WIN GLOBAL COP27 POSITION PAPER
HARNESSING THE POWER OF NUCLEAR - CLEAN ENERGY, WATER, TRANSPORTATION AND JOBS

WHO WE ARE

Women in Nuclear Global (WiN Global) is a non-profit organization of women working professionally in various areas of nuclear energy and radiation applications. Since our foundation in 1992, we have been strong advocates for environmental sustainability, diversity, and gender equality. To power a thriving, inclusive future for all, we are committed to promote an evidence-based dialogue with the public to raise awareness about the essential contributions of nuclear technology to people and society, especially as part of the solution to the climate crisis and as a key element to achieve the United Nations Sustainable Development Goals (SDGs).

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EXECUTIVE SUMMARY

Climate change is one of the most significant challenges facing humanity today, which is why States across the globe are pursuing deep decarbonization. Developing and deploying clean energy solutions will ensure a better future for everyone but will disproportionally affect traditionally disadvantaged and vulnerable groups, including women and children.

Current nuclear power technology and in service nuclear power plants are very important in supporting climate action. This paper is focused on emerging nuclear technologies and outlines the benefits that advanced nuclear can provide and, in particular, those it can offer to some of the most vulnerable communities. These benefits, delivered by micro or small modular reactors, include energy resilience, energy independence, and affordable, economic, reliable and secure baseload power. They can be enhanced with dual-use technology features of nuclear power plants to enable vulnerable communities to have access to clean water through desalination and clean transportation through hydrogen production. Finally, the addition of clean energy infrastructure can provide clean jobs across a wide variety of skills, expertise and trades for local community members, including women.

Women and children, as traditionally vulnerable and disadvantaged groups worldwide, are heavily affected by climate change. This is why we need to take action and pursue deep decarbonization. Nuclear power and its benefits are a part of this solution.

Harnessing the Power of Nuclear
CLEAN ENERGY, WATER, TRANSPORTATION AND JOBS

Climate change is one of the most significant global crises facing humanity today, which is why States worldwide are pursuing deep decarbonization. Developing and deploying clean energy solutions will ensure a better future for everyone, but will have outsized impacts on traditionally disadvantaged and vulnerable groups, including women and children. Extreme weather events, including droughts and floods, are affecting access to clean water, exacerbating food scarcity in many regions, and threatening existing energy infrastructures that provide power to schools, businesses, and homes.

If we are to reverse the current trend, we need to develop and deploy greenhouse gas-free energy solutions that are affordable, accessible, and suitable for a wide variety of populations and geographic regions. The maintenance of in-service nuclear power plants is essential in reducing carbon emissions globally. With the introduction of emerging advanced nuclear technologies ensuring future power generation remains sustainable and reliable for future demands. In this paper, we advocate the inclusion of nuclear energy solutions because they can provide carbon-pollution free electricity and access to clean water, clean hydrogen to power vehicles, and the potential for clean jobs.

Nuclear energy in the form of micro and small modular reactors is particularly well suited to meet growing energy demands because it has a light footprint in comparison with other renewables like solar and wind and can be implemented regardless of local climate. It also provides stable baseload power that is reliable, resilient, and secure. The clean hydrogen these reactors generate can be used in hydrogen-powered vehicles, including personal vehicles and public transit, thereby providing mobility to women and girls seeking medical services and transportation to/from work and school. Importantly, this energy source has other vital applications that can help to provide access to clean water and, therefore, hygienic sanitation facilities for many communities. Finally, the addition of clean energy infrastructure can provide clean jobs for local community members, including women.

BENEFITS OF NUCLEAR

Below, we elaborate on the benefits that nuclear can offer to vulnerable communities.

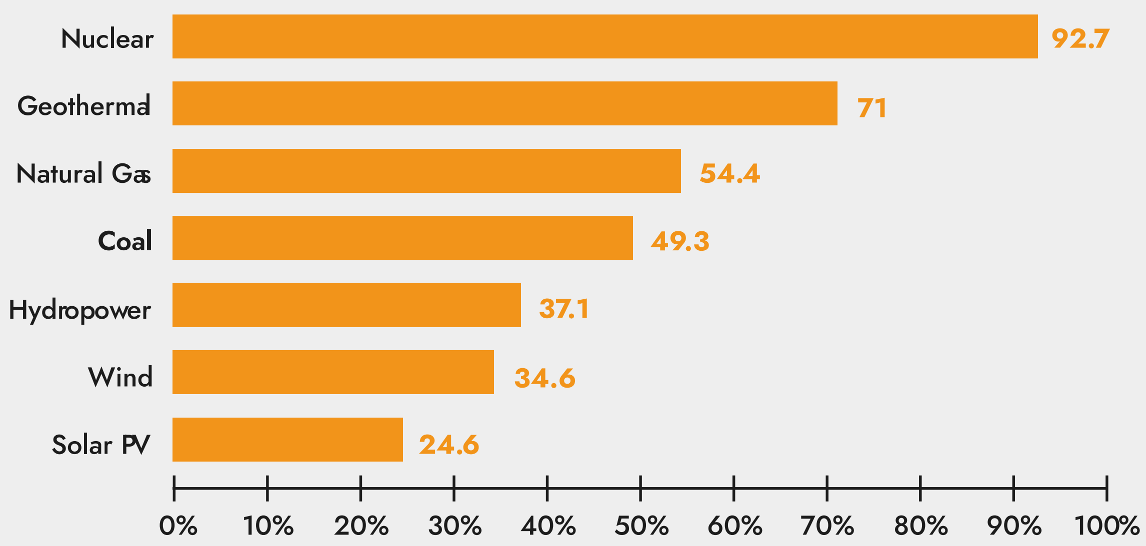
Energy resilience

As States around the world experience rapid clean energy transition, the International Energy Agency (IEA) forecasts that renewables will be able to meet only 80% of the rising global clean energy demand in the next ten years[1]. This massive transition is supported by the United Nations and International Monetary Fund (IMF), which have called for the expedited retirement of coal plants, and the simultaneous increase in green energy sources through strategic investments, a strategy called the global 'green recovery'[2].

While renewable energy sources like solar and wind have been promoted as a solution to climate change, they are intermittent and have lower capacity factors (the period that they are available to provide power) than other generation options. (*See Figure 1*).

UNITED STATES CAPACITY FACTOR BY ENERGY SOURCE 2021

Figure 1: Comparison of capacity factors of US energy sources in 2021[3]



1. Cozzi, L., World Energy Outlook 2020.
2. Kanak, D.P. How to replace coal power with renewables in developing countries. 2020. Available: https://www.weforum.org/agenda/2020/05/how-to-replace-coal-and-accelerate-the-energy-transition-in-developing-countries/
3. Administration, U.S.E.I., What is Generation Capacity? 2020, Office of Nuclear Energy: US

An electricity grid must be stable. Many grids with a high penetration of renewables rely on a firm capacity, which is usually provided by coal, natural gas, or a hydrocarbon-powered generator (diesel or propane) to maintain stability and avoid major power outages. The variable nature of renewables makes accurately predicting and adjusting a power plant's output difficult for power plant managers, who are tasked with meeting energy demands that fluctuate both hourly and seasonally.

The struggle to maintain a reliable electricity supply can be witnessed in the case of Australia's electricity grid when its energy market operator activated the Reliability and Emergency Reserve Trader (RERT) mechanism in 2017 to manage the lack of supply compared with demand. This problem turned into a trend that recurred six times during the summer seasons of 2017–18, 2018–19, and 2019–20 with the latest emergency reserve activation in May 2021[4]. The State of Energy Market — the Australian Energy Regulator's (AER's) annual report on the energy industry — stated that these issues were exacerbated by the significant development of large-scale renewable resources, lower forecast peak demand, and minor generation and transmission augmentations[5].

In the North American region, states such as California that have announced their goals to rapidly decarbonize are currently experiencing an energy reality check. Due to the extreme heat during the summer of 2022, energy consumption skyrocketed in the afternoon resulting in a massive increase in energy consumption as residents turned on their air-conditioners[6]. The peak demand could not be met with renewable sources, which supplied only slightly over a quarter of the energy needed; the rest was generated by gas-fired power plants[7]. California's increased energy demand coincides with a multi-year drought that is stressing the region's hydroelectric-power supplies.

California's lawmakers bore witness to the state's reliance on fossil-fuel plants during these heat waves as solar arrays failed to meet energy needs. This prompted the life extension of Diablo Canyon nuclear power plant for another five years — a move that would help combat the region's energy shortages while preventing millions of tons of carbon from

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4. (AER), A.E.R., State of Energy Market 2021. 2021, AER.
5. Ibid.
6. Dawid, I California's Energy Reality Check. 2022; Available: https://www.planetizen.com/news/2022/09/118734-californias-energy-reality-check
7. Ibid.

being released into the atmosphere[8]. California serves as just one example of the crises many other regions are facing as the impacts of climate change increase in severity.

Purpose and economic competition

One barrier some regions have faced to adopting nuclear is the cost associated with the infrastructure needed for large light water reactors (LWRs). Compared to LWRs, small modular reactors (SMRs) require less infrastructure. They also have a lighter environmental footprint than LWRs, wind and solar. In principle, SMRs rely heavily on factory-based fabrication to either construct the complete reactor module or fabricate major reactor sub-assemblies as individual modules[9]. The modular method of process simplification and design standardization allows the reduction of risk-associated costs (e.g. weather delays, component failures, work redesigns) and also promotes efficiency in construction, operation, and decommissioning phases[10].

As a result, SMRs can be constructed faster and, due to their modularity, can start generating revenue soon after the first unit arrives while subsequent units are still under construction. This reduces the initial investment and the need for credit[11]. These are significant advantages that could expedite the development of nuclear energy programmes, which is critical given the world's need for a rapid energy transition (i.e. expansion of renewables and the retirement of fossil-fuel power plants) that can provide stable energy supplies.

Furthermore, with advanced SMRs' ability to load-follow and remain flexible to variability in demand from renewables, several notable publications (e.g., the Intergovernmental Panel on Climate Change (IPCC) report) have stated that nuclear energy plays an important role in combating climate change and will make a key contribution to a low-carbon energy transition[12].

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8. Rott, N. California lawmakers extend the life of the state's last nuclear power plant. 2022. Available: https://www.npr.org/2022/09/01/1119778975/california-lawmakers-extend-the-life-of-the-states-last-nuclear-power-plant.
9. Omar, H., G. Graetz, and M. Ho, Decarbonizing with Nuclear Power, Current Builds, and Future Trends. The 4Ds of Energy Transition: Decarbonization, Decentralization, Decreasing Use and Digitalization, 2022: p. 103-151.
10. Ibid.
11. Ibid.
12. (IPCC), I.P.o.C.C. All about the IPCC report on climate change. 2022. Available: https://www.orano.group/en/unpacking-nuclear/all-about-the-ipcc-report-on-climate-change#:~:text=The%20IPCC%20has%20also%20studied,at%20almost%209%25%20in%202050

Many coal-fired power plants around the world are currently experiencing a rapid decline in capacity that will continue according to the US Energy Information Administration (EIA), which projects a further reduction of 4.8% in coal consumption[13]. Studies have shown that nuclear technologies are uniquely suited to repurposing existing coal infrastructures because they include cooling water delivery systems, demineralized water, potable water, and site fire protection, and do so at affordable cost[14]. Furthermore, due to its compact and modular reactor design, this could provide an opportunity for local communities who live in remote locations with limited access to water and have smaller electricity grids to access a stable and reliable energy supply[15].

Affordable energy

A popular argument made by nuclear opponents is that apart from a longer construction period to build nuclear power plants, they are also more expensive than other low-carbon energy sources such as renewables. Undeniably, the cost of wind and solar has rapidly declined to the point where it is cheaper than new fossil fuels[16].

However, if the levelized cost of electricity (LCOE) is used as the tool for energy technology comparison, the LCOE of nuclear in 2025 is reported to have a range from about $55 to $95 per MWh compared to coal (almost $100/MWh) and gas ($80/MWh). For the non-dispatchable sources of electricity, onshore wind power with a capacity of more than 1 MW has the lowest energy cost at $40–$50/MWh, utility-scale solar photovoltaic costs $40–80/MWh, while offshore wind costs roughly $80–110/MWh[17 18].

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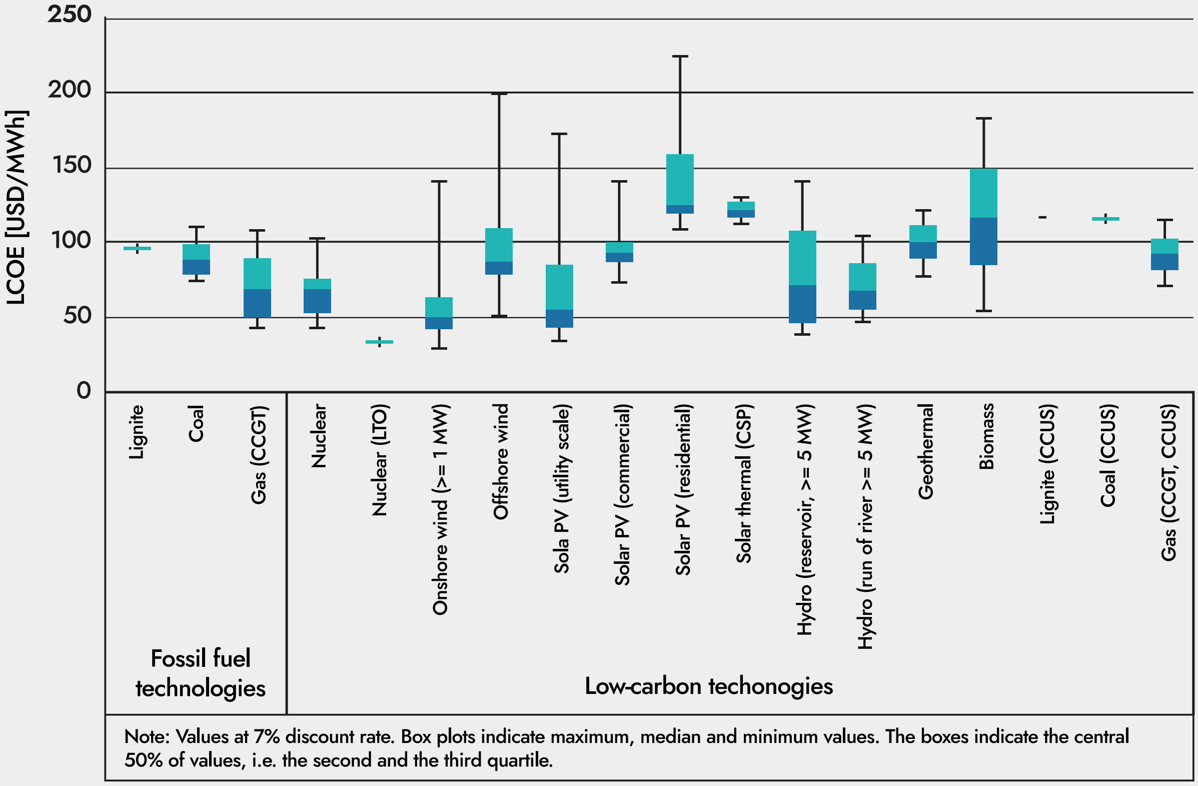
13. Snook, M. EIA lowers 2022 coal consumption estimates as plants retire. 2022. Available: https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/coal/071222-eia-lowers-2022-coal-consumption-estimates-as-plants-retire.
14. NuScale Power, L. The Changing Role of Coal in Electrical Generation. 2022. Available: https://www.nuscalepower.com/environment/coal-plants
15. Energy, O.o.N. Benefits of Small Modular Reactors (SMRs). Available: https://www.energy.gov/ne/benefits-small-modular-reactors-smrs#:~:text=Small%20modular%20reactors%20offer%20a,security%20compared%20to%20earlier%20designs
16. Regenpower. Why renewable energy prices are declining? 2021; Available: https://regenpower.com/articles/why-renewable-energy-prices-are-declining/#:~:text=In%20most%20places%20in%20the,6.8%20cents%20per%20kilowatt-hour.
17. Lorenczik, S., et al., Projected costs of generating electricity-2020 edition 2020. Organisation for Economic Co-Operation and Development.
18. Dalton, D. Cost Report / Nuclear Is 'Most Affordable Dispatchable Source Of Low-Carbon Electricity'. 2020. Available: https://www.nucnet.org/news/nuclear-is-most-affordable-dispatchable-source-of-low-carbon-electricity-12-3-2020

Figure 2: LCOE by technology[19]



However, the weakness of the LCOE is that it considers only plant-level costs and ignores the "effects at the system level in the sense that specific technologies demand additional investments in transmission and distribution grids or demand specific additional reconfigurations of the electricity systems"[20]. In other words, the whole system cost (e.g. renewable integration into the electricity system that includes intermittent generation backup and grid strengthening) projects an opposite outcome to energy users who have already felt the impact of rising energy costs.

To achieve the lowest system cost without compromising national deep decarbonization goals (i.e. >83% decarbonized), nuclear needs to be part of the solution. Disregarding this could result in massive spending. For example, Australia could end up spending more than AUD20 billion per year as the capacity is forced to expand fivefold to meet the demand with 100% renewable energy in the form of wind and solar[21].

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19. Dalton, D. Cost Report / Nuclear Is 'Most Affordable Dispatchable Source Of Low-Carbon Electricity'. 2020; Available from: https://www.nucnet.org/news/nuclear-is-most-affordable-dispatchable-source-of-low-carbon-electricity-12-3-2020
20. Aldersey-Williams, J. and T. Rubert, Levelised cost of energy–A theoretical justification and critical assessment. Energy policy, 2019. 124: p. 169-179.
21. Geoff Bongers, A.B., Stephanie Byrom & Nathan Bongers, Decarbonised Electricity. The Lowest Cost Path to Net Zero Emissions. 2021, Brisbane, Australia: Gamma Energy Technology P/L. 85.

Energy independence

As the world's energy systems undergo a significant shift towards clean energy, the massive implementation of a wide array of required clean energy technologies is witnessed by the efforts of an ever-increasing number of States and businesses to reduce their greenhouse gas emissions to net zero. Many of the technologies required for this shift depend on minerals like copper, lithium, nickel, cobalt, and rare earth elements.

Solar photovoltaic facilities, wind farms, and electric vehicles require more of these minerals than plants powered by fossil fuels. For example, an onshore wind farm needs nine times more mineral resources than a gas-fired power plant. A typical electric car needs sixfold the mineral input of a regular automobile. As the share of renewables has expanded since 2010, the average quantity of minerals required for a new unit of electricity generation capacity has climbed by 50%[22].

Over three-quarters of world's output of lithium, cobalt, and rare earth elements is under the jurisdiction of the producing States. In other circumstances, one nation accounts for about half of global production. The concentration level is even higher in the processing and refining industries, which could be a concern for businesses that use imported minerals to produce solar panels, wind turbines, electric motors, and batteries because these supply chains can be quickly affected by legislative changes, trade restrictions, or political unrest in a small number of States[23].

22. IEA, I., The role of critical minerals in clean energy transitions. 2021, International Energy Agency Paris, France.

Figure 3: Critical mineral needs for clean energy technologies[24]

	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminium
Solar PV	High	Low	Low	Low	Low	Low	Low	Low	High
Wind	High	Low	Moderate	Low	High	Moderate	High	Low	Moderate
Hydro	Moderate	Low	Low	Low	Low	Moderate	Moderate	Low	Moderate
CSP	Moderate	Low	Moderate	Low	Low	High	Moderate	Low	High
Bioenergy	High	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Geothermal	Low	Low	High	Low	Low	High	Low	Low	Low
Nuclear	Moderate	Low	Moderate	Low	Low	Moderate	Low	Low	Low
Electricity networks	High	Low	Low	Low	Low	Low	Low	Low	High
EVs and battery storage	High	High	High	High	High	Low	Low	Low	High
Hydrogen	Low	Low	High	Low	Moderate	Low	Low	High	Low

Relative importance of minerals for a particular clean energy technology ● **High** ● **Moderate** ○ **Low**

Solar PV: solar photovoltaic system | CSP: concentrating solar power | EVs: electric vehicles | REEs: rare earth elements and critical minerals | PGMs: platinum group metals

Restricted access to the minerals necessary for clean energy technologies can pose threats to national interest and national security. Ostensibly in the light of this, the US Government released the Strategy to Restore American Nuclear Energy Leadership, outlining suggestions for how the United States may reclaim its lead in nuclear energy[25]. Nuclear is one of the low-carbon technologies with lower mineral intensity. Key minerals needed by nuclear power include chromium (2190 kg/MW in 2019), copper (1470 kg/MW), nickel (1300 kg/MW), hafnium (0.5 kg/MW) and yttrium (0.5 kg/MW)[26]. In addition, the US Department of Energy (DOE) funded several projects to commercially develop emerging technologies that can increase the supply of rare earth elements from nuclear fuel reserves[27].

23. IEA, I., The role of critical minerals in clean energy transitions. 2021, International Energy Agency Paris, France.
24. Ibid.
25. Energy, D.o. You Can't Have True Energy Independence Without Nuclear Energy. 2020. Available: https://www.energy.gov/articles/you-can-t-have-true-energy-independence-without-nuclear-energy.
26. IEA, I., The role of critical minerals in clean energy transitions. 2021, International Energy Agency Paris, France.
27. Energy, D.o. You Can't Have True Energy Independence Without Nuclear Energy. 2020. Available: https://www.energy.gov/articles/you-can-t-have-true-energy-independence-without-nuclear-energy.

Clean water through desalination

Ensuring access to clean energy is critical to creating a more equitable society. Access to clean water is a basic human right required to sustain life. Nuclear energy can help to provide both clean energy and clean water.

Population growth, urbanization and increased industrialization has led to increased competition for clean water globally. In 2021, UNESCO released a report on the state of world water and highlighted that the COVID-19 pandemic hit the world's most vulnerable people (women, children, and the elderly) the hardest, resulting in over three billion people and two out of five health care facilities without adequate access to water and hand hygiene facilities[28].

Climate change is also affecting access to safe, clean water with an estimated one-fifth of the world's population currently without access[29]. In an effort to address this shortage, the 2015 initiative "Global Clean Water Desalination Alliance —H2O minus CO2" was launched at COP 21. In this initiative, the overall objective is to encourage a reduction of CO2 emissions from water desalination through governments, non-government organizations and industry to contribute to actions and policies. Members of the Alliance also pledged to contribute to clean energy supply and to incentives for enhanced energy efficiency, system integration and demand response[30]. The IAEA has supported desalination through nuclear energy for more than twenty years and runs two programmes for Member States — the Desalination Economic Evaluation Programme (DEEP) and Desalination Thermodynamic Optimization Programme (DE-TOP)[31].

Nuclear desalination is not a new technology. In fact, the process has over 150 reactor years of experience globally[32]. Moreover, as advanced reactors bring the cost of nuclear power down, options for desalination become cheaper, including the potential use of offshore desalination plants. A design from Core Power proposes floating nuclear-

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28. UNESCO World Water Assessment Programme. UNESCO UN World Water Development Report 2021. [Internet] UNESCO; 2021 Available from: https://unesdoc.unesco.org/ark:/48223/pf0000375750
29. World Nuclear Association. Desalination. 2020, World Nuclear Association, London UK. Available: https://world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-desalination.aspx
30. Global Clean Water Desalination Alliance. H2O minus CO2 Concept Paper. 2015. Abu Dhabi, United Arab Emirates. Available: http://www.clca.columbia.edu/Global-Water.pdf
31. IAEA, Nuclear desalination. 2020, International Atomic Energy Agency, Vienna, Austria. Available from: https://www.iaea.org/topics/non-electric-applications/nuclear-desalination
32. World Nuclear Association. Desalination. 2020, World Nuclear Association, London, United Kingdom. Available: https://world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-desalination.aspx

powered desalination vessels with variable power output (from 5 to 70 MWe), with the 5MWe offering a daily output of 35,000 cubic metres of freshwater (the capacity of 14 Olympic sized swimming pools)[33]. The dual-use functionality of nuclear power plants can provide the most vulnerable people on earth with both the clean energy and clean water necessary for survival.

Clean transportation through hydrogen production

Carbon-pollution free electricity is integral to reducing greenhouse gas emissions. Another major source of greenhouse gases is transportation. According to the IEA, 80% of emissions produced globally are from shipping, transportation, industrial and building heat[34]. In order to reduce these emissions, we need to overhaul our transportation industry.

In July 2022, 26 States and the European Union produced hydrogen roadmaps or strategies, claiming that hydrogen would be the way to reduce CO2 emissions generated by transportation[35]. Hydrogen is the future of fuel. It is clean, flexible, storable, and safe, producing only water as an emission[36]. Hydrogen can be used to power fuel cell electric cars, buses and trains, providing cheap, clean and reliable transportation.

Nuclear power can produce hydrogen without carbon emissions. Nuclear power plants produce high quality steam that can be used for many industrial processes, including hydrogen production. This steam can be electrolysed and split into pure hydrogen and oxygen[37]. A 1000 MWe nuclear power plant can produce more than 150,000 tonnes of hydrogen each year[38].

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33. Baraniuk, C. Could Nuclear desalination plants beat water scarcity? 21 June 22. BBB.com
Available: https://www.bbc.com/news/business-61483491
34. Nuclear Hydrogen Initiative. Hydrogen Production from Carbon-Free Nuclear Energy. 2022, Nuclear Hydrogen Initiative, North America. Available: https://cdn.nuclear-hydrogen.org/wp-content/uploads/2022/07/25201728/NHI_NHProduction_Report_07.25.22.pdf
35. Ibid.
36. Commonwealth of Australia. Australia's National Hydrogen Strategy. [Internet] COAG Energy Council Hydrogen Working Group; Canberra, Australia. 2019. Available: https://www.dcceew.gov.au/sites/default/files/documents/australias-national-hydrogen-strategy.pdf
37. United States Department of Energy. Could Hydrogen Open New Markets for Nuclear. Office of Nuclear Energy. 2020. Washington DC, United States. Available: https://www.energy.gov/ne/articles/could-hydrogen-open-new-markets-nuclear
38. Ibid.

Additionally, nuclear power is reliable and has the capacity to produce clean hydrogen at scale to be stored and used as fuel. Advances in reactor design can tailor dual-use output for optimum power and hydrogen production[39]. The dual-use functionality of nuclear power plants can provide women and girls with clean reliable energy and clean fuel for transportation to attend school, work, or travel to safety when in crisis.

Clean and stable jobs for communities

Nuclear power plants can revolutionize our energy industry by producing carbon-pollution free electricity, clean water, and clean hydrogen. These processes require a skilled workforce. Thus, integrating nuclear has the potential to create a wide range of stable and well-paid jobs for local community members — from skilled tradespersons such as carpenters or electricians, to professionals in law, human resources and communications and specialists in engineering and technology such as nuclear and chemical engineers, scientists and health and safety staff.

According to the Nuclear Energy Institute, a nuclear power plant employs, on average, 500–800 workers. Their ability to operate for 80 years or more means that they employ multiple generations in a community[40]. During construction, a nuclear power plant site can employ up to 7,000 workers with up to 50% higher salaries than other energy generation sources[41].

In comparison, an average coal power plant provides a community an average of 200 stable jobs for approximately 40–50 years per plant site[42]. Therefore, nuclear power plants not only provide jobs in a clean energy market, but they also do so longer and with more competitive salaries. As a result, traditionally skilled coal-centric communities can transition to skilled nuclear communities and, thus, increase local salaries and job stability.

Finally, nuclear power can also help create manufacturing jobs given that the power plants can generate heat to be used in manufacturing. As coal and gas fired plants

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39. Nuclear Hydrogen Initiative. Hydrogen Production from Carbon-Free Nuclear Energy. 2022, Nuclear Hydrogen Initiative, North America. Available: https://cdn.nuclear-hydrogen.org/wp-content/uploads/2022/07/25201728/NHI_NHProduction_Report_07.25.22.pdf
40. Nuclear Energy Institute. Jobs. Available from: https://www.nei.org/advantages/jobs
41. Ibid.
42. Peabody Energy. Economic Benefits of a coal-filed power plant compared to natural gas. Nuclear Regulatory Commission. United States. Available: https://www.nrc.gov/docs/ML0911/ML091120541.pdf

are phased out, the requirement to maintain heat production for industry remains. Nuclear power will ensure that these industries receive carbon-free, sustainable, and affordable energy[43].

Conclusion

Women and children, as traditionally vulnerable and disadvantaged groups, are heavily affected by climate change. This is why we need to take action and pursue deep decarbonization. Nuclear power and its benefits are a part of this solution. The benefits of nuclear power for the green energy community, delivered through advanced reactors, include energy resilience, energy independence, and affordable, economic, reliable and secure base-load power. These benefits can be enhanced with dual-use technology features of nuclear power plants to provide access to clean water through desalination, enabling vulnerable communities to improve health and hygiene. Clean transportation made possible through hydrogen production enables children to go to school and adults to travel to work. The addition of clean energy infrastructure can provide clean jobs across a wide variety of skills, expertise, and trades for the local community, including women.

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43. American Nuclear Society. Use of Nuclear Energy for the Production of Process Heat. American Nuclear Society, Position statement #14. Available: https://ans.org/pi/ps/docs/ps14.pdf

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