sweden		Australia, Colombia, Morocco, Singapore

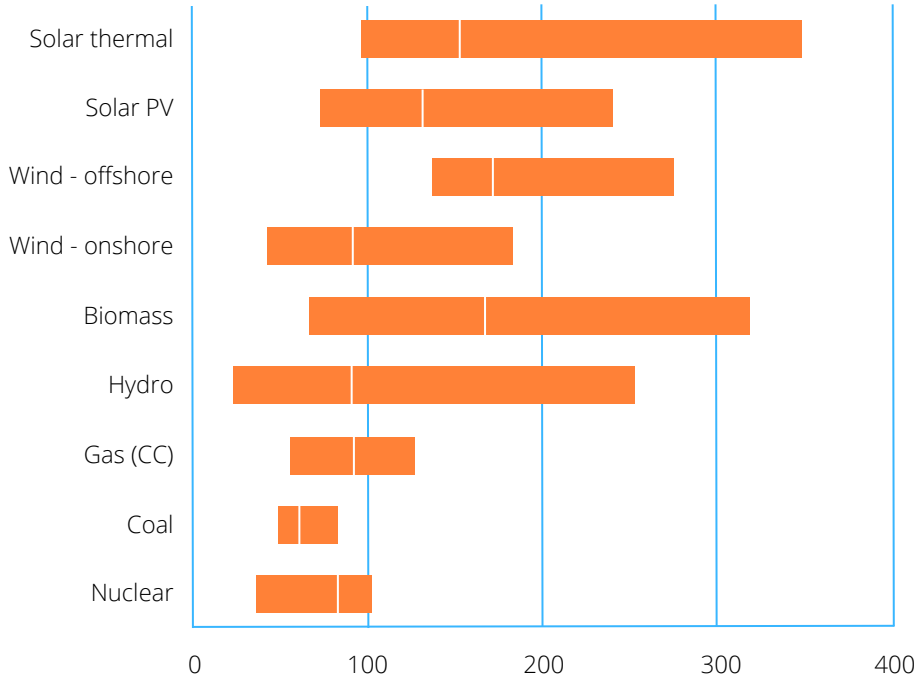
Nuclear energy in national commitments and strategies, mid-2022 (International Atomic Energy Agency, 2023)

Some key features for the Global Stocktake 2023:

- According to the IEA (2023), only 11% of global clean power investment is for nuclear energy.
- It is anticipated that in the next Global Stocktake in 2028, more nuclear energy will be reported as part of many countries' energy mix as they try to meet their NDC targets.
- By 2050, renewables and nuclear will need to displace most fossil fuel use with nuclear electricity doubling in capacity to reach net zero carbon emissions according to the IEA (2022).

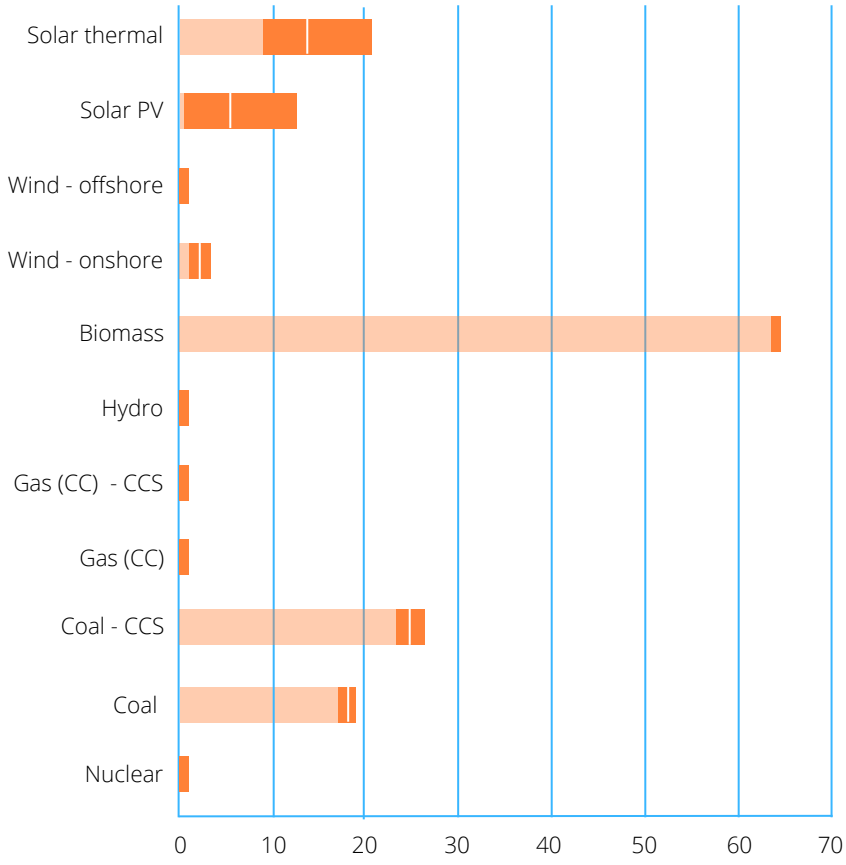
Nuclear is Affordable and Clean Energy

According to the United Nations Economic Commission for Europe, nuclear energy has a median life cycle emission of 5.1 g of carbon dioxide per kilowatt hour, which is comparable to wind (7.8 g) and lower than solar (23 g) (United Nations Economic Commission for Europe, 2022). It has helped avert 2 million air pollution-related deaths (Kharecha, 2013).



Levelized costs of electricity generation (US $2013/MW·h) at 7% market discount rate. Bars indicate low, median and high estimates (International Atomic Energy Agency, 2017)

Another advantage of nuclear energy is its energy density, as it occupies significantly less space compared to other energy sources. It is the most land-efficient energy source, requiring up to 27 times less land per MWh than solar and 330 times less than onshore wind farms (Ritchie, 2022). In countries with limited renewable energy potential, nuclear energy provides energy security by supplying clean baseload energy with a minimum land footprint.



Life cycle land occupation (m -year/MW-h) required

While the initial capital or construction costs of a nuclear plant are considered high, the cost per unit of electricity produced decreases over time as the plant operates for several decades. Cost overruns due to typical construction delays have been identified as a major cost factor in nuclear projects, primarily in the United States and Europe (Eash-Gates, 2020). However, countries like South Korea have managed to build reactors more efficiently and at a lower cost, both domestically and in the United Arab Emirates (UAE) (World Nuclear Association, 2023).

Small modular reactors (SMRs) have the potential to improve the economics of nuclear energy in several ways. They are smaller in size and can be manufactured in factories before being transported on site, which reduces construction costs (Murakami, 2022). This approach allows for standardised production and streamlined manufacturing processes, leading

to economies of scale (Murakami, 2022).

Many countries have successfully integrated nuclear energy into their national grids, providing clean and affordable power. France, for example, heavily relies on nuclear energy, with over 70% of its electricity coming from nuclear sources (International Energy Agency, 2021). Thanks to nuclear energy, France boasts the lowest emissions per capita of any advanced economy in the world (International Energy Agency, 2021). Electricity prices in France are below average in the European Union (EU), in spite of having some of the highest taxes on electricity in the EU (International Energy Agency, 2021).

Nuclear in water supply and agriculture

Nuclear desalination offers a potential solution to water scarcity in regions with limited freshwater resources (Shatilla, 2020). Desalination processes, such as reverse osmosis or multi-stage flash distillation, use nuclear energy as a heat source to separate salt and impurities from seawater. This approach provides a sustainable source of clean water and reduces the strain on traditional freshwater sources, promoting water supply security. It has been used in Brazil, China, Spain, and the UAE.

Furthermore, nuclear technology plays a role in water resource management. Isotope tracers and nuclear-based sensors accurately assess groundwater reserves and water movement in hydrological systems (Vystavna, 2022). This information helps inform water allocation and conservation plans, which are crucial to water security.

Nuclear-derived, sterile insect technique (SIT) is an environmentally-friendly method of insect pest management, specifically targeting insect pests. Chemical

insecticides have broad-spectrum effects, e.g., unintentionally killing non-target organisms such as pollinators and natural predators (International Atomic Energy Agency, n.d.). With SIT, unlike chemical insecticides, insects do not become resistant to SIT, and this technique does not involve harmful chemicals detrimental to human health (International Atomic Energy Agency, n.d.).

Finally, subjecting food to controlled radiation doses eliminates harmful microbes, reducing the risk of foodborne illnesses. This process, known as food irradiation, not only furthers public health but also advances international trade by fulfilling the sanitary requirements of different countries. In the face of climate change, food irradiation extends shelf life, reduces food waste, and conserves water, energy, and land resources (International Atomic Energy Agency, 2015). Furthermore, this process does not significantly alter nutritional value, taste, or texture (International Atomic Energy Agency, 2015).

Nuclear in healthcare

Nuclear medicine uses radionuclides to diagnose and treat various medical conditions, including cancer, heart disease, and neurological disorders (International Atomic Energy Agency, 2017). Over 40 million nuclear medicine procedures are safely carried out throughout the world every year (International Atomic Energy Agency, 2017). These procedures include diagnostic imaging techniques, which use small amounts of radioactive material, called radiotracers, to diagnose and provide information about the functionality of specific organs.

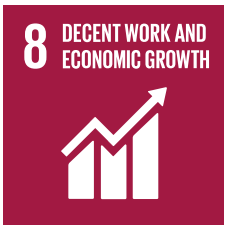
Another type of nuclear medicine is radiation therapy, a treatment technique that uses high-energy radiation to treat various types of cancer, including breast, prostate, and lung cancer. Radioisotopes are used to generate the high-energy radiation to kill cancer cells (Mayo Clinic, 2023). All these types of nuclear medicine help improve quality of life and life expectancy.

Nuclear in industry

Industries such as automobile manufacturing, steel production, electronics manufacturing, and consumer goods production rely on a stable power supply to ensure smooth operation of heavy machinery, industrial equipment, and assembly lines. Nuclear plants are reliable, capable of operating 24/7, and are resilient to weather fluctuations.

Aside from power, radioactive isotopes are used for a variety of industrial applications, cobalt-60 and caesium-137 are used for non-destructive testing of materials. Isotopes are also used in nuclear gauges to measure the density, thickness, and moisture content of materials. These gauges are widely used in construction, civil engineering, and mining industries to ensure the quality and integrity of building materials.

Nuclear power plants (including SMRs) can be used for non-electricity applications using process heat (International Atomic Energy Agency, 2021). Some reactors also support hydrogen production, and thus, are a clean alternative to high CO2 emitting fossil fuel plants, which currently generate the bulk of hydrogen (The Royal Society, 2020). Co-generation of electricity and energy for non-electrical applications improves overall plant thermal efficiency, thereby reducing waste heat and improving economic viability.



Nuclear creates jobs & economic growth

The nuclear energy industry can play an essential role in job creation and economic growth, providing short- and long-term employment and economic benefits (NICE Future, 2022). Studies show that the number of direct jobs created at a nuclear energy plant range between 400 and 1,000 employees per gigawatt of electricity.

Country	Nuclear Capability (GWe)		Direct	Indirect	Induced	Total Estimated Jobs
France	63		125,000	114,000	171,000	410,000
South Korea	18		29,400	36,700	27,400	93,500
United States	98		70,000		430,000	500,000

Countrywide job creation from nuclear programs (NICE Future, 2022)

In countries like France and the United States, nuclear workers earn one-third more than those in the renewable sector. Philippe Costes, former Senior Advisor at World Nuclear Association stated that, “While nuclear provides jobs locally around the plant and in regional economies during construction similar to wind, during operation only nuclear provides significant and sustainable jobs to the local and regional economies.” (Watson, 2022)

New nuclear plant projects internationally are currently in the licensing and advanced planning stage. As a result, the years ahead will see a surge in demand for materials, components and services for the global nuclear industry (U.S. Department of Energy, 2020). The US Department of Commerce estimates the global market for nuclear products, services and fuel at $500-$740 billion over the next 10 years (U.S. Department of Energy, 2020).

South Korea is a prime example of the correlation between nuclear industry growth and economic development. Investment in the South Korean nuclear sector spurred advancements in engineering, manufacturing, and construction, which benefited the nuclear industry and had positive spillover effects on sectors like transportation and logistics. Moreover, the nuclear industry's growth stimulated the creation of a robust domestic supply chain, fostering the emergence of various specialised suppliers ranging from steel manufacturers to electrical equipment providers.

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Nuclear energy is a key source of clean energy.

About N4C

Nuclear for Climate is a grassroots initiative co-founded in 2015 after the COP21 conference in Paris. It gathers over 150 associations, professionals, scientists and enthusiastic volunteers from all around the globe with the goal of educating policymakers and the public about nuclear energy and encouraging its use for those cases where it can be helpful as one of the solutions as a carbon-free energy for the energy transition and to mitigate climate change.

Contact

netzeroneedsnuclear.com

@nuclear4climate_

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