2021

Yes to Nuclear Perspectives

Improving the world's understanding of nuclear power

Sustainable Development Goals Perspective

Industry Perspective

Country Perspective

THE NEW NUCLEAR WATCH INSTITUTE
NUCLEAR 21 PERSPECTIVE FOR YOUR DECISIONS
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Yes to Nuclear Perspectives

This year we have launched a new joint initiative 'Yes to Nuclear Perspectives', backed by Nuclear-21, Nuclear Innovation Alliance (NIA), and World Nuclear Transport Institute (WNTI).

The aim was to explore how nuclear science and technology can help mankind to achieve the 17 UN Sustainable Development Goals by the target date of 2030. These SDGs were set by the UN General Assembly in 2015, the same year that COP21 led to the signing of the Paris Climate Accord by almost 200 countries. During 2021 NNWI has evaluated the role of nuclear power in relation to each of the SDGs in a series of monthly publications leading up to COP26 in November.

Website

www.newnuclearwatchinstitute.org/yestonuclear

Welcoming this initiative NNWI Chairman Tim Yeo said "We want to improve the world's understanding of nuclear power and its far-reaching applications. The benefits of nuclear go far wider than simply the provision of low carbon electricity to tackle climate change. They extend to a wider set of energy services decarbonising transport, heating and industrial applications while continuing bringing high value solutions in agriculture and medicine."

Nuclear-21's founding partner and managing director Luc Van Den Durpel said "The coming decade is crucial in tackling sustainability challenges. Nuclear science and technology solutions are crucial to get us effectively on this path towards a more prosperous future for us all. As Nuclear-21 we strongly embrace this initiative seeking to bring science-based decisional support information on how the nuclear community can ensure this future."

NIA executive director Judi Greenwald noted "NIA's mission is to bring economically competitive advanced nuclear energy to the world in support of decarbonization. Next generation nuclear technologies can support Sustainable Development Goals – providing modern energy services and enabling emerging economies to industrialize without emissions."

Welcoming the opportunity to collaborate in this initiative, Captain Simon Chaplin, WNTI, said "that with the right information, from trusted and reliable sources, people can understand the benefits and overwhelming evidence that support the nuclear industry."

Martin Porter, Secretary General, WNTI added "Climate change is a current global challenge and how we address it will shape the future of the whole planet. Advances in new nuclear technologies offer us the opportunity to adopt safe, clean, and affordable solutions that will take us towards a sustainable, thriving environment and provide opportunities to all communities of the world."

Initiative Partners

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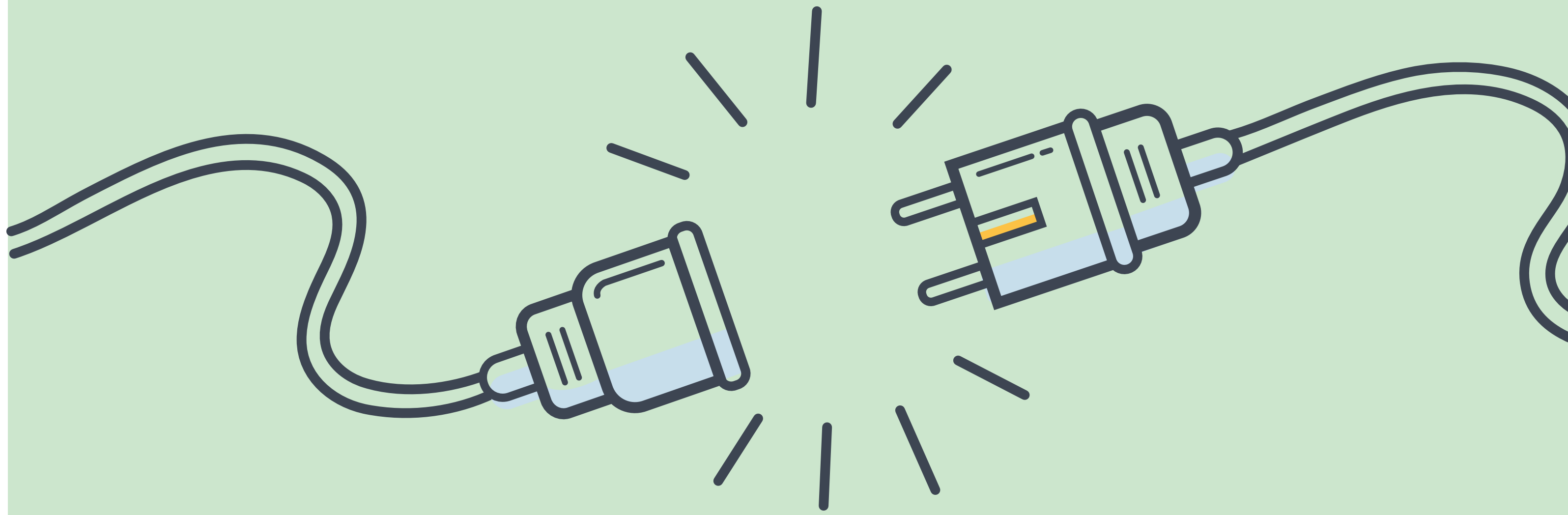

About New Europe

Published weekly since 1993, New Europe is an independent weekly newspaper bringing the most important European news and analysis to an international audience. With no political affiliation, New Europe presents factually correct information in a non-superficial format and provides readers with a wide range of analyses and opinion pieces concerning politics and policymaking that take place in the global arena. New Europe's objective is to provide a source of valued information and to be a platform for policymakers to enjoy an open dialogue. Our audience includes European and American government institutions, policymakers, politicians, business stakeholders and other loyal subscribers in more than 150 countries around the globe.

Articles

- 'Yes to Nuclear' for heavy decarbonization
- Small Modular Reactors to offer cheaper, more flexible nuclear energy
- Nuclear energy to improve healthcare services and food production
- Water and the nuclear solution to safeguard our most precious natural resource
- Nuclear energy – Driving economic and human potential
- Nuclear technology towards peaceful pursuits has significantly expanded

www.neweurope.eu

Media Partner

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INITIATIVE PARTNER

The New Nuclear Watch Institute (NNWI), a London-based internationally focused think-tank

NNWI is an industry supported think-tank, focused on the international development of nuclear energy as a means for governments to safeguard their long term sustainable energy needs. We strongly believe that nuclear power is vital to achieving binding Paris Climate Agreement objectives and tackling the challenge of climate change.

We believe that the right way to secure widespread recognition of the beneficial contribution of nuclear energy is to encourage the widest possible and best informed debate about energy and climate change. This debate should acknowledge the benefits of nuclear power in medical and other areas beyond energy.

In pursuit of this goal NNWIi organises a range of events in the UK, the EU and further afield. Some of these are invitation-only private round-table discussions with industry leaders, policy makers and opinion formers. On other occasions we speak out publicly at conferences, seminars and in the media.

Tim Yeo
Chairman

Tim has a longstanding commitment to the nuclear energy industry dating back three decades to when he was Minister of State for the Environment with responsibility for climate change policy in the UK Government. He later served in the Shadow Cabinet as Shadow Secretary of State for Trade and Industry before being elected as chairman of the UK Parliament Energy and Climate Change Select Committee.

Tim is chairman of PowerHouse Energy Group plc, a listed UK company developing technology to convert plastic waste into hydrogen. He is a director of Getlink SE, one of the largest listed companies in France which owns and operates the Channel Tunnel, the low carbon transport link between the UK and the EU for both passengers and freight. Tim is the Honorary Ambassador of Foreign Investment Promotion for South Korea and has worked in China on climate related projects including the design of China's carbon trading markets and on carbon capture utilisation and storage with the UK-China (Guangdong) CCUS Centre.

Wake up world

In 2021 the world finally woke up and smelt the coffee. Scientists have warned for 25 years that greenhouse gas emissions must be cut immediately to halt global heating. Until recently however most people, including nearly all government ministers and many business leaders, have buried their heads in the sand.

COP26 prompted an overdue reality check. It's now beyond dispute that net zero must be reached no later than mid-century. Gradually the human species is realising that its survival depends on taking action on a scale and at a speed never previously contemplated, let alone achieved. At COP26 it also became clear that the updated national plans are not yet ambitious enough to get us anywhere near net zero.

Unless this action is taken now hundreds of millions of people will start fleeing homes which have become too hot or too flooded to live in before the end of this century. The cost of this action, and the disruption it causes, will increase substantially if significant progress isn't made before 2030.

The good news is there's still time to prevent catastrophe. Both the technologies and the resources needed to solve the problem already exist (though future innovations may help enormously when they are available). All that's lacking is the will power.

Nuclear's big opportunity

All this creates a huge opportunity for nuclear energy. By helping to decarbonise electricity generation nuclear can set an example to the energy industry and many other industries including transport, construction, steel, cement and agriculture, all of which must travel towards the same net zero goal.

Only two countries France and Sweden have ever cut fossil fuel consumption as quickly as every developed country must now do. In the wake of the 1974 oil crisis both did so by massive and rapid investment in nuclear capacity.

NNWI in action

During 2021 NNWI has promoted wider recognition of nuclear as an essential part of the global solution to climate change through our regular webinars. These feature expert presenters from all over the world and enable the online audiences to question speakers and engage in lively discussion.

Reports published by NNWI in 2021 included "Energy Security in the Age of Net-Zero Ambitions and the System Value of Nuclear Power". This shed new light on how nuclear can maintain and strengthen energy security as energy systems decarbonise.

In November NNWI hosted, jointly with the World Nuclear Association, a well-attended evening reception at COP26 in Glasgow. This brought together many leading personalities from the nuclear industry and the academic world.

Yes To Nuclear

In February NNWI also launched the Yes to Nuclear initiative jointly with the support of our partners Nuclear 21, the Nuclear Innovation Alliance and the World Nuclear Transport Institute. Our media partner for Yes to Nuclear is New Europe, the independent weekly paper which brings European news and analysis to an international audience.

Yes to Nuclear makes the important but often overlooked wider case for nuclear by highlighting the benefits which nuclear delivers beyond its long-established role as the only supplier of reliable large scale very low carbon baseload electricity. Our monthly series of Yes to Nuclear Perspectives showed how the impact of nuclear directly promotes eight of the UN Sustainable Development Goals and indirectly promotes the other nine.

The renaissance of nuclear power

An important landmark in the spring of 2021 was the publication of the report of the European Commission's Joint Research Council. This ended the Commission's traditional ambivalence by strongly endorsing nuclear on safety, health and environmental grounds.

Looking ahead to 2022 NNWI believes that the prospects for nuclear are now better than at any time in this century. The tired old debate about whether to invest in renewables or nuclear has largely been replaced by a common-sense recognition that both are needed and the faster capacity can be ramped up the better.

COP26's first formal acknowledgement that coal must be phased out was welcome. The progress made in facilitating greater linkage and compatibility of carbon trading systems and the wider use of carbon pricing is also extremely positive for nuclear.

NNWI looks forward to working with all our friends around the world in 2022 to encourage the nuclear renaissance which will strengthen humanity in its urgent fight against climate change.

INITIATIVE PARTNER

The Nuclear Innovation Alliance (NIA), a non-profit “think-and-do” tank

The Nuclear Innovation Alliance (NIA) is a non-profit “think-and-do” tank working to enable advanced nuclear power as a global solution to mitigate climate change. Through policy analysis, research, outreach, and education, we are catalyzing the next era of nuclear energy. The Nuclear Innovation Alliance (NIA) is a non-profit “think-and-do” tank working to enable advanced nuclear power as a global solution to mitigate climate change. Through policy analysis, research, outreach, and education, we are catalyzing the next era of nuclear energy.

Our mission is to bring economically competitive zero-carbon emission energy to the world by supporting entrepreneurialism and accelerated innovation and commercialization of advanced nuclear energy systems.

The world needs economic, flexible, secure, zero-carbon energy that can scale up rapidly to expand energy access while halting climate change. The next generation of nuclear energy can join with other clean energy sources to meet these needs. Governments, universities, civil society, and the private sector can work together to drive the innovation needed to make nuclear power competitive and scalable for global use.

Our team is passionate about clean energy and leaving the world better than we found it. We are non-partisan, working across the political spectrum to ensure that all communities can benefit from advanced nuclear energy. We have backgrounds in engineering, science and technology, policy, law, and social sciences, and seek to combine our strengths with the input of other stakeholders and experts to make positive change in the nuclear arena.

Judi Greenwald
Executive Director

Ms. Greenwald has over 35 years of energy and environmental policy leadership experience in the public and nonprofit sectors, including the U.S. Congress, the White House, the Environmental Protection Agency, the Department of Energy, the Nuclear Regulatory Commission, and the Center for Climate and Energy Solutions (C2ES, formerly the Pew Center on Global Climate Change). Highlights of her distinguished career include working on the 1990 Clean Air Act Amendments as congressional committee staff; overseeing energy and environmental programs at C2ES and DOE; co-founding the Carbon Capture Coalition; advising U.S. state and regional greenhouse gas initiatives; and collaborating with stakeholders to advance both economic and environmental goals.

She has focused extensively on deep decarbonization through the interplay of public policy, technology innovation, human behavior, and markets. She served as Deputy Director for Climate, Environment, and Energy Efficiency at US DOE’s Energy Policy and Systems Analysis Office, and the Senior Climate Advisor to the Energy Secretary. She is a fellow at Princeton University’s Andlinger Center for Energy and the Environment. Ms. Greenwald received a B.S. in Engineering, cum laude, from Princeton University, and an M.A. in Science, Technology, and Public Policy from George Washington University.

Nuclear Energy and Sustainable Development

Climate change presents one of the most urgent challenges for global leaders striving to achieve sustainable development. In the United States, the Biden administration has set ambitious goals to decarbonize the electric sector by 2035 and the entire U.S. economy by 2050. NIA believes advanced nuclear energy is essential to catalyze and decarbonize development in the coming decades. Through advanced nuclear deployment at scale, we can protect the environment and realize economic growth and development.

Nuclear energy is carbon-free and does not emit air pollution, which reduces global emissions and saves lives. Advanced reactors can play a major role in deep decarbonization, complementing renewable energy with flexible power generation, providing thermal storage, and supplying non-electric sectors such as heating, hydrogen production, industrial processes, desalination, and direct air capture.

Advanced reactors are expected to have lower costs than conventional reactors. They come in multiple sizes and with a range of characteristics, making them adaptable for evolving power markets and other sectors. Establishing a new industry can bring high-paying jobs and equitably benefit communities. By catalyzing American innovation, we believe that U.S. companies can meet the growing demand for carbon-free energy both domestically and internationally.

NIA in Action

NIA works to produce and disseminate reports, briefs, primers, and other materials to educate government leaders, industry, the investment community, partner NGOs, labor organizations, members of the public, and other important stakeholders.

In February 2021, NIA released the “U.S. Advanced Nuclear Energy Strategy” in collaboration with the Partnership for Global Security. This report laid out a joint strategy for U.S. leadership on commercialization of advanced reactors—a whole-of-society approach with collaboration between government, industry, civil society, and other nations to bring advanced reactors to market to reduce global emissions, provide domestic jobs, and support national security.

Also in 2021, NIA released a report on U.S. Nuclear Regulatory Commission fee reform, a “101” primer on advanced nuclear reactor technology and current designs, a brief for state-level policymakers on advanced nuclear energy, and a due diligence guide for potential advanced nuclear investors.

To access the full suite of NIA educational tools and materials, visit www.nuclearinnovationalliance.org/resources.

INITIATIVE PARTNER

Nuclear-21, an independent expert cabinet

Nuclear-21 is an independent expert cabinet providing bankable decision support driving policy, strategies and business development towards optimised nuclear-based solutions.

With more than 300 person-years of collective experience and expertise in nuclear policy, strategy and business development, we provide our customers with new perspectives in business development. Our mission is to support you in nuclear technology-to-business decisioneering. We seek to ensure your strategic and programmatic performance in nuclear energy, nuclear medicine, radioactive waste management, radiation diagnostics and radiation applications in clean technologies.

We seek to enrich our client's decisions on nuclear policy and business strategies towards the development of safe, economic and sustainable nuclear solutions. We operate worldwide with offices currently in Belgium, France and the United Kingdom.

Luc Van Den Durpel
Founding Partner

Luc Van Den Durpel graduated in 1989 as civil engineer and nuclear engineer from the University of Ghent (Belgium) where he also obtained his PhD on nuclear energy systems analysis.

He initially conducted research at the Nuclear Research Center in Belgium. He joined the OECD Nuclear Energy Agency in Paris (France) in 1998 to conduct international studies on advanced nuclear energy systems and specifically advanced nuclear fuel cycle R&D. Early 2002, he joined US-DOE's Argonne National Laboratory (ANL, US) in the context of Generation-IV and specifically nuclear energy system scenarios next to running his consultancy business.

In March 2009, he became Scientific Director and International Expert at AREVA NC's Corporate Research and Innovation Directorate and in October 2011, he became Vice-President Strategic Analysis and Technology Prospective at AREVA's Corporate R&D. After leaving AREVA in March 2015, he launched the internationally operating consulting firm Nuclear-21 supporting governments, utilities, industry, waste agencies and R&D-laboratories in nuclear technology-to-business decisioneering.

He is, among other assignments, member of the Scientific Council of CEA (France) and Board Member of the American Nuclear Society.

Viewpoint

For millennia now, and certainly for the past few centuries, societal prosperity has depended squarely on the availability of energy – energy to, yes, bring comfort to our daily lives, but even more importantly to spur economic development and improve our wellbeing. Affordable and reliable energy allowed our ancestors to provide food with greater efficiency, to work more productively and at higher industrial standards, and to elevate standards of living. These advancements came hand-in-hand with energy transitions characterised by the introduction of new power generation and transmission technology – i.e. from animal and wind-powered energy to the steam engine to biomass and coal to gas and nuclear. Historically, the trend has been towards more energy-dense technologies to respond to higher energy demand from industrialisation, urbanisation, and overall human development. But over the 20th century, these transitions came at an exorbitant environmental cost, and it is urgent that, over the 21st century, humankind comes to uncouple its progress from unsustainable ecological practices. Business-as-usual is no longer a viable option if we hope to protect the planet – our collective home.

Nuclear energy, derived today from nuclear fission (and probably also by nuclear fusion by the end of this century), provides the only way forward to ensure that such an uncoupling is both efficient and sufficiently sustainable and stable to keep our home, i.e. this planet, habitable. Nuclear energy can buttress renewable energy sources such as wind, solar, and geothermal for optimally sustainable energy mixes with minimal environmental impacts.

While nuclear energy already has a very low ecological impact, continuous development by different stakeholders is what will ensure that industry provides even better solutions tomorrow. The industry's prime objectives include increased adaptability to various energy demands and associated markets and continuously optimising reactor technologies and associated fuel cycle(s) to reduce the use of natural uranium resources, the amount of radioactive waste, and the geological footprint associated with both. More than 70 years of nuclear R&D has provided us with the options that can and will need to be deployed before 2050 if we are serious about climate change.

The future of nuclear energy will be based on light-water reactors (LWRs) and heavy-water reactors (PHWRs), whose perfect track record will surely make them the backbone of any sustainable electricity generation mix. It will also depend on other advanced reactors technologies, such as high-temperature gas-cooled reactors (HTGRs), fast-spectrum reactors (FRs,) and molten-salt reactors (MSRs), which increasingly play a role in pathways to reduce the volume and heatload of radioactive waste, guarantee the responsible management of nuclear materials, and minimise future reliance on natural resources such as uranium and thorium.

Our challenge is to reconcile nuclear energy options with the conditions of the energy market and the socio-political context.

From development of methods to applying assessment tools to strategic advice, Nuclear-21's activities are geared towards reconciling nuclear energy with a sustainable future for humanity.

INITIATIVE PARTNER

The World Nuclear Transport Institute (WNTI), a global non-governmental membership organisation

WNTI are a global non-governmental membership organisation headquartered in London, UK. Our mission is to be recognised as the voice of the Nuclear Materials transport industry by utilising its members skills and knowledge to maintain and improve the safe, secure, efficient and reliable transport of Nuclear Materials.

We collaborate with our members to influence regulatory change affecting the transport of nuclear materials and represent our members interests to a number of intergovernmental organisations, UN specialized agencies and nongovernmental bodies. W

WNTI are committed to raising awareness of the crucial, and unquestionable, role that nuclear power will play in the global effort to reach the net zero-emission target.

To achieve this, we have some simple objectives:

- to promote the continued development and worldwide use of Nuclear Power
- to support, consult and participate in the work of governmental and non-governmental bodies in regulating and promoting safe transport of Nuclear and Radioactive Materials.
- to maintain a forum to communicate good practice, innovation, and views.
- to support research development and testing for systems and components for transport.

Martin Porter
Secretary General

Martin entered the UK nuclear industry, joining BNFL at Sellafield, in 1983 to take up a post in the emerging health science of Occupational Hygiene. Martin is a University of Manchester Occupational Health Post-Graduate and worked for 25 years in the field of Occupational Hygiene and Chemical Safety at Sellafield.

In 2008 his work as a senior event investigator introduced him to radioactive material transport and a change of career ensued when Martin was appointed Head of Operations for nuclear transport at Sellafield Limited. In this position he was responsible for many fuel, high level waste and reprocessed product shipments around the globe. During his time at Sellafield he was a Board Member and Chair of the UK nuclear industry transport committee (RAMTUC), a Board Member of the UK radioactive transport emergency response mutual aid scheme (RADSAFE), Chair of the World Nuclear Transport Institute (WNTI) Back-End Working Group and a member of the World Nuclear Transport Institute (WNTI) Advisory Committee.

In April 2020 Martin took up his current role as Secretary General at the World Nuclear Transport Institute, based in London, UK. In his WNTI role, Martin is focussed on helping ensure that future nuclear missions are transport-enabled with the appropriate capability and fit-for-purpose international regulations.

Nuclear power in sustainable development

Nuclear power will play an increasing role in combating the global environmental crisis, indeed net zero by 2050 cannot be achieved without nuclear power.

Advances in nuclear technology are now accelerating the opportunities to adopt nuclear power on a greater scale. Traditionally, large scale nuclear sites with high-capacity nuclear plants have been used to generate electricity for national networks. This will continue, but alongside this technology a new generation of small modular reactors (SMR) are being developed that can bring sustainable, reliable and zero carbon energy to those communities that previously relied on fossil fuel power stations.

SMR's are built in factories using production line methods that reduce costs and allow scalability. These SMR's are constructed in modules that are then taken to the site of operation where they are assembled for use. Some designs of SMR are containerised and are transported in a 'turn-key' state, also making them ideal for rapid deployment such as in disaster relief.

Modular characteristics allow flexibility to scale up to meet rising energy demands by adding further modules. These SMR's can be either land based or sited on floating barges or offshore platforms. This makes them ideal for supplying energy to remote communities and small islands. The supply of constant, reliable and carbon free energy to these communities will allow them to achieve sustainable development far more easily. These regions will no longer be dependent on external energy supplies, and the SMR will also offer a source of skilled employment.

Reliable and sustainable energy from large scale nuclear sites as well as SMR's will bring economic growth to the regions that they serve. In the past, the reliance on fossil fuels resulted in a trade off between development and sustainability. The climate emergency is a direct result of those policies.

By providing clean energy, nuclear power can offer economic growth, industrial progress, and social development without the harm and stigma of fossil fuels. This sort of economic growth will lift poorer communities out of poverty, offering skilled and well-paid employment, while also providing a healthy, resilient, and sustainable living environment. This in turn leads to good education and safe communities for future generations.

COP26 AND BEYOND

COP26 and beyond

Yes to Nuclear Perspectives

What would you like to see beyond COP26?

Tim Yeo, New Nuclear Watch Institute

The message loud and clear from COP26 is that the world is finally moving towards cleaner energy. Even louder and clearer is the message is that it is moving far too slowly.

Without a drastic acceleration of this progress there is no chance whatever of keeping the rise in average surface temperature below 2C. Every country must come to COP27 in Egypt next autumn with a revised Nationally Determined Contribution which is compatible with 2C.

Even more importantly these NDCs can't just be a target to be achieved decades hence after today's leaders retire. Each one must be backed up by a detailed practical plan setting out the actions which will be taken to achieve that target.

This is no small challenge. Historically only two countries have ever cut their fossil fuel consumption as fast as every country must now do if dangerous irreversible climate change is to be prevented.

France and Sweden showed the way back in the 1970s in the wake of the first oil shock. Both did so by investing heavily in a rapid increase in nuclear energy capacity.

Of course half a century ago, nobody foresaw the possibility of plentiful renewable energy. Nor did they anticipate a time when using the abundant reserves of coal, oil and gas would threaten the conditions of climate stability on which the enormous economic advances and population growth of the last two hundred years have been based.

The other key message from COP26 is that keeping the temperature rise below 2C is a task which can't be left to the 2030s and 2040s. To achieve this goal we must start now and make substantial progress in this decade.

No technical problem prevents this from happening. The technology to decarbonise almost entirely two of the highest emitting industries – electricity generation and surface transport – already exists. All that's needed to begin tomorrow is the political will to do so.

Decarbonising surface transport depends heavily on electricity so the most urgent task is to end the use of coal and gas for electricity production. This requires massive expansion of renewable energy capacity, mainly solar and wind power because most of the best potential hydro-electric resources are already being exploited.

But it is already clear that relying too heavily on intermittent sources of energy compromises the ability of any nation to maintain that continuous supply of electricity on which modern business and social life depends.

This is why the renaissance of nuclear energy is so critical. It provides the reliable baseload power needed to complement renewables.

Furthermore the development of advanced and small modular reactors will enable nuclear to reach new locations unsuitable for large plants. Floating nuclear plants will add more flexibility.

Beyond COP26 we need universal acceptance of the key contribution which nuclear can make to overcoming climate change, a halt to all fossil fuel exploration, faster closure of all coal fired power stations and early phaseout of all unabated gas plants.

Nothing less than this will ensure humanity's survival.

Judi Greenwald, Nuclear Innovation Alliance

For two weeks, world leaders and climate activists gathered in the United Kingdom to tackle one of the world's greatest challenges: climate change. At the eleventh hour, COP26 concluded with the Glasgow Climate Pact, a success for participating countries and an indication of sustained international interest in achieving our climate goals. Through the pact, member states agreed to accelerate progress towards addressing climate change by introducing new and more aggressive emission and temperature targets. Most notably, new pledges were made on methane gas pollution control and deforestation, and COP26 called for an end to fossil fuel subsidies -- all significant steps towards limiting global warming to the 1.5-2.0 degree Celsius threshold established by The Paris Agreement in 2015.

Historically, nuclear energy has not been well represented at COP, even though it is carbon- free. This changed at COP26, where nuclear energy finally became a key part of these important climate discussions.

As the world works to address climate change, it is increasingly apparent how nuclear energy can play a key role in achieving human prosperity while also protecting the planet. Nuclear energy allows member states to incorporate Sustainable Development Goals into domestic agendas without sacrificing economic opportunity. In a report released before COP26, the IAEA detailed how nuclear technology can provide greenhouse gas- free electricity and also be used as a part of a "climate-smart" agricultural and water management system. For example, some member states struggle to obtain ready access to clean water; certain radionuclides can be used to develop water saving technologies. Additionally, advanced nuclear technology can power desalination plants to tackle water insecurity. All these applications are enabled by the development of national nuclear energy programs and infrastructure, as well as global support, investment, and cooperation in the development of advanced nuclear energy technologies and regulatory frameworks.

This is the message that experts and activists attending COP26 shared with world leaders to ensure that nuclear energy plays a key role in the climate solution moving forward. By harnessing the power of nuclear energy, countries will be able to power cities and rural communities using clean, carbon-free energy, decarbonize industrial processes, and sustain high-quality jobs and thriving communities.

Moving forward from COP26, the Nuclear Innovation Alliance and others in the nuclear energy community are taking steps to include the nuclear energy community in international climate and energy development conversations. At COP26, Nucala Power and the Romanian national nuclear company Nuclearelectrica announced an agreement to construct a NuScale small modular reactor plant by 2028. Similarly, countries like South Africa identified nuclear energy as an attractive option to help phase down their existing coal reliance as advanced nuclear power plants can be sited at retired coal plants and utilize certain existing infrastructure.

NIA sees an emerging narrative taking hold on the global stage that recognizes the inherent and potential advantages of nuclear energy as a complement to other clean and renewable energy sources in combating climate change and driving sustainable global development. At future COP summits and other international engagements, nuclear energy deserves a seat at the table for the sake of humanity and the environment.

Luc Van Den Durpel, Nuclear-21

The world is facing tremendous challenges induced by humankind's unsustainable environmental practices. Economic development, especially over the past 50 years, has come with far too much greenhouse-gas emissions, emissions that have already led to significant challenges, with much more destabilising consequences to be expected if we fail to decarbonise quickly and effectively.

Shining a spotlight on all potential scenarios of environmental upheaval, COP26 was meant to be a platform for discussing the most suitable policies to optimally reduce, and better yet, mitigate the consequences of out-of-control emissions. But, yet again, we saw science-based approaches jeopardised by the ideological agendas of certain participants. At the same time, we saw that many countries are taking a systematic view on these challenges and increasingly embracing a science-backed long-term approach while promoting an effective and achievable path towards decarbonisation, rather than a path constrained by ideology.

Let nuclear energy be the game-changer between ineffective and inefficient approaches and those that achieve our environmental goals using minimal natural resources, money, expertise, thereby preserving these resources for use for other important societal needs.

While the increased societal and political enjoyed by nuclear energy in many countries is a positive development, the international financial market, which is increasingly integrating environmental, social, and governance (ESG) criteria in its decision-making, remains a crucial source of support. Our current task is, therefore, to ensure the appropriate positioning of nuclear energy in ESG investment portfolios.

This will require the nuclear energy community to clearly communicate how its accomplishments today will translate into tangible and bankable options tomorrow, to effectively handle intranuclear challenges (such as increasing the effectiveness of newbuild projects, improving radioactive waste disposal techniques, etc.), and to be coherent on its prime objectives (i.e., further improving LWR-designs, making SMRs workable in multiple energy markets, advancing nuclear for beyond 2050, etc.).

The coming decade is crucial for nuclear energy. We will either fail to provide the planet with sustainable solutions or make them happen. We cannot afford to dilute our message and need to act efficiently to secure both existing and newbuild projects, all the while transitioning towards more integrated nuclear energy systems and providing tangible solutions to meet societal needs.

Martin Porter, World Nuclear Transport Institute

COP26 was seen as an opportunity to place new nuclear technologies within the green energy mix in the global drive to deliver decarbonisation and limit global warming to 1.5C. At the opening address session, the Prime Minister of Barbados, Mia Mottley, delivered an impassioned call to world leaders to consider all nations and work together to ensure that the threat of global warming and rising sea levels was mitigated as best it could. Within the address Ms Mottley called for three phases of response - Voices, Ambitions and Actions. The voice of nuclear was loud, proud and prominent at COP26, no more so than the 'net zero needs nuclear' messaging so ably championed by the Young Generation Network and its collaborators. The sentiment of this messaging was also at the forefront of COP26 interventions made by the International Atomic Energy Agency, the International Maritime Organisation, the World Nuclear Association, the New Nuclear Watch Institute, the World Institute of Nuclear Security and the World Nuclear Transport Institute as well as many others. It cannot be denied that the voice of nuclear, in both energy and propulsion, presented an articulate and compelling argument but we need to now hold the mirror up and ask ourselves 'so what next?'. Clearly, if we follow Ms Mottley's mantra then we need to consider our ambitions and our future actions.

It may be said that our ambitions are clear and captured in the 'net zero needs nuclear' message, but what does that mean? New nuclear energy generation technologies are evolving at speed and this was made even clearer when the UK SMR Consortium, led by Rolls Royce, announced that a government/private funding deal had been secured, this being broadcast during the second week of COP26. There has also been significant progress in developing fusion as a civil energy source whilst a number of entities are exploring the potential for nuclear to be used to generate green fuels such as hydrogen and ammonia. All in all, there is much optimism and opportunity for a nuclear energy renaissance. Alongside this, molten salt reactors and other technologies provide similar opportunities in providing a nuclear maritime propulsion energy source. Collectively, these technological innovations provide us with an industry ambition to modernise the nuclear portfolio and contribute to the global efforts in constraining warming through decarbonisation.

So what actions are required to realise our ambitions?

COP26 demonstrated to the world the synergy that exists within the nuclear community. The power of collaboration, when policy makers and non-governmental organisations work together, was palpable and clearly generated substantial energy. This collaborative ethos must be preserved in order to deliver the necessary actions without gap or overlap. COP26 was not finite in so much as we cannot fool ourselves that it came and went. The voice that was clearly so loud at COP26 needs to be sustained, and arguably increased, in order to deliver the necessary actions and outcomes. It is nowhere near a foregone conclusion that nuclear will join renewables in the future configuration of energy and propulsion, that will only be realised if the power of the nuclear lobby is maintained until such time as there is a global will to accept nuclear as a sustainable, green contributor to carbon reduction. As Ms Mottley so eloquently directed the COP26, Voices, Ambitions, Actions.

YES TO NUCLEAR PERSPECTIVES

COP26: How nuclear can help the planet achieve Net-Zero

Nuclear power offers the world an abundant future if it is embraced, said speakers at an event jointly organised by the New Nuclear Watch Institute (NNWI) and World Nuclear Association (WNA) during COP26 in Glasgow. Nuclear technology has now developed to the point where it could save the planet from catastrophic climate change and, if introduced safely and more widely, could help countries avoid the path of economic scarcity.

Delegates attending the COP26 from all over the world came to the event to hear about how a proven technology - nuclear – should have its rightful place alongside renewable forms of energy as the world aims for net-zero carbon emissions.

Speakers were looking to the future, imagining a world free of fossil fuels. While NNWI Chairman Tim Yeo describes the magnitude of the task ahead of us, he believes that nuclear can and must lead the world's transition to net-zero. It is a technology that has been neglected for too long but is uniquely suited to the task ahead.

Director General of World Nuclear Association, Sama Bilbao y León, delivered an eloquent plea for the world to think in terms of abundance, not scarcity – and for all nations to move towards a net-zero future together. While noting the significance of meeting in Glasgow, the city where the steam engine was invented, she emphasised the importance of looking to the future, not the past.

Tom Samson, the CEO of Rolls-Royce SMR, encouraged advocates of nuclear energy to tell others "that nuclear is the solution to climate change," before going on to give a brief explanation of the revolutionary work being fulfilled by Rolls-Royce through their production of SMRs.

Warming to the theme of showing more courage in making the case for nuclear energy, Nuclear Industry Association CEO Tom Greatrex revealed that 75% of the power for the COP summit itself came from nuclear and renewable wind energy.

Diane Cameron of the OECD Nuclear Energy Agency remained concerned that nuclear energy does not get referenced enough in debates around clean energy, even by countries that actively use it. But she did recognise that nuclear energy has been included in COP in a way that has never been before.

Her enthusiasm was replicated by Maria Korsnick, the President and CEO of the Nuclear Energy Institute. Polina Lion, Chief Sustainability Officer of Rosatom, took the time to remind us of the benefits of nuclear energy and why we should be excited, not daunted, by the challenge ahead of us. Nuclear energy, she pointed out, is not only a source of electricity, but an agent of change. Jessica Johnson of FORATOM told the guests that "We are in this industry because we are passionate about this industry".

John Gorman, the President and CEO of the Canadian Nuclear Association explained the need to stay grounded, to use the climate crisis as an opportunity for a just transition, and to exercise leadership at this time.

Sustainable Development Goals Perspectives

SDG Perspective

SDG 1, SDG 2, SDG 3

SDG 1 - No Poverty

Energy poverty, or lack of access to reliable electricity, poses a barrier to human health and economic mobility. Universal access to low-cost, clean electricity from nuclear energy can help developing nations to provide basic human needs such as food and clean water, create access to educational and economic opportunities, and develop critical infrastructure to promote sustainable development.

Nuclear isotope-enabled processes are used across the globe to strategically apply scarce water and fertilizer resources in agriculture, as well as monitor soil quality, manage pests, and preserve food harvested for consumption. Even more, advanced nuclear reactors can power water desalination. However, on a more basic level, nuclear energy can reliably provide the clean electricity necessary to transport, store, and prepare food, and can power water pumping, boiling, disinfection, purification, distribution and storage.

As electricity from nuclear energy enables communities to access food and water readily, this not only provides for the health and wellbeing of citizens, but also reduces time previously spent on time-consuming manual processes used to obtain these resources. This, in turn, allows domestic laborers more time to pursue education or earn wages outside of the home.

Conventional and advanced nuclear power plants are infrastructure that require substantial capital investment as well as additional supporting infrastructure investment such as electricity grid updates. When a country builds a nuclear power plant, they are committing to developing and sustaining an electric grid that will not only support that plant, but also provide the basis for future investment in electricity generation. These investments not only modernize domestic infrastructure, but also provide opportunities for economic growth in communities.

SDG 2 - Zero Hunger

Powering sustainable food production

Like many other crucially important goals, sustainable food production can only be secured if dangerous and irreversible climate change is avoided. The first contribution of nuclear energy to this goal is therefore to help achieve the complete decarbonisation of the global power industry as quickly as possible.

The International Atomic Energy Agency has been working for decades with the UN Food and Agriculture Organisation to develop and extend the ways in which nuclear technology can be applied to improve crop and livestock production around the world, to raise food safety, and to conserve scarce water and soil resources.

According to the Food Irradiation Global Market Outlook, nearly 1 million tonnes of food is sterilised with radiation worldwide. Such services are provided by many vendors, from US-based Food Technology Service and Sterigenics International to Rusatom Healthcare – a subsidiary of Russian nuclear giant Rosatom – that offers both isotope supplies and turnkey solutions in the construction of irradiation centres.

Examples of how nuclear technology can be applied include radioimmunoassay methods to help diagnose diseases and monitor the effectiveness of disease control and eradication programmes. In addition, brief exposure to radiation can be used to accelerate genetic changes in plants to make crops such as rice, wheat and soya bean more resistant to disease or drought.

The nuclear derived sterile insect technology sterilises male insects and releases them over pest-infested areas to suppress and eventually eliminate pests and prevent the introduction of invasive species in ways that are environmentally safer than conventional pesticides.

Countries which have benefited from using nuclear technology to improve the sustainability of their food production include Cameroon, Chile, Mexico, Guatemala, and Vietnam.

Ensuring food safety and quality

Food, water, and energy are the basic needs of society. Their continued availability is jeopardised by the long, unsustainable pressure our society has placed on supply chains and the environment. These problems present a complex challenge that must be swiftly addressed to ensure the long-term wellbeing of our planet.

Some meaningful technological advances made since the industrial revolution have drastically increased food production and distribution efficiency across the globe to match rapid population (and thus food demand) growth. Certain nuclear techniques introduced in the 1960s have been critical in helping to combat unsustainable pressure on food systems. In fact, some of the most innovative ways wherein nuclear technologies can help to improve the overall food system - from production to distribution - include:

Qualitative agricultural production insurance and efficiency
- Combating pests and diseases
- Seasonal famine prevention
- Increasing crop production
- Improving soil and water managements

Animal productivity and health
- Improvement of zoonotic disease prevention and eradication of pests

Food safety
- Sterilisation to improve the safety and shelf life of food by destroying microorganisms and insects or to delay sprouting and ripening, thereby increasing the longevity and overall safe provisioning of food

Climate change adaptation and mitigation

SDG 3 - Good Health and Well-being

Powering modern health infrastructure

In 1895, Wihelm Roentgen accidentally discovered X-rays while working in his lab and was subsequently awarded the Nobel Peace Prize in Physics for this work in 1901. Since then, medical professionals in the fields of radiology and nuclear medicine have extensively relied upon nuclear technology to diagnose and treat patients.

The most common application of nuclear technology in the medical field is diagnostic imaging. Over the past century, medical professionals have used radiation techniques, like X-rays machines, to produce 2D and 3D images of parts of the body and subsequently diagnose what medical treatment a patient might need. Similarly, doctors also use medical radioisotopes to track how organs may be functioning and how to subsequently treat them. This is done by ingesting, inhaling, or injecting radioactive material into the body and using computer technology to produce high quality images.

Medical professionals also use radiation to treat cancer patients. Just as a radioisotope can be localized in a specific organ for diagnostic purposes, it can also use radiation to destroy or weaken malfunctioning cells. In this type of treatment, seeds, ribbons, or capsules that contain a radioactive source are placed in your body. External radiation beam therapy is also an option.

Today, more than one-third of all medical procedures involve radiation or radioactive material. Overall, experience proves nuclear technology is a quick, safe, and accurate way to diagnose medical conditions and future advances in nuclear medicine can substantially improve the healthcare industry.

Improving the health of communities

Production of fossil fuels comes with an unacceptable environmental cost. Marine oil spills are all too often reported, and the mining of coal can have a disproportionate effect when compared to the energy produced. One ton of coal produces around 2,000 – 2500 KWh of electricity. Compare this with the 40 million KWh that is produced from one ton of natural uranium, and it is clear that nuclear power can provide a clean and sustainable energy source.

A sustainable environment must be the goal when balancing the need to protect our planet with the need to provide for healthy and prosperous communities.

Sustainable transport is identified as a major factor for improving social and economic wellbeing. A good transport system will provide a reliable route for the movement of people, such as to and from work, as well as an efficient way to ensure the delivery of all goods and services. Currently, this comes with an environmental cost. Over the next two decades it is envisaged that transportation will become the major driving force behind the growing energy demands of the world. Transport is already the largest end-user of energy in the developed world, and this will soon be joined by developing countries. This has serious health implications if fossil fuels are used. The use of fossil fuels produces huge quantities of CO2, NOX, SOX and particular pollution. This air pollution causes climate change, health issues, and damage to land and marine environments. These dangers can be avoided with the adoption of nuclear power.

SDG Perspective

SDG 4, SDG 5, SDG 6

SDG 4 - Quality Education

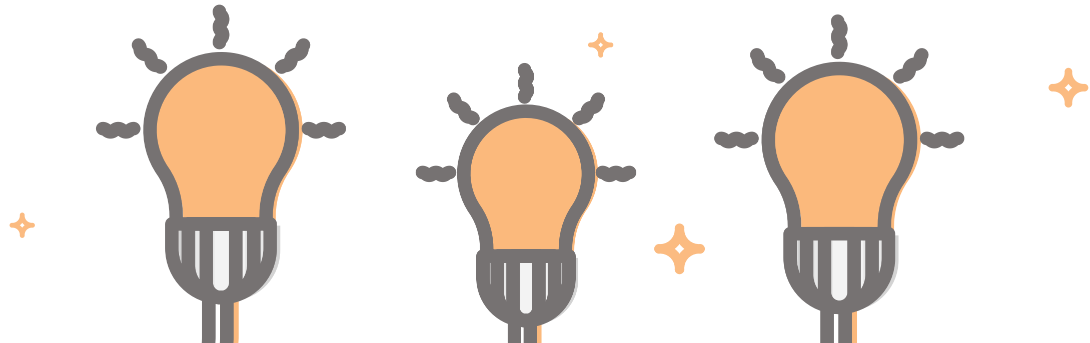
The United Nations Sustainable Development Goal #4 details several targets for education. These include:

- **Equal access for all women and men to affordable and quality technical, vocational, and higher education;**
- **Relevant skills for employment and decent jobs; and**
- **Eliminating gender disparities in education and ensuring equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, and indigenous peoples.**

Nuclear science and technology can play an important role in achieving these goals through various fields including energy, medicine, and agriculture. The need for skilled technicians, engineers, physicists, radiation experts and nuclear medicine specialists creates many opportunities for national and international education and training efforts.

Nuclear medicine has advanced to detect and cure illness, like cancer and cardiovascular disease, but access to this medicine can be limited in developing countries. The need to increase capacity in such regions requires trained and skilled people within these communities, performing well-paid and sustainable work.

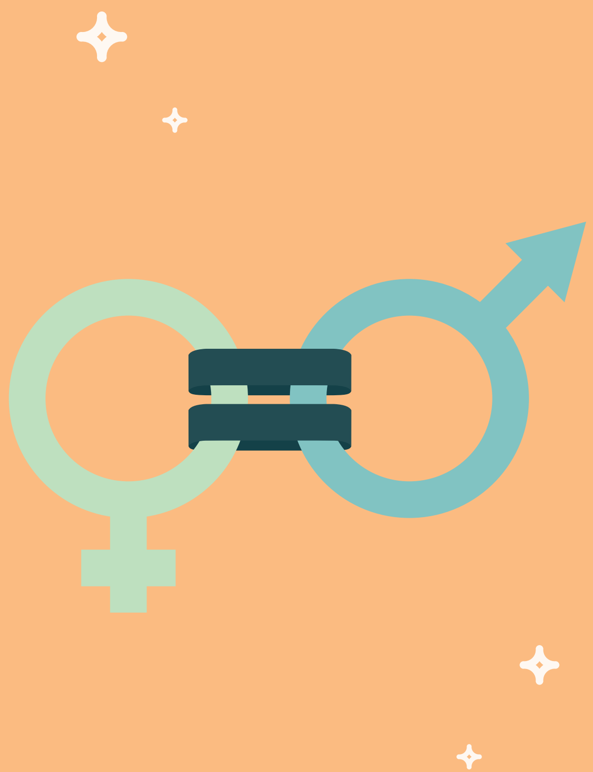
Nuclear energy can play a huge role in bringing quality employment to regions of the world where previously there may have been little prospect of good education and employment. Small modular reactors are being sited in locations that would not previously have had such technology. These complex facilities require a well-trained and professional workforce, supported by a community with a modern system of education for all ages, from early childhood development, through primary and secondary education, and on to higher education.



SDG 5 - Gender Equality

The nuclear energy industry is traditionally seen as a male-dominated engineering field, where men currently outnumber women. However, the nuclear community is actively and publicly addressing the gender balance by committing to attracting and retaining qualified women to the nuclear science and technology sector.

According to the IAEA, men making up more than a three-quarters of the workforce in the nuclear sector worldwide. This hurts the overall industry diversity as well as competitiveness. Providing women with equal opportunities in all levels of the field, not only mid-level management positions will help achieve a more gender-balanced nuclear workforce.



Therefore, attracting and retaining more women into careers in science, technology, engineering, and math (STEM) is an important goal that many countries are pursuing. The nuclear energy community recognizes the valuable role that women play in STEM fields and encourages organizations and businesses to adopt strategies and practices that promote gender inclusivity within this field. To make the nuclear sector more attractive, meaningful change must be achieved by collaborating collectively to remove gender bias, increase the number of women in STEM, and in leadership and mentorship positions.

SDG 6 - Clean Water and Sanitation

Nuclear desalination

The world is facing critical limitations in the availability of fresh water for residential, agricultural, and industrial uses. There has been a growing support for seawater desalination using nuclear energy (called nuclear desalination), which offers a viable option to meet the growing demand for fresh water supply, especially in developing countries with many arid and semi-arid areas.

Nuclear desalination provides a clean, economic, safe, reliable, and readily available solution, and has the potential to become a major sustainable source of fresh drinking water. Furthermore, nuclear desalination is economically competitive with other desalination techniques driven by other sources of energy and does not require additional safety measures than those already in place for existing nuclear power plants.

Although fossil fuels still play a key role in water desalination projects, nuclear energy has recently gained more attention thanks to greater climate change concerns and recent technological advances in nuclear reactor design, such as small modular reactors.

Nearly all modern SMR designs, from Argentina's CAREM to the United States' NuScale, envisage the possibility of use in desalination. Floating SMR-based plants appear particularly promising for this purpose, as they are capable of operating in remote and inaccessible locations suffering from water scarcity. The list of floating projects worth noting includes the molten salt reactor being developed by the Danish startup Seaborg Technologies, Chinese-designed SMRs that are now under construction, and the currently operating Russian-designed "Akademik Lomonosov" and its next generation counterparts. Rosatom has already announced that four such RITM-200 reactor-equipped plants will be connected to the grid by the end of 2030.

In addition, proposals for integrated solutions and systems using multiple energy sources, including nuclear and renewable energy sources, have been introduced in the past decade to meet multiple energy-intensive needs, including water desalination, industrial process steam, district heating, hydrogen production, and electricity generation.

Fresh water for residential, agricultural, and industrial uses

Interest in using nuclear energy for fresh water production has been growing worldwide for more than two decades. The problems of climate change and population growth are placing a greater pressure on access to fresh drinking water, which is becoming increasingly difficult to overcome in many parts of the world facing natural water shortages and increased fresh water demands.

Though nuclear science is known by many as the basis for generating clean, carbon-free electricity, nuclear and isotopic techniques can be used to support the sustainable management of freshwater resources, to improve soil health, and to enhance farming practices and livestock health in support of food production and societal wellbeing.

More than one third of global food production relies on irrigation, which frequently comes from unsustainable groundwater sources. As climate change disrupts weather patterns and global population growth brings about greater demand for freshwater resources, it will be increasingly important for regional water regulation and conservation efforts to be well informed by knowledge of groundwater activity. Isotope hydrology is a nuclear technique that uses radioactive isotopes to determine source, recharge methods, risk of saltwater intrusion or pollution, and management potential of groundwater.

Radioisotopes are also useful for measuring the quantities of nitrogen and phosphorus present in soil. This helps farmers better calculate the amount of new fertilizer needed to meet the demands of any given crop and maintain optimal soil health. It also prevents over fertilization of soil so that excess nutrients do not escape into the natural environment and pollute waterways and harm local biodiversity.

Nuclear techniques can also help with the sterilization of insects that may be harmful to crops and livestock. The sterilization technique helps to control the population of insects without use of pesticides that may present health risks to humans or the environment. These techniques help to sustainably increase crop productivity and livestock health.

SDG Perspective

SDG 7 - Affordable and Clean Energy

Nuclear power as a low-carbon energy source

World energy consumption is predicted to rise nearly 50 percent by 2050, with developing countries projected to become the largest electricity users. China alone is anticipated to account for over 40 percent of the global growth in demand for electricity by 2030.

The challenge is how to meet growing demand without substantially contributing to climate change. As a low-carbon electricity source, nuclear power can play an important role in limiting global emissions.

A nuclear power plant does not produce any carbon emissions during operation. Across the broader lifecycle of a power plant, there are indirect emissions from mining, fabricating fuel, manufacturing components, and constructing and decommissioning the facility. Nevertheless, a 2017 study examining future low-carbon power supply systems for 2050 found that nuclear power's lifecycle emissions ranged from 3.5 to 12 grams of carbon dioxide equivalent per kilowatt-hour of electricity generated, compared to 400 to 900 grams for fossil fuel plants, or approximately 100 grams for hydropower.

In 2018, 448 commercial nuclear power plants accounted for 10.1% of the world's total electricity generated. In terms of low-carbon sources, only hydropower ranked higher at 16.2%. Countries producing large percentages of nuclear power, like France and Sweden, have some of the lowest-emitting electric grids globally.

Looking to future decarbonization, the low-carbon and reliable performance of current nuclear reactors makes a strong case for expanding the share of global electricity generated by nuclear power. Many existing reactors may retire before 2050. New advanced reactor designs can meet the need for replacement power as well as expanding demand. These designs build on the benefits of the current fleet by supplying more flexible, scalable power output with smaller sizes and investment requirements that are well suited to serving emerging economies.

Nuclear power as a reliable energy source

The growing need to protect the energy supply from disruptions while reducing greenhouse gas emissions and contributing to sustainable development requires fresh consideration of the role of nuclear power in dealing with climate change. Nuclear power complements intermittent renewable energy sources because nuclear plants provide affordable and reliable low-carbon electricity able to meet 24-7 demand. Operating at a high capacity factor of 90%, they also contribute to grid stability and reliability.

A wide range of small modular reactors and advanced reactors is currently under development. Some are ready for near-term deployment and offer the prospect of enhanced reliability and flexibility. They will be suitable for decarbonizing a number of industries, boosting the sustainability of this energy source even further. Furthermore nuclear technologies are not only strengthening linkages across the clean energy sector but also more widely with non-energy sectors.

These technologies offer great opportunities for non-electricity applications, such as seawater desalination, hydrogen production and others outside the energy domain, including the provision of medicine, food and clean water. It is clear that the reliability of nuclear power has a far-reaching effect and that nuclear technologies will play a key role in the future decarbonized world and contribute to the achievement of all 17 UN Sustainable Development Goals.

Nuclear power as an affordable energy source

The world thrives on energy for basic needs such as food and heating as well as supporting the economic development and overall societal needs such as urbanisation and transport, all contributing to our well-being. Energy demand has been soaring since the 19th century with the exploding energy demand during the 20th century, hand-in-hand with economic development and generally also increasing well-being for humans, bringing us life-changing experiences while also bringing the first signs of our limits to growth. Energy supply security and energy independence objectives have accelerated the introduction of nuclear power in many of the industrially developed countries since the 1970s.

The extensive use of fossil fuels for energy generation, heating, transport and powering our economic development slowly but steadily created our main challenge for this 21st century and beyond, i.e. how to maintain our overall well-being while decouple economic development from the greenhouse gas (GHG) emissions that lead to climate change and increasingly expose us to potentially irreversible effects of such truly structural planetary changes.

Nuclear power, hardly emitting such greenhouse gases while also having an overall extremely small environmental impact in its supply chain and waste management, is part of the answer to a more sustainable energy supply for our planet. Energy demand management, switching to low-emission energy production technologies such as renewables and nuclear power and a better balance between generation and demand (including energy storage) are the answers propelling our planet onto a more sustainable trajectory.

A very distinctive feature of nuclear power is its overall affordability from such an integrated energy systems perspective. Nuclear power's high and stable return on energy invested can guarantee an overall high degree of competitiveness in a decarbonised energy system. Nuclear power is increasingly essential for overall energy system resilience while also lowering generation costs for the energy system as a whole, especially when renewable intermittent energy sources play a significant role in the energy system market. Thus nuclear power needs to further improve its capital investment requirements and especially further reduce the owners cost, thereby reducing its investment challenge.

Nuclear power as a modern energy source

For at least the past decade global recognition of the scale and urgency of the threat of climate change has intensified dramatically. Doubts that modern economies, which are absolutely dependent on a continuous supply of electricity, can rely exclusively on intermittent renewable energy sources are gaining ground. This underlines the importance of the role nuclear can play in the future generation mix globally, as electricity use continues to grow.

Nuclear's unique features enable it not only to deliver low carbon, affordable and reliable energy but also to contribute to much needed improvements in air quality. In addition it has the means to decarbonize numerous industries while supporting the proper functioning of modern infrastructure.

At the same time progress is being made in developing the next generation of nuclear reactors, which will offer additional benefits beyond carbon-free electricity. Innovation will be important and it is widely recognized that a reliable supply of low-carbon energy is a prerequisite for the achievement of sustainable development goals. The nuclear industry is ready to play its part in the modern world to meet the challenges facing humanity.

Foremost among these challenges is climate change. The goals established in the Paris Agreement will be more easily met if nuclear power and the benefits of the synergies between nuclear and other low carbon energy sources and technologies are harnessed now.

SDG Perspective

SDG 8 - Decent Work and Economic Growth

The nuclear industry supports SDG8 and works towards the promotion of sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. Global economic growth has been generally slowing down for the past decade; however, nuclear power can help increase long-term economic growth and meet key SDG8 objectives. Energy supply security and energy independence objectives have accelerated advancements in technological innovation and creation of a diverse range of decent jobs, in engineering, technical other specialist roles within especially safe workplaces.

IIn addition, world energy consumption is projected to rise by nearly 50 percent by 2050, with some developing countries predicted to become the largest electricity users. Nuclear power, providing access to low-carbon, affordable and reliable electricity, is part of the answer to a more sustainable energy supply, regional infrastructure development and economic growth for many developing countries.

YES TO NUCLEAR PERSPECTIVES I SUSTAINABLE DEVELOPMENT GOALS PERSPECTIVE

Decent work, full and productive employment

The development, deployment and use of nuclear energy demands skilled capabilities. Including both on-site and off-site direct personnel, the average number of direct jobs for a typical Light Water Reactor (LWR) is around 500 – 700. The employment for skilled personnel goes much further than the nuclear power plant fence. The nuclear industry provides many long-term direct and indirect diverse employment opportunities from a wide range of fields and educational backgrounds, offering equal opportunities for all.

It creates high-paying jobs for engineering professions such as chemical engineers, civil engineers, mechanical and nuclear engineers, as well as technicians, radiologists, chemists, mechanics, reactor operators, radiation protection specialists and other scientists. Those skills are required during various stages, such as planning, construction, operation and maintenance, supply chain and decommissioning. All aspects of running a nuclear program demand a diversity of expertise with some 16% of this work force being truly nuclear experts, three-quarters being nuclear trained and some 10% being nuclear aware.

The nuclear industry provides more high-paying and highly trained jobs than other sectors, specifically providing a sustainable source of local jobs contributing to local and regional economic growth.

In addition, according to the UNECE report 'The Role of Nuclear Energy in Sustainable Development', the nuclear industry is one of the safest industrial workplaces. According to IAEA, health, safety, well-being, and the long-term improvement of workplace conditions are priorities for the global nuclear industry, which operates at the highest standards. Employees are respected for their skills and expertise and acknowledged for their contributions. Partnerships are made with educational institutions to provide further training and professional development. Furthermore, important aspects of the criteria for decent work are also addressed by many of the other 16 goals. For example, the nuclear industry is committed to attracting and retaining qualified women and men, including young people and persons with disabilities to the nuclear sector.

Nuclear power as a contributor to economic growth

Economic growth is a common indicator used to refer to an increase in aggregate production in an economy and can be a key measure of poverty reduction and quality of life improvement.

The nuclear power industry can play an integral role in supporting developing countries by contributing to short-term and long-term employment, sustainable investments, and infrastructure development.

Nuclear power is a zero-carbon electricity generation technology capable of producing large- scale,reliable baseload power, which is essential for developing countries that need both to build out their energy systems and reduce CO_2 emissions quickly.

In the United States, the average 1,000-megawatt nuclear power plant employs more than 500 skilled laborers for an estimated $48 million in total labor income per year, a workforce income three times larger than a coal plant of the same size. Beyond direct jobs, nuclear plants can boost local tax bases and provide indirect economic benefits. These plants last many decades, providing jobs over many years.

Small modular and advanced nuclear plants are coming to the market before the end of this decade. They have the potential to be deployed in a wider range of locations, some of which would be unsuitable for large- scale reactors. Once available, they may help to cut the cost of electricity as production is scaled up.

New nuclear power plant construction also has a positive impact on local economies. Construction of new plants demands skilled laborers, including welders, electricians, heavy equipment operators and engineers. At peak construction, 3,500 workers are required to build the plant. Furthermore, a single new plant requires approximately 1,200,000 cubic feet of concrete and 66,000 tons of steel, a significant boost to suppliers of these materials.

In contrast to some fossil fuel-based industries, nuclear energy is a clean technology with no adverse consequences for air quality and very high safety standards. Investment in clean energy could and should be at the forefront of the post-Covid economic recovery, particularly in emerging markets. The long life of nuclear plants makes them stable employers who provide highly skilled and highly paid reliable work with excellent opportunities for women.

Worldwide, nuclear power has proven to provide substantial economic and environmental benefits. As users of a zero-carbon technology, these plants can continue to provide sustainable economic growth in a carbon-constrained world. The rapidly growing concern about climate change is likely to lead to more robust climate and energy policies, and thereby to greater investment in all forms of low-carbon energy. The sharp rise in the EU carbon price in the last three years is a sign of things to come and augurs well for the future of the nuclear industry. All those countries willing to seize this opportunity will reap rewards in the form of higher economic growth.

SDG Perspective

SDG 9 - Industry, Innovation and Infrastructure

Sustainable Industrialization

Nuclear energy systems and, in general, any application of nuclear science and technology, demand a multidisciplinary skill set for high-performing development and industrial deployment of market-competitive solutions. The long time frames required to develop from early ideas through technology qualification and finally industrialisation demand an integrated approach involving many stakeholders. The inclusion of universities, R&D laboratories, small and medium sized enterprises as well as a variety of industrial companies on the international scene are required to make such nuclear development and deployment a success. In addition, high-quality standards require inclusive partnerships with various stakeholders based on a high degree of mutual trust and quality of technical and economic performance.

The nuclear industry already provides great examples of inclusive long-term partnerships with various partners including the development of skills and capabilities as part of newbuild programs. It is gearing towards even higher-performing industrialisation schemes for the newbuilds in the coming decades by integrating innovative industrialisation processes supporting the current reactor fleet as well as the newbuilds and advanced technologies for tomorrow.

The nuclear supply chain for reactor commissioning, operation and maintenance and its nuclear fuel cycle entails among the lowest environmental impact of all decarbonised energy technologies. The high technology character of this supply chain yields sustainable high-paying jobs and technological excellence with important and broad economic benefits.

Fostering Sustainable Nuclear Innovation

Today's global economy is developing the world's natural resources and generating waste streams at an unsustainable rate. A redesign of unsustainable business practices is needed in order to preserve the world's natural resources and the health of future generations. The environmental performance of the commercial nuclear power industry is better than many other energy options, but it also must improve, and sustainable innovations like advanced nuclear reactor technology are needed to address global sustainability goals.

In comparison to conventional nuclear reactors, advanced nuclear construction uses significantly less cement and steel, two emission-intensive materials. While nuclear power plants produce carbon-free electricity during operation, the production of the cement and steel used in their construction releases some carbon emissions. Scientists and engineers have streamlined advanced reactor designs for simplified construction. Reactors like TerraPower's Natrium technology or Westinghouse's SMR will reduce the amount of nuclear-grade concrete by 75-80% when compared to traditional large-scale reactors. Also, most advanced reactor designs will operate at low pressures, eliminating the need for costly steel pressure vessels.

Advanced nuclear reactors are also more energy efficient. Next-generation designs will be able to achieve higher operating temperatures and thereby provide more efficient use of nuclear fuel and generate less waste. These designs will also be able use their excess heat for industrial processes like steel and cement production, water desalination, or hydrogen production, further reducing greenhouse gas emissions and the 40% of energy that is typically wasted in power production.

Sustainable and Resilient Infrastructure

The nuclear industry relies on a multimodal international transport network for the safe, secure and reliable movement of nuclear material between facilities. To ensure that shipments face minimal delays, this network must remain open and free from barriers. Internationally agreed regulations, such as those governing packaging and labelling, ensure that smooth transitions occur at all interfaces within regions and at international borders. The harmonisation of model regulations is also important for material that is transiting between the different regulations that govern road, rail, air, sea and inland waterway transport.

Industry representation at intergovernmental organisations, such as the International Atomic Energy Agency (IAEA), is crucial in ensuring that the industry viewpoint and technical expertise are available to policy makers when drafting legislation. This representation is achieved through non-governmental organisations such as the World Nuclear Transport Institute (WNTI).

Investment in the workforce ensures that qualified and properly trained personnel are available throughout the fuel cycle chain, thus protecting the routes used and ensuring that nuclear power stations receive the fuel that they need.

Investment in engineering, infrastructure and technology ensure that properly fit-for-purpose equipment and systems are available. Specially constructed flasks[1] are used to contain nuclear material during transport and storage, and these flasks are designed to facilitate ease of handling. In many instances, purpose-built transport vehicles are used for land transport, and purpose-built ships are used for maritime transports of the most radioactive materials.

[1] in the US they are called casks

Nuclear as a Driver of Sustainability

Innovation has defined the success of nuclear energy industry in the past and remains essential for the sustainable future. Development of innovative nuclear technologies has shaped national and international efforts to define climate goals consistent with overall sustainable development goals.

Considering the world energy demand and sustainability-related constraints (economic, environmental, and social), nuclear energy represents an ideal option to meet the projected increase in global future energy needs in a sustainable manner and replace ageing infrastructure based on fossil fuels.

According to the OECD Nuclear Energy Agency, innovation in nuclear technologies requires a proper coordination of many policy areas including energy, science and technology development, environmental, industrial, safety and regulatory. Therefore, investments in new nuclear are a driving force behind achieving UN Sustainable Development Goal 9 on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation.

SDG Perspective

SDG 10, SDG 11, SDG 12

SDG 10 - Reduced Inequalities

Energy poverty, or lack of access to reliable electricity, poses a barrier to economic mobility and vitality in developing nations. Universal access to low-cost, clean electricity can help to reduce socio-economic inequalities as well as curb reliance on sources of electricity that contribute to global climate change and air pollution.

Non-emitting electricity sources such as nuclear energy provide firm, reliable power that enables a higher standard of living and empowers greater social equality. In developing countries, for example, many gendered household tasks requiring significant time and manual labor could be made easier with the addition of reliable electricity. This, in turn, would allow men and women more equal time to pursue education or earn wages outside of the home.

Additionally, nuclear energy is a compliance-driven industry that places emphasis on accountability, safety, and strong workplace culture. These facilities can help play a role in government-led or social initiatives for the enforcement of anti-discrimination policies within the workplace. As major employers in the areas where they operate, nuclear energy utilities and reactor developers would also have relationships with the universities, technical schools, and other organizations from which they recruit new talent, and can also influence societal norms if anti-discrimination policies and best practices are emphasised in these learning institutions.

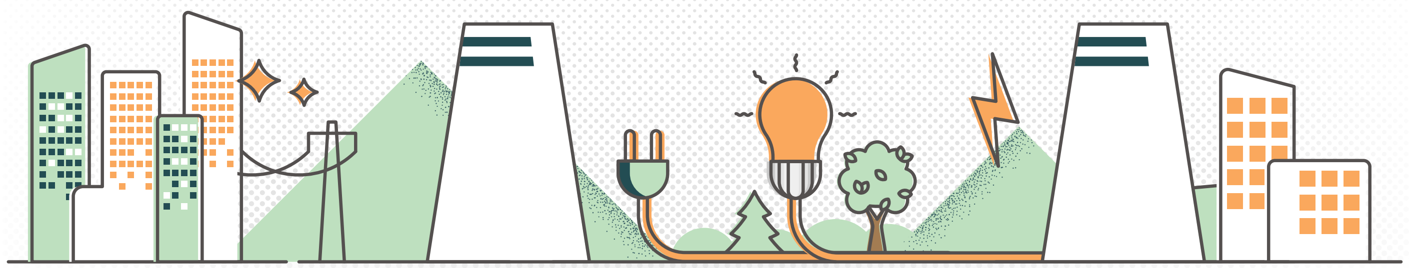
SDG 11 - Sustainable Cities and Communities

Since 2008, more of the world's population has lived in urban areas than in rural areas. This percentage will continue to grow; by 2050, it is expected that two-thirds of the world's population will live in urban communities.

Proper planning is needed to avoid urban areas becoming unsafe and dysfunctional environments. To address this, 156 countries have developed National Urban Policies, but of these, only half are in the implementation stage. This needs to improve if we are to achieve the 2030 Agenda's Sustainable Development Goal 11, "make cities and human settlements inclusive, safe, resilient and sustainable." This must include good housing, clean water and sanitation, reliable and affordable energy, and a good transport network. At present, half of the world's urban population do not have convenient access to public transport, this being defined as not residing within 500 metres of a bus or low-capacity transport system, and 1km of a railway or ferry terminal.

There are also more than 1 billion people living in unsafe, unhealthy, overcrowded shelters with limited or no access to basic services.. A chief difficulty for these urban areas is providing clean and affordable energy. However, nuclear energy can support more sustainable urban development.

Nuclear power plants provide affordable, reliable electricity which is well-suited to supplying cities where there is 24-7 energy demand. Nuclear energy assists in the electrification of public transport, and especially rail networks, without contributing to air pollution.



YES TO NUCLEAR PERSPECTIVES I SUSTAINABLE DEVELOPMENT GOALS PERSPECTIVE

SDG 12 - Responsible Consumption and Production

In 2021, the International Energy Agency published a special report on "The Role of Critical Minerals in Clean Energy Transitions," which states that the mineral demand for the low-carbon power generation to meet climate goals will triple by 2040. This demand is mainly driven by material-intensive power generation sources. However, a relatively low mineral input demand coupled with its high energy density positively contributes to nuclear energy's sustainability.

Generally, nuclear energy requires fewer mineral inputs than other energy sources, mainly copper, nickel, chromium. Instead, uranium is the primary input mineral most commonly used in nuclear reactors to produce energy. However, some uranium is able to be re-enriched or recycled which can reduce the amount of mining, extracting and processing needed.

Because of nuclear energy's low material intensity and current innovations, the efficiency of nuclear power plants can increase and the amount of minerals and materials needed can be reduced even further. In addition, nuclear power generation requires comparatively low land use intensity relative to other energy sources. Therefore, using nuclear technology to tackle climate change is vital for achieving Sustainable Development goals in general.

SDG Perspective

SDG 13 - Climate Action

Industry's commitment to Climate Action

Of all the 17 Sustainable Development Goals, "Take Urgent Action to Combat Climate Change and its Impacts" (SDG 13) is arguably the most important. It addresses directly the existential threat to the human species which the world's changing climate now poses.

It is also the one to which the nuclear energy industry can make the biggest and fastest contribution. The need for very rapid decarbonisation of energy and the complete replacement of fossil fuels is now widely acknowledged. But progress towards these critically important aims remains dangerously slow.

Policy makers continue to ignore the lessons of history. In the past, only two countries, Sweden and France, have ever achieved the scale and speed of decarbonisation which every country must now implement. Both did so by massive investment in nuclear energy capacity.

Nuclear energy is the world's second largest source of low carbon electricity (and the largest within the EU). A recent EU report concluded that Gen III nuclear plants have lower accident fatality rates than any other electricity generation technology. It also found that its lifecycle emissions are comparable to hydro and wind power and that its land requirements are far less than solar or wind.

Technical improvements, including progress on advanced and small modular reactors, are cutting the cost of new nuclear plants. The only barrier to nuclear power increasing its global role is the reluctance of some policy makers to treat it equally with other low carbon energy sources.

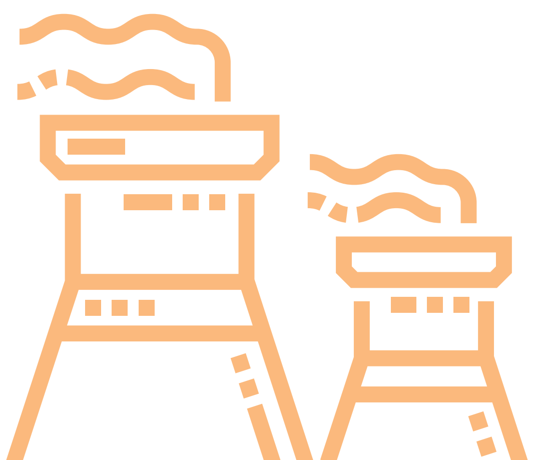
The industry's commitment to helping deliver SDG 13 is unequivocal. 2021 must be the year when governments recognise this. COP26 would be a good place to confirm that they do.

Climate-resilient nuclear power plants

The increasing rate and severity of natural disasters, a consequence of climate change, has had disruptive effects on energy grids. Economies around the world have identified investing in a modern and resilient energy grid as a key priority moving forward. Nuclear energy can play a key role in creating resilient energy systems.

Recent natural disasters have shown nuclear power's resiliency. In 2017, the United States was hit with back-to-back hurricanes. Hurricane Harvey and Hurricane Irma both caused devastating infrastructure damage to South Texas and Florida that left individuals and disaster relief operations without power for days. Fossil fuel plants shut down operations due to flooding, yet nuclear power plants like the South Texas Project, Waterford, and River Bend were able to keep providing gigawatts of reliable energy to the grid. This is because of the strong structures nuclear reactors have that can withstand flooding and strong winds.

Nuclear capacity factors are at an all time high and advanced nuclear energy is expected to build on this trend of continuously improving performance. Advanced reactors will have the ability to restore part of an energy grid independently, or blackstart, in the event of a grid blackout, eliminating the need for fossil fuel blackstart resources. Siting for these reactors may also be below-ground, further shielding plant systems from physical attacks or extreme weather events such as wildfires. Ultimately, having a resilient and secure energy grid matters, which is why investment in advanced nuclear energy is necessary for both existing and new commercial nuclear programs.



Faster decarbonisation with nuclear energy

Decarbonising the energy system is crucial for a more sustainable future for all. What is unique about nuclear power is that it can provide electricity 24/7, and its pre-planned maintenance periods do not cause any intermittency in energy supply. Renewable energy does not always follow similar production patterns and thus grid reliability is improved when renewables are coupled with nuclear power.

Today, nuclear power plants worldwide represent almost half of all decarbonised electricity generation, despite providing only 10% of the world's electricity. Even a small increase in nuclear energy's market share can provide significant assistance to decarbonising electricity generation. In addition, non-electric nuclear applications can accelerate such decarbonisation even further. For example, the production of hydrogen through nuclear energy can be a key factor in overall system decarbonization for many energy-intensive markets.

Nuclear power provides reliable and dispatchable energy by generating electricity at a large scale, usable in residential and industrial areas as well as transport, hydrogen production, and many other sectors. Nuclear energy, alongside other renewable energy technologies and combined with appropriate energy storage solutions, can guarantee a rapid transition towards a decarbonised energy pathway for all.

Production of synthetic fuels

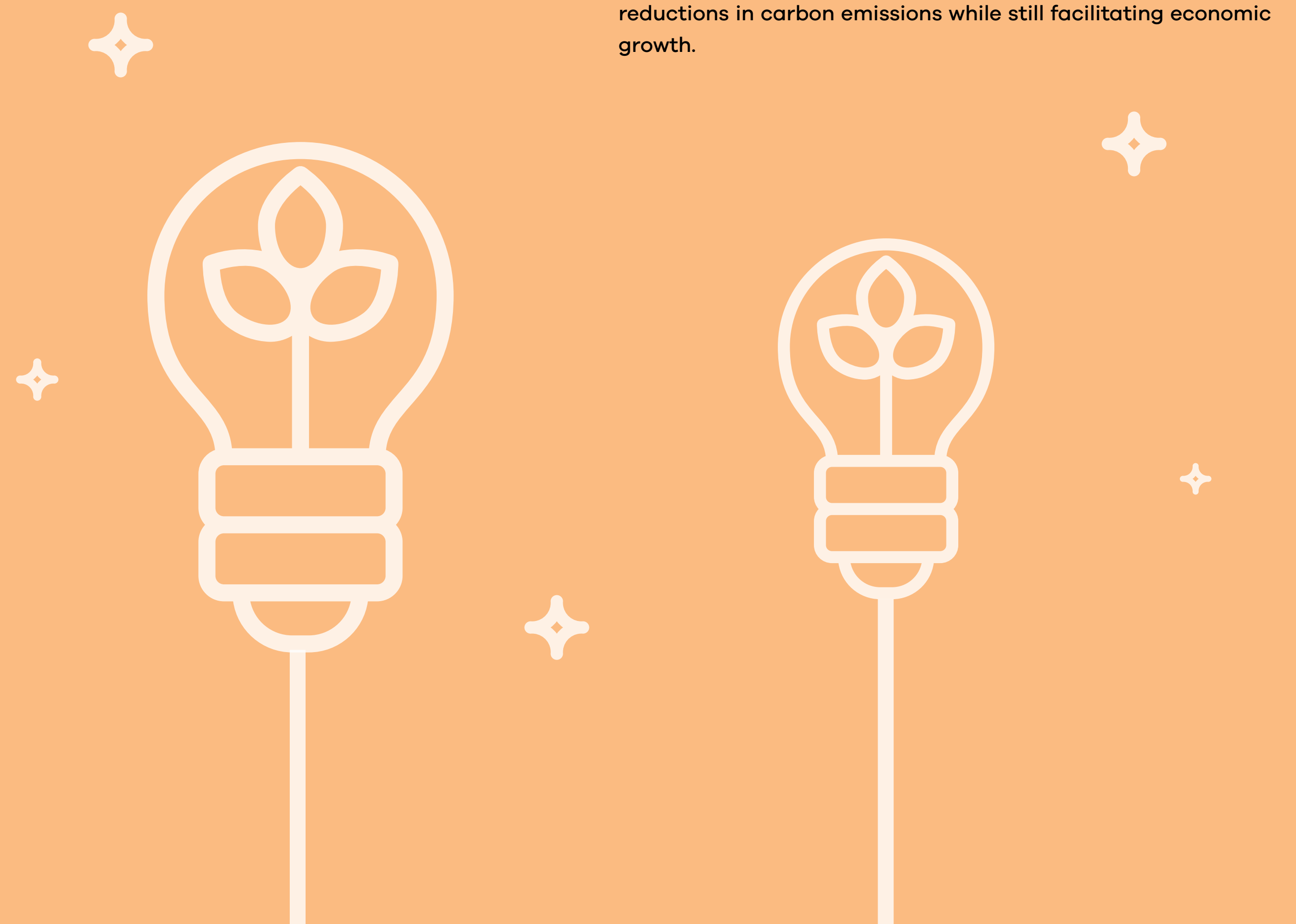
Nuclear power has long been associated with the production of electricity; this being achieved through the heating of water to create steam that drives a turbine. Traditionally, this electricity is exported to, and distributed by, a regional or national grid of heavy electrical cables. In colder regions, any surplus heat from the nuclear power station has often been used to supply district heating.

With the development of advanced reactor designs, additional focus is now being given to other ways to use the electricity generated and how best to utilise the heat.

Some industries require large quantities of heat to function, including cement production, some food production, and desalination of seawater. With modular construction and the portability of many reactor designs, deployment of nuclear power to remote locations can facilitate economic growth in isolated regions and small islands, replacing the need for fossil fuel-burning power stations.

Nuclear power can also produce synthetic fuels. Hydrogen can be produced electrolytically. This zero-carbon hydrogen can be used as a replacement for coke in steelmaking and other metallurgical processes. Hydrogen fuel cells can power vehicles, and ocean vessels can use hydrogen as a replacement for marine fuel oil, either directly or following conversion to ammonia or methanol. Such fuels, when produced using nuclear power, result in near zero emissions.

Adopting these technologies will result in considerable reductions in carbon emissions while still facilitating economic growth.



SDG Perspective

SDG 14, SDG 15, SDG 16

SDG 14 - Life below water

The carbon emissions from burning fossil fuels has multiple consequences of great concern, among which is ocean acidification (resulting from the carbon dioxide dissolving in and reducing the water's pH-level). For millions of years, the average ocean water pH has been around 8.2, while today's average of 8.1 represents a 25% increase in acidity in just two centuries.

The world is facing critical limitations in the availability of fresh The implications of such acidification are manifold, but in large part relate to the reduced availability of carbonate ions in ocean water. Such carbonates are the building blocks for the bottom of our food chain. Phytoplankton, crabs, mussels, corals, and many other species experience a decreased capacity to make shells and skeletons, reducing their chances of survival and successful reproduction. Additionally, studies project that by the end of this century, rising water temperatures brought on by climate change will jeopardize ocean species in such a way that global seafood supply may decline by 50% on average, and economic systems that rely on fishing and tourism revenues may see a 90% decline in business value.

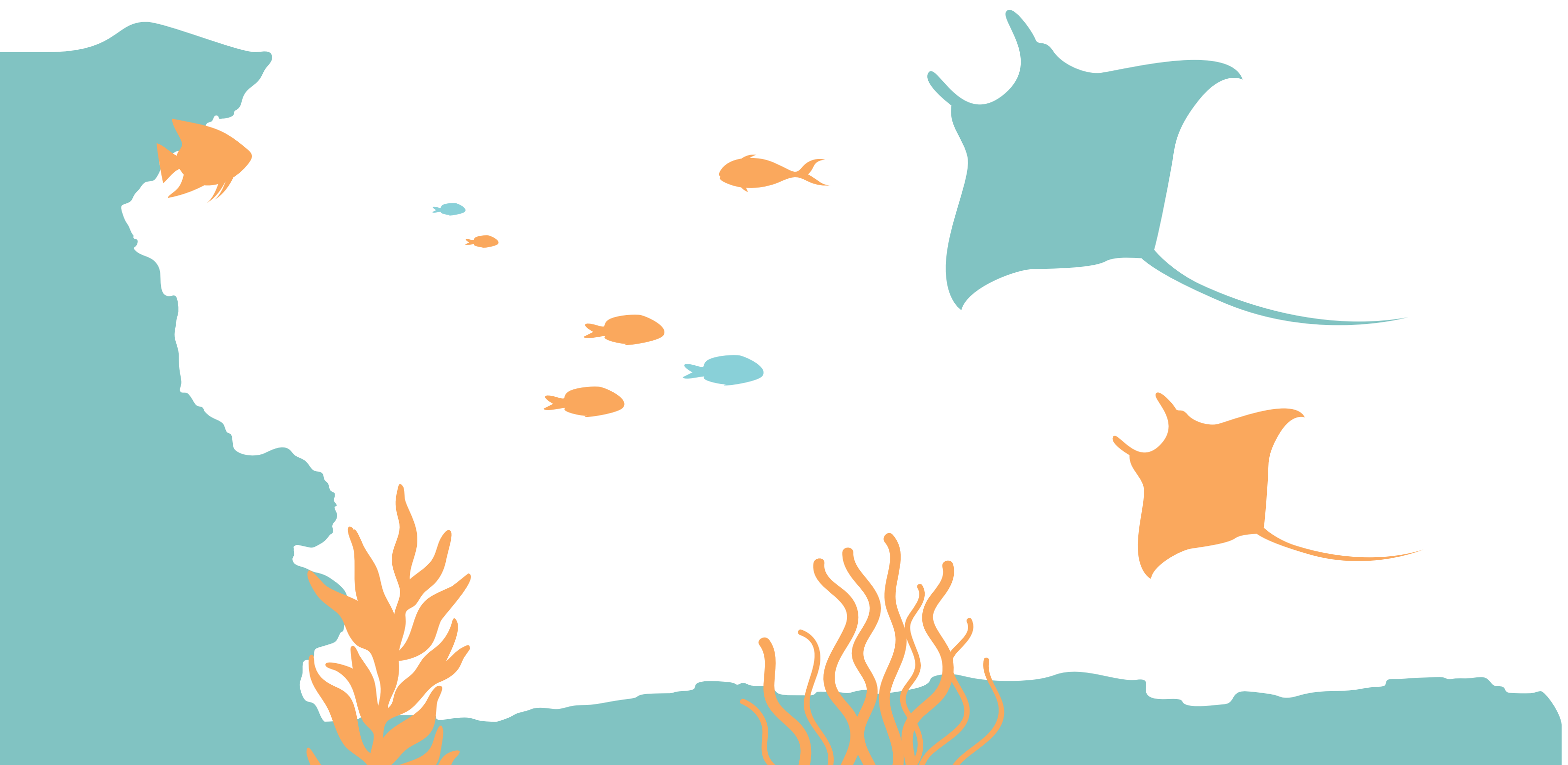
Given the building inertia of these global challenges, decarbonising our energy systems is more urgent than ever. Nuclear power can help to accomplish this now and in the future.

SDG 15 - Life on land

Loss of biodiversity is caused by many factors, but two of the major causes are habitat degradation and loss. This is often caused by urbanisation, agriculture expansions, logging activities and pollution from industry, transport, and human populations.

With growing interest and political eagerness to build out new clean energy it can be easy to overlook the impacts caused when large areas of land or sea are turned over to energy production. In some instances, generation facilities can be easily incorporated into an already disrupted landscape with minimal impact on biodiversity. However, the buildout of infrastructure on undeveloped land still has that potential to disrupt the natural environment. Thus, an important objective for biodiversity conservation must be to minimize this impact to the greatest degree possible.

Due to the sheer density of nuclear fuel, today's nuclear power plants require a relatively small land mass footprint to produce a similar amount of power as other clean energy sources. Additionally, advanced reactors such as a small modular reactor require a fraction of the area that even conventional plants occupy. Nuclear power can provide a constant, reliable, and clean source of energy, without having to sacrifice natural habitats or compromise biodiversity priorities.



YES TO NUCLEAR PERSPECTIVES I SUSTAINABLE DEVELOPMENT GOALS PERSPECTIVE

SDG 16 - Peace Justice and Strong Institutions

Nuclear technology for peaceful uses has significantly expanded for the generation of electricity. Worldwide, in the early 1980's, the output of nuclear electricity represented about 500 MWh while today's production reaches around 2500 TWh, representing 10% of the electricity consumption.

Nuclear technology use has diversified in strategic areas. There are prospects for further development to meet future challenges and growing needs for water, non-electrical power, food, and other industrial processes (oil extraction, art preservation, etc.), in addition to medical applications.

Fresh or potable water supply is scarce in some regions in particular in the Middle East or in Africa and the desalination process is already implemented in many countries. Nuclear reactors can provide electricity or generate heat to power a desalination plant. SMRs are better suited in isolated with poor infrastructure while larger nuclear power plants can be associated with larger desalination facilities together with electricity supply.

Nuclear energy can also contribute to district heating or cooling systems and more importantly to hydrogen production. Hydrogen is considered as a very promising, reliable, and cost-effective clean source to fuel transportation.

Use of isotopic techniques can contribute to meeting the food supply challenge through in particular, food preservation, and supporting agriculture by water savings, soil quality and nutrients assessment, insect pest management (flies, grasshoppers).

Overall, nuclear science and technology applications provide a daily tangible contribution to the wellbeing of this planet and an increased use of such nuclear applications could ensure our path towards true sustainability.

SDG Perspective

SDG 17 - Partnerships for the Goals

UK Perspective

Nuclear promotes progress towards the achievement of the 17 UN Sustainable Development Goals more than any other energy technology. The UK has long been a leader in the global debate about climate policy. Part of its large international development aid programme is aimed at helping poorer nations accelerate their transition away from fossil fuel dependence.

Due in part to its pioneering role in the nuclear energy industry, the UK is well poised to nurture partnerships with governments, civil society organisations, trade unions, and educational and research institutes as well as the UN and other international bodies such as the Commonwealth.

The huge job creation impact of new nuclear construction makes the industry a natural partner for developing countries emerging from the Covid-driven economic slump. The attractive employment opportunities for women in nuclear address SDG 5, while the quality of the jobs promotes SDGs 3 and 10.

Particularly exciting new partnerships will be created in countries where investment in new nuclear plants is being made for the first time. These include Bangladesh, Egypt, Turkey and Poland. By making the construction of new nuclear plants part of their post-Covid recovery strategies these countries can ensure that sustainability is a foremost priority.

The success of this approach will be enormously helped by partnerships for the SDGs. In addition to the types of partnership already mentioned, cooperation between national regulators can lead to more harmonization of safety standards and more secure international supply chains. Recognition that providing all communities with affordable clean energy needs both nuclear and renewable energy could give rise to other productive global partnerships as well.

European Perspective

Many European countries have been using nuclear energy since the early years of its development; some have become international players in the nuclear industry , having a strong nuclear R&D infrastructure and skilled workforce. Virtually all European countries have at least developed the nuclear competencies required to perform nuclear R&D and maintain regulatory compliance. This nuclear infrastructure and strong knowledge base is a product of collaboration among European countries that was normalized in the 1990s when new plant construction was less common and an interest from other countries in new projects was typical.

On nuclear R&D, various EURATOM framework programs allowed for a more consent-driven and coordinated approach among European nuclear R&D (including the European Joint Research Centers). This was strengthened even further with the Sustainable Nuclear Energy Technology Platform (SNETP) that convenes almost all nuclear actors within Europe to develop shared goals for nuclear development.

The continuous need for a skilled nuclear workforce and to attract young professionals to the field, coupled with an observed reduction in the output of talent from nuclear educational programs, led to the creation of the European Nuclear Education Network (ENEN). ENEN provides a model for other regions in the world to undertake similar approaches.

European nuclear actors and the European Union (via various mechanisms such as EU DEVCO) are pursuing international collaboration regarding the safe use of nuclear energy as well as action on sustainable development and the affordable use of nuclear energy in diverse regions around the world.

YES TO NUCLEAR PERSPECTIVES I SUSTAINABLE DEVELOPMENT GOALS PERSPECTIVE

US Perspective

Rapidly developing countries typically face high population growth, leading to a high rate of increase in electricity demand. While addressing climate change is important, developing countries cannot afford to risk hindering economic growth, and so rely on heavy carbon-emitting energy. However, developed countries like the United States have a unique opportunity to change this.

With the highest Gross Domestic Product in the world, the U.S. has the ability to invest financial resources in emerging nuclear technologies with the expectation that they can be used to provide clean and reliable power to developing countries. Currently, the U.S. Nuclear Regulatory Commission (NRC) has 45 bilateral agreements with other countries that are used to share technical and regulatory information to primarily developing countries with smaller or nascent commercial programs.

Although the NRC is considered a leader in the global nuclear community, a lack of nuclear innovation has allowed the U.S. to fall behind other countries in nuclear energy leadership.

According to the International Atomic Energy Agency, a "solid group" of about a dozen countries are expected to be in prime positions to build their first nuclear reactor in the coming decade, around the same time advanced reactors are expected to be ready for commercialization. Countries like Egypt and Belarus have already taken the initiative to join the IAEA and begin their nuclear energy programs. As member states, they will have access to support from the global nuclear energy community, including from the NRC, in order to develop advanced nuclear programs that can safely, effectively, and sustainably help eliminate poverty and hunger.

Infrastructure and Transport Perspective

Participating in a virtual panel discussion on 'Partnership for the Goals' at the World Health Summit (WHS) in Berlin, IAEA Director General Mr Rafael Mariano Grossi said there is a clear need for United Nations agencies, research organizations and civil society groups to organize more closely around common issues to take collective action toward achieving the 17 United Nations Sustainable Development Goals (SDGs).

And it is the IAEA that is making significant contributions to these goals through the promotion of nuclear technology in green power generation, pharmacy, and food production.

Since the early days of nuclear power, the nuclear industry has recognised the importance of developing lasting partnerships with governments, NGO's, educational institutes, and many UN bodies such as the IAEA.
It is out of these co-operations that many of the cornerstone principles of nuclear transport were formed; principles that protect workers, the population, and the environment during the transport and subsequent safe use of nuclear material.

As more countries embrace nuclear energy to meet their climate goals the lessons learned and experience gained, from those nations that adopted this technology first, will give valuable insight towards a safe and successful program.

New technology will also figure prominently in future legislation. SMR production may include the fuelling and sealing of reactors, as part of the construction process, prior to transporting the SMR to the chosen site of operation. Similarly, at the end of its operating life, the SMR may need transporting to a decommissioning facility with spent fuel still inside.

INDUSTRY PERSPECTIVES

Industry Perspectives

Industry Perspective

Nuclear-produced hydrogen

Direct impact

Indirect impact

Low-carbon energy source

Hydrogen is quickly emerging as an energy source with the potential to decarbonize transportation, industry, and other sectors. Burning hydrogen emits water and no carbon dioxide. However, current hydrogen production is dominated by fossil fuel processes, causing lifecycle carbon emissions. Nuclear energy can help increase global production of hydrogen in a low-carbon manner.

The two most common methods of producing hydrogen are steam-methane reforming and electrolysis. Steam-methane reforming currently accounts for nearly all commercially produced hydrogen in the United States. The process intermingles steam with fossil methane to create discrete quantities of hydrogen, carbon monoxide, and carbon dioxide. In total, steam-methane reforming emits over seven times as much carbon emissions as hydrogen gas produced.

Electrolysis involves splitting hydrogen molecules from a source of water using an electric current. The process does not result in byproducts besides hydrogen and oxygen. However, electrolysis is electricity-intensive and only as clean as the electricity used. When renewable or nuclear power produces the electricity used, or when carbon is captured from steam-methane reforming, hydrogen becomes a low-carbon energy source.

Many projects are now exploring the use of conventional nuclear energy to supply electricity for hydrogen production. Further, research is ongoing into how advanced nuclear reactors can supply electricity, heat, or both to separate hydrogen from water. For example, in a high-temperature electrolysis process, direct heat produced from high-temperature gas-cooled advanced reactors is used to thermochemically split hydrogen from water. The overall thermal-to-hydrogen efficiency for this process can be up to 50% (double the efficiency of conventional electrolysis). This high output to input ratio means hydrogen produced via advanced nuclear reactors could become increasingly cost competitive as the technologies mature.

Affordable energy source

Hydrogen, as an energy carrier and not an energy source, holds important potential to replace oil in transport and in other applications. The main features that can propel the use of hydrogen relate to its complementarity with electricity (via electrolysis) and the circular nature of production and use while also providing a feedstock for producing fuels such as ammonia.

Today's hydrogen production largely goes hand-in-hand with the emission of CO_2 from the steam reforming of natural gas or coal gasification. The projected larger demand for zero-carbon hydrogen would mostly be based on electrolysis using low-cost electricity or, somewhat later, through the decomposition of water by direct use of heat via thermochemical processes. A decarbonised energy source for electricity and heat is anyhow required.

Today's nuclear power plants (NPPs) can already produce hydrogen via low-temperature electrolysis and by using nuclear heat assisting steam reforming of natural gas. Combining both heat as well as electric after-heating may lead to higher-temperature steam electrolysis. Later on, advanced NPPs providing higher working temperatures could opt for high-temperature thermochemical hydrogen production.

In a wide range of future scenarios, nuclear power is projected to provide competitive hydrogen production routes, given the low-cost base-load production cost for NPPs and the potential to exploit the dispatchability of NPPs to provide both electricity and process heat especially in high-share intermittent renewable energy markets.

Generation-III/IV NPPs and small modular reactors (SMRs) may also better respond to regional hydrogen production demand. The avoidance of important costs for transporting hydrogen, particularly from dispersed low-energy-density and intermittent renewable energy sources, through an increased co-location of nuclear power with hydrogen production plants would be beneficial as economies of scale will matter.

YES TO NUCLEAR PERSPECTIVES I INDUSTRY PERSPECTIVE

Reliable energy source

The production of hydrogen using nuclear power rather than renewable energy has several advantages. Firstly, nuclear power can supply energy at a far higher capacity, because it produces at maximum power over 90% of the time, allowing greater operational efficiency and continuous production of hydrogen, which is essential for its far-reaching industrial applications.

Secondly, much less land is required to produce hydrogen using nuclear power than renewable energy sources. Thirdly, the production of hydrogen using nuclear power will stimulate investment in the wider infrastructure upon which an integrated European clean hydrogen economy could begin to evolve and enable Europe to contribute to the 90-fold increase in global hydrogen production capacity that the International Energy Agency believes is needed by 2030 to keep the increase in average surface temperature below 1.5 C.

Low-carbon nuclear-produced hydrogen will provide a reliable energy source that will be an essential component of the global energy transition, removing or substantially reducing the role of fossil fuels.

Modern energy source

A significant departure from business as usual is urgently required to address the threat of climate change and to protect the environment. The production of hydrogen using nuclear energy is now attracting worldwide attention as demand for sustainable energy and for the development of new energy generation technologies to meet the need for cleaner energy sources increases.

For hydrogen production, nuclear energy is well suited and well-aligned with climate protection goals. This is leading many countries to actively explore the options of nuclear hydrogen as a non-carbon energy carrier and a promising alternative fuel.

The development of nuclear hydrogen offers great opportunities for the symbiosis of nuclear and hydrogen energy alongside renewable energy. This could lead to the formation of a more sustainable global energy system and strengthen energy security in countries that develop domestic production capacity.

Viewpoint

Initial IMO Strategy on reduction of Greenhouse Gas (GHG) emissions from ships.

In 2018, the International Maritime Organization adopted the Initial IMO Strategy on reduction of Greenhouse Gas (GHG) emissions from ships. This has set the following targets,

1. Reduction of CO_2 emissions per transport work (carbon intensity), as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008;

2. For the first time a reduction of the total annual GHG emissions from international shipping by at least 50% by 2050 compared to 2008, while at the same time pursuing efforts towards phasing them out as called for in the vision, for achieving CO_2 emissions reduction consistent with the Paris Agreement goals.

The Strategy has proved to be a catalyst to various initiatives on low-carbon and zero-carbon fuels for shipping, and several options are being pursued, such as nuclear-powered vessels, hydrogen-based synfuels, ammonia converted from hydrogen, and hydrogen fuel cells. Each of these options have merits although suitability can depend greatly on the size of the vessel and its trading pattern.

Fuel cell technology, and hydrogen-based synfuels, are already in use in certain sections of shipping. For this to continue, and grow, a reliable and sustainable source of hydrogen must be readily available to the maritime industry.

There are several companies developing technology for floating nuclear power plants that, along with electricity production, could produce zero-carbon hydrogen for marine use. Most major ports already have large areas of land currently used for the storage of marine fuels with dedicated bunker fuel supply berths. These facilities offer the ideal locations to securely moor floating nuclear power plants that could then be engaged in the production of green hydrogen.

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Industry Perspective

Nuclear Industry and Transport

Direct impact

Indirect impact

Safe and secure nuclear transport

The transport of radioactive materials has a long history spanning several decades, with transports regularly taking place by road, rail, air, river, and sea. A stringent regulatory regime has been developed at both international and national levels. These all ensure that the safety and security of radioactive material is robustly assured when being transported.

The basic concept is that safety is vested principally in the package containing nuclear materials. The package must provide shielding to protect workers, the public and the environment against the effects of radiation, to prevent an unwanted chain reaction, to prevent damage caused by heat and to provide protection against dispersion of the contents.

A graded approach is applied when determining transport security requirements, where measures are employed as deemed appropriate. These range from the design of the package and vehicle used as well as security forces, access control, employee screening, satellite tracking and coordination with local and national security authorities.

To ensure security, transportation preparedness programs have been developed to assist state, tribal, and local responders with essential emergency services. Funds provided to these groups support continued training and have allowed for communication centers, telemetric monitoring technology, and other critical infrastructure to be built in communities that fall within radioactive material transportation routes.

Shipping this material has also encouraged innovation. Ongoing projects with the U.S. Department of Energy and the U.S. Navy are designing and testing new casks, buffers, and escort railcars for future large-scale transport. The railcars will use the most advanced designs and technologies available. Internationally, shipping casks have been designed and constructed to safely transport radioactive material.

Sustainable development aspect

Given the significant current challenges of climate change and decarbonisation of a number of sectors and sub-sectors, in industry, transport, and heating, nuclear power is well suited to serve as a decarbonising agent in the energy transition. With transportation of radioactive material being an integral part of the nuclear industry, the nuclear industry could play a role in transportation decarbonisation.

Transport safety and security is not only a vital component during all stages of the nuclear fuel cycle, but it also has a direct and indirect impact on all 17 Sustainable Development Goals. As a result of the increased use of radioactive materials in various industries, medicine, and agriculture, the transport sector has become a key priority for decarbonisation, offering further protection of the environment,ensuring clean air, water, soil and boosting agricultural production.

YES TO NUCLEAR PERSPECTIVES I INDUSTRY PERSPECTIVE

Decarbonisation of the transport industry

Transport is a vital part of our lives, allowing us to travel across continents and cultures for leisure and facilitating the delivery of a variety of goods and services. Most of the transport today is based on fossil fuels with a high degree of electrification in public transport systems and a slow increase, though still marginal, of such electrification in private transport. The transport sector overall is responsible for about 25% of the world's total energy-related GHG emissions.

Achieving a more sustainable transport future requires some combination of the following: reducing the transport needs overall, modal shifting towards lower-carbon transport systems, lowering the energy intensity and reducing the carbon intensity of the fuels used. Nuclear can provide a more sustainable solution for transport in three domains:

- Enabling increased electrification in public and private transport by providing low-carbon electricity;
- Fueling freight transport as a propulsion energy source as has been practiced in some nuclear-powered freight vessels and ensuring a highly performing service in the military domain;
- Providing a prime low-carbon energy source for hydrogen production, as hydrogen is potentially a very effective and high-performing energy carrier for low-carbon heavy-freight transport.

In addition, nuclear-produced hydrogen has been rightly identified as a vital tool in the necessary decarbonisation of transportation sub-sectors that would otherwise prove difficult and expensive to decarbonise via electrification. It can be employed in new and novel applications as a means to replace current fossil fuel use and deliver wider decarbonisation (as well as fuel diversification).

In industrial and transport applications, hydrogen can be used in the production of liquid transport fuels to replace oil. The greater deployment of hydrogen fuel cell electric vehicles (FCEVs), in tandem with the deployment of hydrogen refuelling stations (HRSs) are one means of decarbonising the transport modes requiring longer distances and faster refuelling times, such as trains, heavy-duty trucks and long-distance coaches.

Nuclear-produced hydrogen may also play a role in the decarbonisation of the aviation and shipping subsectors, which together account for roughly 5% of total global emissions. This remains a long-term possibility as several technical and commercial obstacles must first be overcome. Using ammonia made from zero-carbon hydrogen in shipping is a potentially promising option.

Viewpoint

Radioactive Material Transport

For over 50 years, consignments of radioactive material have been transported throughout the world. It is estimated that each year about 20 million transports take place, with a safety record that has ensured that there has never been a transport incident involving nuclear materials that has caused significant radiological damage to people or the environment.

Consignments are carried by road, rail, air, sea, and inland waterways. These have included fuel cycle material as well as radioactive material for other uses such as cobalt sources for medical use. It is likely that the number of these shipments will grow as the world tackles global challenges such as increasing access to essential medical services and combating energy poverty.

With the increased focus on nuclear science and technology, the necessary transport of radioactive material will bring new opportunities for the transport industry, building on the knowledge and capability that has been developed over the decades.

It is also exciting to follow the developments in nuclear technology that will enable the transport industry to become cleaner and greener. For many years transport has supported the nuclear industry through the safe and reliable delivery of its cargo. Now, as we embrace the United Nations Sustainable Development Goals, the nuclear industry can play an ever-increasing role in the energy mix that will support the transport industry with cleaner, greener fuel options such as electric vehicles and fuel cell technology.

David Ohayon
Chairman, World Nuclear Transport Institute
Director Waste Business Line, ORANO TN

Industry Perspective

Nuclear Waste Management

Nuclear waste from current and future uses of nuclear energy

Nuclear energy produces waste like any industrial or human activity, though the amount of waste is more than 1000 times smaller than any other energy-producing technology, as nuclear fuel has a very high energy density not matched by any other fuel..

A typical nuclear reactor of 1 GWe capacity produces, on average, 20 tonnes of spent fuel which is the equivalent of 9 grams of spent fuel per year for a typical family. The amount of uranium mined for a family's annual electricity demand is around 100 grams. Of those 9 grams annually, only 0,5 grams are considered as radioactive waste; the other constituents of the spent fuel can be recycled into new fuel as part of a circular economy.

Apart from spent fuel, nuclear reactors and their fuel cycle produce operational waste which is, compared to spent fuel, much less radioactive and already part of mature industrialised waste management activities around the world for safe and environmentally responsible final disposal.

The spent fuel does contain long-lived radioactivity, however, the radiological risks of spent fuel or any other radioactive waste from the processing of spent fuel does not present an environmental risk as interim and geological disposal facilities are well-engineered to contain such radioactivity for the appropriate length of time.

More integrated waste management practices are currently being deployed by the nuclear industry worldwide to minimise the amount and improve the characteristics of radioactive waste produced from nuclear energy and to further reduce any concerns with respect to long-term safety and environmental impact.

Nuclear waste management for sustainable development

The use of nuclear energy can create waste issues with spent fuel, which require responsible long-term management. Siting nuclear waste management facilities is a challenge that may pose a roadblock to clean, carbon-free nuclear electricity. However, advanced reactor technology and careful waste management could mitigate concerns.

The most sustainably-managed nuclear waste is the waste not generated. Many advanced nuclear reactor designs produce less waste as they create power. New types of fuels that these reactors use are designed to last longer in the reactor core than traditional fuels. Thus, over time, they produce more energy and less waste. Certain advanced reactors can also consume nuclear waste from currently-operating nuclear reactors. This innovation would also reduce the total amount of nuclear waste that requires permanent storage.

All reactors generate some amount of waste. In the United States, waste is stored on site in large, concrete containers. Though it is safe, it is regarded as an interim solution. Permanent solutions must be tailored to the waste's composition to protect human and environmental health for current and future generations. Consent-based policy solutions can ensure that local communities receive social and economic benefits from siting a waste storage facility.

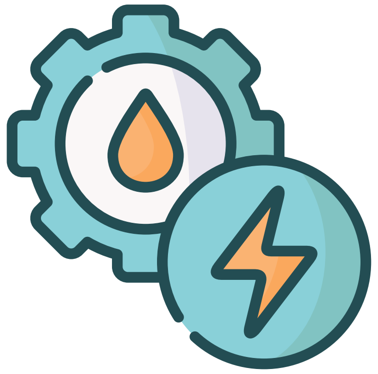
U.S. law dictates that nuclear waste from commercial reactors must ultimately be disposed of and isolated in a deep geologic repository, the preferred management option in many other countries as well. New methods of waste isolation utilising drilling technologies commonly used in the oil and gas industry are under development.

Sustainable management of spent fuel

Fuel used in a nuclear power plant generates electricity for three to five years. After this time, it becomes less efficient and needs to be replaced. This spent fuel still contains 96% of the original uranium, but also about 3% of waste products, and 1% of plutonium. At this stage, spent fuel can either be sent for storage pending final disposal, or reprocessed to recover the uranium and plutonium.

The residual uranium can be recycled. The plutonium which is produced in the reactor is fissile, i.e., it can support a nuclear chain reaction. It can be combined with uranium to produce Mixed Oxide (MOX) fuel. The waste products are transformed into a solid insoluble glass form by a vitrification process and stored pending final disposal, for instance into a deep geological repository.

There is also new technology being developed that will allow radioactive waste to power a new age of nuclear power stations and small modular reactors. In doing so, these reactors will also produce waste, but in much smaller quantities than initially taken in as fuel. In addition to this, there are also other technologies, such as Nano Diamond Batteries, that can utilise fuel cycle waste to generate power. These batteries incorporate a betavoltaic cell using Carbon-14 which emit beta particles, generating electrical current. These batteries have low power, compared to current battery technology, but have a lifetime that can extend to hundreds of years. This makes them ideal for applications where replacement is not easy.



Viewpoint

by Nuclear Waste Management Organization

The NWMO completes fuel cycle as the potential of nuclear power continues to be explored.

Canada has been generating electricity from nuclear power to light our homes, businesses and cities for over half a century. As global demand for energy grows and the need to address climate change intensifies, nuclear power is increasingly part of the conversation.

The Nuclear Waste Management Organization (NWMO) fulfils an important part of the nuclear fuel cycle. We are the guardians entrusted to ensure Canada's used nuclear fuel is safely managed for the very long term, in a manner that protects people and the environment for generations to come.

In 2002, the Government of Canada assigned responsibility for the long-term management of Canada's used nuclear fuel to the NWMO. Canada's plan, also known as Adaptive Phased Management, emerged through a three-year dialogue with Canadians and Indigenous peoples.

Canadians made it clear that they want to move forward now on managing used nuclear fuel and not leave the burden for future generations. The NWMO is working collaboratively with Indigenous peoples and communities currently involved in our site selection process to do just that. We are on track to identify a single, preferred site by 2023, having gradually narrowed our focus over the past several years.

Canada's plan calls for used nuclear fuel to be contained and isolated in a deep geological repository, a system of naturally occurring and engineered barriers, in an area with informed and willing hosts. A deep geological repository is considered international best practice, and the project will benefit from the best available science and research, including Indigenous Knowledge.

As the potential for nuclear power to assist in the fight against climate change is explored globally, Canadians and Indigenous peoples can rest assured that the safe, long-term management of the country's used nuclear fuel is well in hand.

nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Industry Perspective

Heavy Industry Decarbonisation

Energy-intensive industries

Large industry and manufacturing such as cement, steel, aluminium, paper, chemical and mining are often reliant on sizable quantities of energy to sustain production.

Electricity is one of the main energy forms used, but there is often a requirement for high-temperature heat such as that used in cement and steel production. This heat is generated through the burning of fossil fuels.

New technologies, such as some crypto-currency platforms, also have huge energy requirements due to the high electrical demands of computer processing.

These industries collectively contribute large volumes of air pollution including harmful gases and small particulate matter that are causing serious threats to public health and damage to our environment.

Industrial activities emit carbon dioxide, nitrous oxide, methane, and fluorinated gas, all of which are potent greenhouse gases (GHG). This is all adding to the well documented and proven climate emergency.

Unchecked, these emissions will have a catastrophic effect on our planet. This crisis is further fuelled as developing countries seek prosperity through industrialisation.

Renewables such as solar and wind generation cannot alone meet the growing demands for energy. Therefore, to sustain the increasing levels of industrialisation, while also ensuring that global targets for GHG reduction are reached, the world's leaders must embrace nuclear technology.

Decarbonisation of heavy industry

Heavy industry accounts for 22% of global carbon emissions. Steel, cement, oil refining and chemical industries all require large quantities of high temperature heat. Most of this heat is currently produced using fossil fuels, even though advanced nuclear reactors could reliably deliver high temperature (>400°C) steam to power these sectors.

In fact, about half of all energy produced globally is used for heat. Add in the transport industry and these sectors alone could emit more than 500 Gt of CO_2 between now and 2050. That is 100 Gt more than the maximum which can safely be emitted if the rise in average global surface temperature is to stay below 1.5°C.

The shipping industry, a big emitter that has largely escaped regulation, relies on cheap fuel oil. Nuclear is a proven, reliable transport power source only held back by its historically high cost. Now that the EU carbon pricing is high enough to drive investment in low carbon alternatives, the advantages of nuclear energy as a climate solution are becoming clear.

Heavy industry will face growing pressure, not least from investors, to cut its fossil fuel consumption. Broader implementation of climate policy including carbon pricing, coupled with border tax adjustments to prevent carbon leakage, could accelerate decarbonisation without penalising individual first mover companies who are willing to act now to reduce their carbon footprint.

This would help deliver the emissions cuts that heavy industry must make. It would also make nuclear energy much more attractive for many industrial processes.

New nuclear technologies

Decarbonising the industrial sector, which accounts for about a fifth of global CO_2 emissions, is a key part of an economy-wide decarbonisation effort. The nuclear sector is developing advanced reactor designs that meet tomorrow's changing energy needs as well as provide additional advantages for a more holistic, sustainable nuclear energy system.

Advanced nuclear technologies are designed to provide not only electricity, but also energy to various non-electric services such as process heat for industrial applications, electrolysis-based and heat-process based hydrogen generation, water desalination and district heat. Current advanced generation technologies including light-water reactors and next-generation advanced reactors could significantly help in decarbonising the heat necessary in both the industrial and domestic sectors, and ultimately mitigate the carbon footprint of heavy industry.

Some of these advanced nuclear technologies are expected to generate temperatures above 600°C, which are required by some of the industrial processes hardest to decarbonise, such as chemical and steel production.

In the EU, a quarter of industrial processes depend on high-temperature heat (above 400°C), which could be generated by next generation advanced reactors. Additionally, lower temperature nuclear heat could be used to heat homes through district heating systems.

Role of SMRs in eliminating heavy industrial emissions

Reducing emissions from fossil fuel-intensive industrial processes is an essential step to achieving international and national decarbonization goals. Many different advanced reactor designs have an advantage over conventional reactors as they can not only generate carbon-free electricity, but also provide process heat for district heating, desalinization, hydrogen production, and other energy-intensive manufacturing and refining processes.

Many advanced reactor concepts are currently in development to help accomplish this. A key player among them will be small modular reactors (SMRs) that use the same, or similar, water-cooled technology as most conventional reactors operating today. Water-cooled SMRs bridge the gap between conventional and non-water cooled advanced reactors because they incorporate many elements of this familiar technology, while also improving safety, efficiency, and flexibility.

Water-cooled nuclear technology is mature; it is well tested, has years of operating experience, and is well-understood by regulators. Thus, these water-cooled SMRs will likely have the fastest path to market, kicking off power- and industrial-sector decarbonization, with other advanced technologies following in subsequent years.

An example is NuScale Power's water-cooled SMR concept called the NuScale Power Module (NPM) that generates a gross output of 77 MWe. NuScale's larger plant configurations are comprised of several of these modules. One NPM is useful for supplying energy to distributed centers of industrial activity. NuScale states that the NPM can be sited in many places, including on retired coal power plant footprints, "to supply energy for electrical generation, district heating, desalinization, and other process heat applications."

Viewpoint

Decarbonizing Heavy Industry with Clean, Advanced Nuclear Technology

Decarbonizing the global economy represents a significant undertaking. Industry contributes 21% of greenhouse gas emissions globally, according to the U.S. Environmental Protection Agency. However, it remains one of the most difficult sectors to transition to carbon-free technologies. Fortunately, advances in nuclear energy technologies prove they have an important role in achieving the world's decarbonization goals and addressing climate change.

Industrial processes, like producing hydrogen, petrochemicals and steel, require high-temperature heat and traditionally rely on fossil fuels burned on-site for energy. Many clean energy technologies available today do not operate at high enough temperatures to decarbonize these processes. That's where advanced nuclear technologies come in. These technologies operate at the temperatures needed to generate the heat to power these processes without creating emissions.

Advanced reactor technologies, like the NatriumTM technology and Molten Chloride Fast Reactor (MCFR) design, will provide the clean, reliable and efficient energy needed to decarbonize heavy industry. The Natrium reactor is a sodium-cooled fast reactor and the MCFR design is a type of molten salt reactor. Both technologies will operate at higher temperatures than conventional reactors, thus offering applications to decarbonize industrial processes.

To advance next-generation reactor technologies, the U.S. Department of Energy (DOE) launched its Advanced Reactor Demonstration Program (ARDP), which seeks to demonstrate advanced reactors this decade through cost-shared partnerships with U.S. industry. In October 2020, TerraPower received $80 million in initial funding to demonstrate the Natrium technology. Relevant to TerraPower's MCFR design, DOE also selected the Molten Chloride Reactor Experiment proposal, with Southern Company as the prime, to receive funding as part of the ARDP's risk-reduction pathway.

The ARDP continues the momentum for the years of research, design and testing behind advanced reactor technologies that will power our clean energy future and help to decarbonize everything from electricity generation to energy-intensive industrial processes.

Industry Perspective

SMRs & AMRs for the sustainable development

UK Perspective

The essential role of nuclear power in promoting achievement of the 17 UN Sustainable Development Goals and in combating climate change is now well understood. Until recently however, nuclear power plants have mainly delivered large quantities of low-carbon baseload electricity in areas where widespread grid capacity already exists.

The arrival of Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs) is about to change that. By the end of this decade a new generation of nuclear reactors may introduce previously undreamed of flexibility to the way in which nuclear power contributes to greater energy security and affordability in all parts of the world. Reactors with a capacity of 300MW will be capable of being effectively deployed in places where grid connections have not yet been established.

The modular nature of these plants will also hold out the prospect of lower construction costs and reduced capital requirements. This will make nuclear power available to many more countries and regions.

The UK government recognises the potential benefits of SMRs and is actively supporting the development of the new technology which is needed. This is being done with the aim of reestablishing Britain as a significant supplier of nuclear equipment.

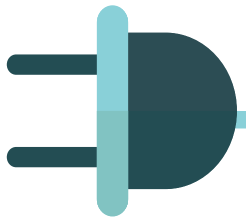
By extending the places where nuclear power can be delivered and by cutting the cost of new nuclear generation capacity SMRs and AMRs will enable nuclear to play an even bigger role in overcoming the threat of irreversible climate change.

European Perspective

Nuclear energy has significant potential to serve the world's energy needs while also decarbonising industrial processes and energy services. Evaluating sustainable development requires a more systemic view of the decarbonisation chain from energy resources to the services they provide, including sustaining rapidly growing electrification in many parts of the world. As such, there is an increasing need for nuclear power to help meet local and regional electricity demands and provide non-electricity power for industrial and residential use, as well as specialized uses such as water desalination.

While there is an ongoing demand for larger nuclear power plants in Europe, new SMRs will be optimal for many of these new market uses while also offering new and affordable investment opportunities.. Within Europe, SMRs also have a market niche in replacing fossil-fuelled generating plants and providing new decarbonised power to developments and industrial centres.

In due time, AMRs can further improve the sustainability of nuclear energy by reusing the spent fuel from older nuclear reactors and reducing our reliance on natural uranium resources. More integrated nuclear energy systems on a global level hold the promise to provide 365/24/7 sustainable energy to all while decarbonising our socio-industrial undertakings and reducing the amount of natural resources used and spent fuel to be managed in the long term.



US Perspective

SMRs and non-light water advanced reactors will be important technologies for combating climate change throughout the world. Companies in the United States are pursuing these technologies to meet growing domestic and global development needs.

To meet its own domestic commitments for decarbonization by 2050, the U.S. must work to minimize carbon emissions in its energy, transportation, and industrial sectors. Advanced nuclear energy, including SMRs, can play an important role by providing carbon-free electricity, clean hydrogen, and heat for industrial purposes.

The U.S. government and private developers, utilities and investors are currently working to demonstrate several advanced reactor technologies by the end of this decade. These demonstrations could pave the way for many new reactors to follow. Some of these reactors will add new capacity to the electrical grid, while others are set to replace fossil fuel generation.

In June 2021, one advanced nuclear developer, TerraPower, announced they would build their reactor, Natrium, in Wyoming at the site of a retiring coal plant. The project will provide carbon- free energy, and the project site allows the new reactor to access existing plant structures and transmission lines. The project will also promote economic stability and job growth for the local community once dependent on the coal plant.

Energy Security of SMRs and AMRs

SMRs and AMRs are fast becoming a viable energy option that will not only help steer the world towards its climate goals, but at the same time offer a reliable and green source of energy to remote communities where traditionally dirty and less dependable energy solutions were employed.

An SMR can provide a constant and reliable source of power, while at the same time providing energy security.

Remote communities, such as small islands and isolated regions, previously relied on fossil fuel burning power stations or hundreds of kilometres of power cables to meet their energy needs. This reliance came with many risks – supplies of fuel could be interrupted by bad weather or supply chain issues. Without these risks, communities are far better placed to deal with varying energy demands. A reliable power source can also keep services and industry running through naturally occurring events and disasters.

This energy security can also be used to the advantage of more developed and populated regions. Locally-sited SMRs can provide for the energy needs of heavy industry without placing a strain on national grids. Vital services, such as hospitals, can be assured of their energy supply without the risk of interruption while back up generators come online.

Viewpoint

by World Nuclear Association

World Nuclear Association is the international organization that represents the global nuclear industry and promotes a wider understanding of nuclear energy among the public and key decision makers.

For over 60 years, nuclear energy has provided much of the world with reliable and always-on low-carbon power from gigawatt-scale reactors. To this day, such large-scale reactors remain the only proven, reliable and cost-effective low-carbon technology ready to be deployed at the scale and in the timeframe required to meet the Paris Agreement goals. It is essential that their continued deployment is fast-tracked to meet the increasing global demand and need for clean and reliable electricity.

Meanwhile, a growing array of over 70 small modular reactor (SMR) designs are at various stages of development and hold great promise for the near future. The technologies, designed with modularity and factory fabrication in mind, are numerous and diverse. Due to their small size, the capital outlay per unit is lower, and the smaller overall size of projects may make financing more straightforward.

To balance diseconomies of scale, SMRs aim to foster economies of series through the creation of a global market, as already proven in other industries (e.g. shipbuilding, aircraft). Countries seeking to benefit from using SMRs in their energy mix should proactively work on streamlining international licensing and regulatory processes where possible.

As SMR designs reach commercial maturity, their role in decarbonization is expected to grow rapidly. They will complement large reactors, broadening the markets and applications of nuclear energy, providing process heat, hydrogen, or electricity where the use of large-scale units proves impractical. Working together, large and small nuclear plants will play a key role as humanity rises to the dual challenge of reducing harmful emissions, whilst providing more affordable clean energy to more people.

WORLD NUCLEAR ASSOCIATION

Industry Perspective

Nuclear applications in food and agriculture

Global food security

Global food security benefits directly from the wider adoption of sustainable food production practices. It is also helped by improved food safety and by increased international trade in food, as well as by greater local self-sufficiency.

Nuclear techniques can improve food safety by addressing the problem of harmful residues and contaminants in food products. Traceability systems can be strengthened by using stable isotope analysis.

Greater food safety also facilitates growth in food trade and combating food fraud. Countries as far afield as Pakistan, Mozambique and Angola already benefit from the use of these techniques. Nuclear derived technologies have also been successful in developing cross breeding programmes which can lead to more productive and climate-resistant animals.

They have also been used to help farmers in Kenya develop small scale irrigation projects. Seasonal famines can be alleviated by new mutant crop varieties which can shorten the growing process and enable farmers to plant additional crops during the growing season as has been successfully done in Bangladesh.

In all these ways developments in nuclear energy deliver benefits beyond their main purpose of providing very low carbon electricity. Cooperation between the nuclear and agricultural industries is leading to healthier and better nourished people in many parts of the world.

Applications in food and agriculture

The phenomenal opportunities that nuclear energy provides to communities are numerous, and technology advancements play a vital role in ensuring that the overall health and wellbeing of communities are met. Nuclear technologies commonly known as "N-tech" are supported by the IAEA and FAO. They not only contribute to improving energy and power production, fuel cycle and radioactive waste management, but also play a vital role in boosting human and environmental wellness. Some of the techniques used are:

- Sterilization Insect Technique (SIT): This is used to eradicate invasive pests that have a higher chance of survival due to climate change caused by anthropogenic greenhouse gas emissions. This ultimately aims at reducing reproduction of toxic insects for the greater good of the human and natural environment.

- Stable Isotope Technique used for soil and water management: Scientists can monitor soil quality and detect poor health by introducing nuclear isotopes, which help to determine when a boost in fertilizer is needed. Fertilizer, however, contaminates water which is harmful to human and marine life as it encourages algae growth which reduces oxygen levels in water. Scientists also use isotopes to monitor pollution levels in water.

Sustained food supply and resource-efficient agriculture would be jeopardised without such use of nuclear techniques. Continued use of such nuclear techniques may well become critical in light of new environmental challenges, e.g., climate change and diminishing biodiversity, to functionally sustain a robust food network that serves the global population.

YES TO NUCLEAR PERSPECTIVES I INDUSTRY PERSPECTIVE

Climate change adaptation

As the global population continues to grow and climate change increases the risk of drought and other extreme weather patterns, agricultural methods can adapt to sustainably increase resource-use efficiency and productivity with the application of nuclear technologies.

Nuclear technology is often discussed in the context of electricity production; however, certain conventional and advanced nuclear reactors can also produce radioactive isotopes that have agricultural applications. For example, radioisotopes have been used to produce high-yielding crop seeds and for determining the efficacy of fertilizers on different plants. These and other specialized techniques allow scientists to determine the exact nutrient and water demands of crops, making it possible to develop sustainable practices for different regions and prevent the overuse of vulnerable, resource-scarce environments.

Advanced nuclear reactors supplying electricity also benefit the agricultural sector. Many advanced reactor designs consume less water in operation than conventional reactors, leaving more of the resource available for agricultural use. Moreover, certain advanced reactors will be able to power water desalination, helping to create more fresh water for irrigation. Additionally, because nuclear fuel is so energy dense, nuclear power plants require far less land area to operate than other energy sources. This means that less rural or undeveloped land must be diverted away from agricultural use to meet electricity demand.

Some advanced nuclear microreactors are designed to be portable and can flexibly provide power to assist with disaster response to extreme, climate-related weather disruptions that could impact national or regional food systems. More generally, nuclear energy contributes greater resilience to electric grids, enabling the safe and efficient cultivation, harvest, distribution, and preparation of food globally.

Viewpoint

by Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture

The application of nuclear technology has a proven record in increasing agricultural production, protecting crops and animals, and improving food safety. Higher and more reliable yields not only improve farmers' livelihoods, they also mean better quality and safer food for consumers.

Nuclear science and application are dedicated to transformational and incremental innovation across five areas of food and agriculture, mainly in the areas of animal production and health; plant breeding and genetics; insect pest control; soil and water management and crop nutrition; and food safety and environmental protection. Through its focus on nuclear applications in food and agriculture, the Joint FAO/IAEA Centre provides dedicated solutions that contribute towards national, regional and global attainment of the Sustainable Development Goals.

Comparative advantages attributable to nuclear techniques include the following, with Member States receiving the full benefits of these techniques. With nuclear and isotopic tracers used as markers for research, traceability becomes a huge advantage. With radioactivity, advantages come by way of induced genetic variation, sterility and sterilization. Radio and stable isotope techniques also present a comparative advantage on measurability as well as nuclear techniques having more accuracy relative to conventional analytical methods. Finally, unique sensitivity and specificity contribute to nuclear techniques' mix of comparative advantages.

In future, the Joint FAO/IAEA Centre will continue its further contributions in applying innovative technologies to sustain the intensification of agricultural production and improvement of global food security. It will support techniques to strengthen resilience of livelihoods to threats and crises in agriculture and promote efficient agricultural and food systems for sustainable management and conservation of natural resources. Nuclear's role in agriculture has been significant in contributing to the Joint Centre's milestones and will mark next stages in meeting global challenges worldwide.

Qu Liang, Director,
Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture

IAEA
Joint FAO/IAEA Centre
Nuclear Techniques in Food and Agriculture

Industry Perspective

Heat applications - potential role of nuclear cogeneration

Cogeneration of heat and power

The main function of today's operating nuclear power plants is electricity production. However, many countries are also interested in applying nuclear energy to help meet 'difficult to decarbonise' industrial, commercial, and residential energy demands. Combining the heat and power operation of a nuclear power plant can help optimize energy flows and minimize energy losses, thus improving a country's energy efficiency and energy security without the output of carbon emissions.

Apart from traditional biomass burning, most heat that is used in industry or the commercial sector is currently generated by burning fossil fuels. A switch to a carbon-free source of heat like nuclear energy is required to address concerns about current levels of carbon emissions.

The cogeneration of heat and electricity generated by nuclear power plants, depending on the reactor type, has the potential to power district heating for residential and commercial buildings, industrial process heat supply, desalination of seawater, and hydrogen production.

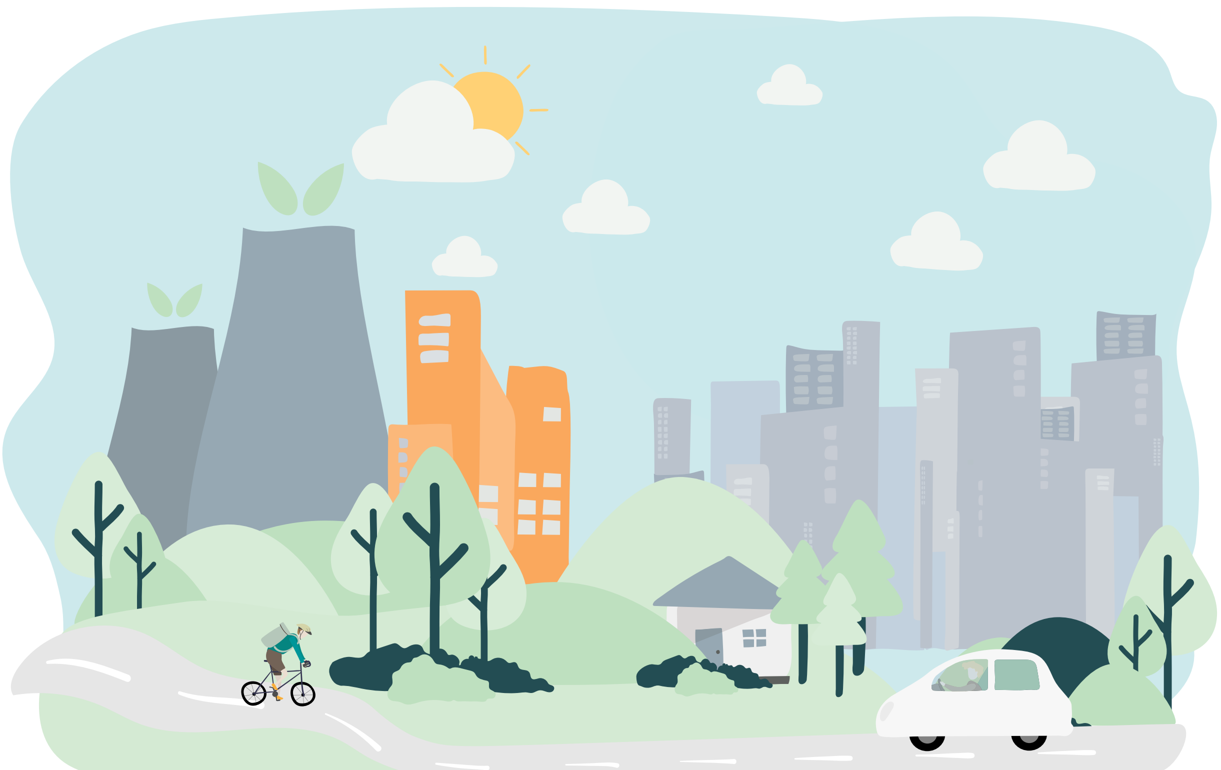
Small modular reactors represent a particularly suitable option for nuclear cogeneration applications, and would enable the use of heat available in areas where the size or other attributes of conventional nuclear power plants are not as well suited.

Nuclear energy for heat applications

In order to mitigate the effects of climate change, countries will need to reduce their carbon emissions and use energy more efficiently. For power plants, this means learning how to make use of excess heat typically wasted when producing electricity. Advanced nuclear energy can solve this problem by supplying carbon-free electricity and heat that can be used for residential, industrial, and other purposes.

The ability to heat homes more efficiently can help reduce carbon emissions. With district heating, power plants are able to provide buildings with the thermal energy produced in their plant to heat buildings and provide warm water. The benefit is that district heating improves energy efficiency, reduces emissions, and simplifies operation and maintenance costs.

Advanced reactors also have the potential to decarbonize other economic activities. Due to advances in materials engineering, advanced reactors will be able to operate at higher temperatures than conventional reactors. Sodium cooled reactors and liquid metal cooled reactors will be able to produce temperatures up to about 600°C, which is optimal for certain applications like co-production of hydrogen. Other technologies, like very high temperature reactors, will have the ability to produce heat at a temperature high enough for cement making or steel manufacturing, two of the most carbon-intensive processes in the world.



Using nuclear heat in district heating and industrial processes

District heating involves the production and distribution of steam or hot water from a central, underground plant. The hot water or steam is transmitted through a thermal piping network and distributed to multiple residential or commercial buildings to meet heating needs. This process is cost efficient as consumers avoid having to install their own expensive boilers.

District heating is regarded as more sustainable since the centralization of heat generation results in an overall reduction in energy inputs necessary to produce sufficient heating for all compared to more distributed heating methods.

Nuclear power is a good fit for district heating as the economies of scale for such applications prefer multiple 10's to 100's MWth decarbonized energy sources which both large-scale as small modular reactors can provide. There are already cases of nuclear power plants enabling district heating as far back as the 1960's (e.g., the Ågesta reactor in Sweden), as well as in Russia and Ukraine. Additionally, various advanced reactor designs, such as high-temperature reactors, are currently being developed for district heating and other specific industrial heat applications.

Viewpoint

Bohunice NPP heating network

The Bohunice Nuclear Power Plant is unique in Europe — as a low-carbon source it supplies electricity as well as heat for district heating in its vicinity. Heat supplied from a nuclear source is ecological — it is produced by high-performance combined heat and power generation without greenhouse gas emissions; and the cheapest — more than 30% cheaper than the average price of heat on the Slovak market. Over two thirds of the heat supplied is used for household heating, the rest for industry.

Specific heat supplies in hot water are reliably provided by the heating system for end customers — family houses in Jaslovske Bohunice municipality, homeowner communities, schools, offices, institutions, sports grounds, recreational facilities, railways, industrial companies in surrounding towns. Three hot water pipelines run from the Bohunice NPP since 1988 or 1997 resp.: 21 km pipeline to Trnava; 16 km pipeline to Hlohovec and Leopoldov; and one for industrial use on the NPP site, incl. JAVYS company. The annual heat supply from Bohunice NPP is about 1.6-1.8 mil. GJ.

The heat supply system consists of a heat exchanger station and pipes with diameter of up to 700 mm, which gradually branch into smaller connections to customer transfer stations.

Water temperature in the heat feeder is outside-temperature-controlled and ranges from 90 to 140°C. The returning water is about 40°C colder. The heat pipeline water is heated in the power plant exchanger station by steam taken directly from turbines and is fed to transfer stations of customers, where it heats the secondary heating water or tap water.

by Slovenske Elektrarne

SLOVENSKÉ ELEKTRÁRNE

Industry Perspective

Construction of nuclear power plants

Introduction

Recognition of the vital role that nuclear energy plays in combating climate change is gradually spreading. As safety and quality standards for nuclear power plants regularly evolve to match best practices, the costs to construct such facilities are also changing. The capital costs and long construction times historically present when building conventional nuclear plants mean that it is essential that the nuclear industry and governments around the globe make strides towards cutting the costs of new builds and support public and private long-term investments in new nuclear capacity.

Nuclear power plants have a key role to play as countries work hard to reduce their reliance on fossil fuels. According to a recent report by the United Nations Economic Commission for Europe (UNECE), nuclear power currently generates about 10% of the world's electricity, which represents more than a quarter of all low-carbon electricity. Its reliable, 24/7 operation helps mitigate energy fuel price volatility and improves the reliability and resilience of electrical grids with high shares of variable renewables. Therefore, construction of new nuclear power plants alongside other clean energy sources can help deliver on both the Paris Agreement and the 2030 Agenda for Sustainable Development.

Economic perspective

Commercial nuclear power plants not only provide over 50% of the clean electricity in the United States, but also provide economic benefits to workers, local communities, and the nation as a whole. On average, workers in the nuclear industry earn $39 per hour, have a high union rate of participation, and have a large amount of opportunities for veteran employment—all of which are the highest amongst zero-carbon emitting energy technologies. These nuclear jobs are typically permanent and are over 30% higher than average salaries in the area. Nuclear facilities also provide millions of dollars in direct local and state tax revenue and other indirect benefits. Construction of advanced nuclear reactors could help revive domestic manufacturing supply chains and revitalize export of US technology and manufactured goods.

The materials, fuels, and services procured for nuclear projects have the potential to involve all 50 states and international partners. Initial investments in nuclear projects would stimulate demand for industries like pumps and valve manufacturers, steel and concrete producers, and create opportunities for skilled trade workers including electricians, welders, and steel workers. Internationally, every export of $1 billion would also create an additional 5,000 jobs to support nuclear projects abroad, stimulating local economies across the globe.

Environmental and sustainability perspective

Over 400 nuclear reactors operating worldwide today avoid annual emissions of nearly two billion tonnes of greenhouse gases; hydrogen production; cogeneration; local environmental aspects.

Over the past five decades according to data published by the IAEA, electricity generation has seen an exponential growth in producing greenhouse gas emissions. Representing a significant share of energy related emissions, fossil fuels are still the primary source of electricity globally. Today, nuclear energy produces the same amount of carbon emissions as wind, proving to be a safe source of energy and the essential tool for combating climate change and meeting the 1.5°C pledge in the next few decades.

Today, construction companies face rapidly evolving challenges, including the threat of global climate change. The aim to reduce climate change consequences and help communities and biodiversity to survive and adapt is at the heart of the building industry. The nuclear industry does its best to apply the environmental standards within which industry can operate, such as protecting and improving the quality of air, land, and water. In addition, materials used during the construction of nuclear power plants are not in short supply and most are readily recyclable, which minimizes construction's impact on the environment and any doubts concerning its sustainability.

Nuclear construction around the globe

The unprecedented volatility on the 2021 fossil fuel market—creating conditions that led to a gas crisis in Europe – clearly demonstrates the need for a backup energy source resilient to price shocks. It is equally clear that such a source is nuclear energy, which is not exposed to such fluctuations in fuel prices. Thus, the world needs a stable pipeline of new nuclear build projects to ensure that its energy demand is properly met.

Today, there are 51 nuclear power reactors under construction worldwide, 14 of which are in China. A positive sign is that there have been many nuclear newcomers in recent years; 2020 saw the first-ever commercial reactors in the UAE and Belarus connected to the grid. In 2023, Turkey and Bangladesh are expected to launch their first nuclear units at the Akkuyu and Rooppur plants, respectively. Egypt plans to start construction of its first El-Dabaa plant next year. All this indicates how more and more countries are opting for nuclear energy as a part of their generating mix.

Despite these good indicators, the World Nuclear Association's Harmony programme maintains that, to achieve a 1.5°C target, new nuclear build projects need to be increased to an annual connection rate of 33 GWe over the next decade. Estimates place the average plant construction period at six years, not counting preliminary work—mainly of a regulatory nature—that can span years. This means that both vendors and governments must strategically reduce the time and cost of construction, in part through innovation and adoption of best practices.

Specifically, this could be achieved by further strengthening international networks working to develop a unified regulatory and financial approach. The combined efforts of the industry and government to increase the pace of nuclear construction around the globe can ensure that decarbonisation deadlines are met on time.

Industry Perspective

Nuclear applications in medicine

Introduction

The beneficial contribution of nuclear technology to the production of electricity via commercial nuclear power plants is well-known worldwide. But most are unaware that the impact of nuclear technology is even greater for non-energy applications, such as applications in medicine, agriculture and industry. Medical uses of nuclear technology are perhaps the most widely known, ranging from diagnostic to therapeutic applications, and sterilization of equipment.

134 out of 195 countries operate nuclear medical facilities. Nuclear medicine is applied to various departments of medicine: oncology, cardiology, neurology, pneumology or even paediatrics. It helps to diagnose and treat complex diseases, such as cancer. Without a doubt, innovation in research and development is a driving force in nuclear medicine. New devices, radiopharmaceuticals, clinical applications, and evidence-based medicine are produced at a fast pace. Nowadays, theranostics being one of the main development domains with significant questions to specific radioisotopes to be provided.

Overall, nuclear medicine is growing, on average, by some 10% yearly from today's market value of around 6.5 B$.

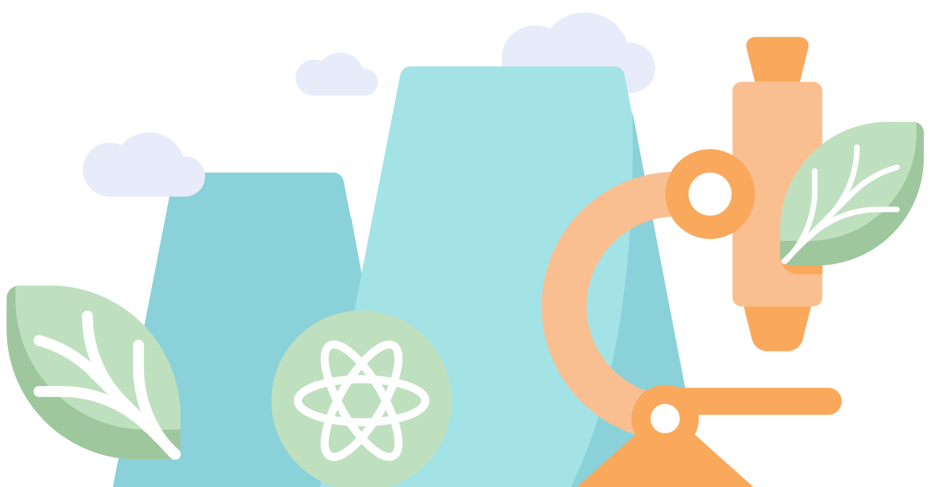
The development of nuclear medicine has been very successful since its beginning. Reaching far beyond electricity generation, the field of nuclear medicine has been innovative and able to quickly adapt to new scientific developments and clinical needs for the past couple of decades and there is no question that the future of this field is bright.

Some nuclear vendors expand their expertise to the medicine sector, defining a new era in current and future diagnostic and therapeutic procedures. For instance, this year Framatome established Framatome Healthcare to unite under the new brand all medicine-related activities. And Rusatom Healthcare which is a Rosatom's subsidiary develops its competencies in nuclear medicine by taking part in the construction of hospitals, building sterilization centres, fabricating isotopes and manufacturing of medical equipment.

Diagnostic techniques

For many years, people have had the perception that radioactive materials can be harmful to the body and, when uncontrolled, this can often be the case. However, advances in nuclear medicine have brought great benefits. Diagnostic techniques in nuclear medicine use radiopharmaceuticals (or radiotracers) which emit gamma rays from within the body. These procedures use small amounts of radioactive material for scans and diagnostic techniques. This treatment helps to trace diseases and abnormalities in the human body at the earliest stage. The function and activity of organs can be imaged by registering the gamma rays as they are emitted from the body, as both soft tissue and bone can be examined. The tracers used are generally short-lived isotopes, and can be administered orally, by injection, or by inhalation, depending on which is most appropriate for the procedure being conducted.

The benefits of these procedures far outweigh any risks that are present due to the exposure to radiation, and nuclear medicine is now widely accepted as a vital part of health care. Nuclear medicine continues to be developed and the latest imaging technology, known as Positron Emission Tomography (PET) can be used in effective, and non-evasive, cancer diagnosis.



YES TO NUCLEAR PERSPECTIVES I INDUSTRY PERSPECTIVE

Therapy techniques

The history of nuclear medicine begins with Henry Bequerel's discovery of radioactivity in 1898. A few years later in 1903, Alexander Bell suggested placing radioactive sources near tumours to treat them. Turns out, Bell was onto something. Since then, the field of nuclear medicine has advanced significantly and nuclear techniques are now commonly used to treat cancer patients and others with medical conditions.

One of the most famous isotopes in nuclear medicine is Iodine-131. Iodine-131 was first discovered in 1938 at the University of California, Berkeley by Glenn Seaborg, a nuclear chemist and a pioneer of nuclear medicine. It is most famous for its use to treat cancers of the thyroid gland using beta radiation, but has also been used in other applications like diagnosing abnormal liver function, renal (kidney) blood flow, and urinary tract obstruction because it is also a weak gamma emitter. I-131 is extremely convenient because it combines easily with other elements, like sodium, for easy ingestion as either a pill or liquid, and has an 8-day half life, meaning that it flushes out of the body quickly. Studies of the efficacy of I-131 treatment have shown long-term cure of thyroid cancer approaching 80% and today, thyroid cancer is one of the most curable cancers with an over 90% survival rate, due in part to advances in nuclear science.

FORATOM and Nuclear Medicine Europe Position Paper

Lifesaving nuclear medicine applications deserve better recognition and support at EU level

The position paper titled 'Medical Uses of Nuclear Technology: Role, Challenges & Perspectives", jointly published by the FORATOM and Nuclear Medicine Europe in June 2021, explains the technicalities of nuclear medicine, presents the scope of the current nuclear medicine sector in the European Union as well as highlights the challenges that have to be overcome both at regulatory and supply chain levels.

"Nuclear technology offers many different important applications apart from providing low-carbon electricity at an affordable cost. Nuclear medicine is one of them as it enables access to diagnostic and lifesaving treatments technologies. Although the EU is involved in the nuclear medicine sector and its developments, more has to be done to address the current challenges in order to maintain the edge that the EU enjoys today in this field globally".

Yves Desbazeille, FORATOM Director General

"The European nuclear medicine sector – like the wider nuclear industry – faces several challenges, from negative attitudes towards nuclear energy/radiation, uncertainty over funding in new nuclear energy capacity and management of nuclear waste. It has, however, also its own challenges, such as a regulatory system that needs improvement, sustainable reimbursement models and equal access to modern equipment and applications across all member states. We recommend that nuclear technology and its non-power applications should be better recognised and supported at EU level. We also call for an EU roadmap dedicated to nuclear medicine research and development".

Antonis Kalemis, President of Nuclear Medicine Europe

Source

www.foratom.org/press-release/lifesaving-nuclear-medicine-applications-deserve-better-recognition-and-support-at-eu-level/

Country Perspectives

Country Perspective

The United States of America

Overview

56 nuclear power plants

94 nuclear reactors

02 nuclear reactors under construction

Generation mix

38%	23%	20%	7%	7%	2%
natural gas	coal	nuclear	wind	hydro	solar

US nuclear facts

55% Nearly 55% of carbon-free energy comes from nuclear

475,000 Nuclear supports 475,000 jobs in the US

93% In 2019, the US nuclear fleet had an average capacity factor of 93%, making nuclear energy the most reliable source of energy on the grid

YES TO NUCLEAR PERSPECTIVES I COUNTRY PERSPECTIVE

Viewpoint

Nuclear Energy, Current and Future, is Essential to Climate Goals

The U.S. operates the largest fleet of nuclear reactors and produces more electricity from nuclear energy than any other country. Globally, nuclear energy is second only to hydroelectricity among zero-carbon sources, and nuclear has far more potential for growth.

Energy from nuclear reactors that are already running, and from advanced reactors that are quickly moving toward deployment, will be essential to helping the United States meet President Joseph R. Biden's goal for decarbonizing the electric system, and meeting commitments now that U.S. is rejoining The Paris Agreement. Nuclear energy will also help attain the decarbonization goals now in place in many of the 50 states, and of dozens of electric companies. Nuclear energy is becoming the climate uniter among policy makers, drawing support from both political parties.

A focus of that bipartisan support is advanced reactors, which will also provide heat that will displace the coal and fossil gas that are used in industries, and to producing hydrogen, or hydrocarbon fuels using recycled carbon, to power applications that cannot be electrified.

Thus, nuclear technology will move the energy system to a sustainable basis, and will balance the variable demand of modern economies with the variable supply from wind and solar, with clean, emissions-free energy.

To do that job, the new nuclear capacity will have to differ from what is already running. The current generation are workhorses, running at full power more than 90 percent of the hours of the year, but advanced reactors are designed to vary their output, to work with intermittent, weather-based generating sources in a complementary way. Some can even run at 100 percent power continuously but store the energy for times when it is most needed.

This combination of baseload and variable carbon-free nuclear generation is the path to net-zero emissions.

There is plenty of room for new zero-carbon generators of all sorts. Today, nuclear energy already provides nearly 20 percent of the electricity used in the United States, but the bulk of the system, more than 60 percent, relies on fossil fuels. And to decarbonize transportation, home heating and other applications that now use oil or gas, we will need more electricity, and we will need it to be from zero-carbon sources. So a vast increase in nuclear generation will be needed, along with solar, hydro and wind.

Nuclear energy will be essential to the Biden Administration's desire to restart the economy as we emerge from the pandemic and Build Back Better. We will need to add nuclear and other carbon-free sources as promptly as we can, and to retain the carbon-free generation we have now, including nuclear, even in places where coal or natural gas look to be less costly in the short term.

But to stabilize the climate, we will need to decarbonize not only the United States, but the whole world. That will require a generation of reactors that can be designed and manufactured in countries that have the industrial and technological base to do so, and then exported around the world. The need is very large, as a recent survey by Third Way, a non-governmental organization in Washington, DC, indicates.

Developing countries are already cooperating in this effort. They face the double challenge of decarbonizing and making their energy sources sustainable while also expanding their systems to serve their populations and fuel growth.

The transition will not be simple or instant. We would be helped by unambiguous recognition from the global community that nuclear energy is a clean, sustainable source of energy, and by an international commitment to technology-neutral standards for meeting clean energy goals.

Country Perspective

French nuclear industry

Overview

18 nuclear power plants

56 nuclear reactors

01 nuclear reactor under construction

Generation mix

70%	11%	8%	6%	2%	2%
nuclear	hydro	thermal	wind	solar	biofuels

France nuclear facts

70% of electricity in France comes from nuclear power

70% Those in France pay 70% less for electricity than in Germany, a country whose electricity is not of nuclear origin

6.7% With its 220,000 employees and 3,000 companies, French nuclear industry accounts for 6.7% of French industrial employment

YES TO NUCLEAR PERSPECTIVES I COUNTRY PERSPECTIVE

Viewpoint

France, a worldwide leader in decarbonized electricity production

Five years on from the signing of the Paris Agreement, France is a worldwide leader in terms of decarbonized electricity production with about 50g CO2/KWh: more than 90% of the electricity produced in France is decarbonized, coming mainly from nuclear energy (70%) complemented by renewables such as hydropower, wind power and solar panels. France will rely on its low-carbon electricity to decarbonize other sectors of its economy which still rely heavily on fossil fuels, such as transport and habitat heating, to reach its goals of achieving net zero carbon emissions by 2050. According to SNBC (Stratégie Nationale Bas-Carbone), electricity consumption should increase by 30% by 2050. This increase should be even higher, as France just announced an ambitious national plan to develop the production of low-carbon hydrogen.

France has the second largest nuclear fleet in the world, with 56 reactors in operation under a unique operator, EDF. The large proportion of nuclear electricity in France leads EDF to operate its fleet on a load-follow mode, adjusting constantly nuclear output to follow electricity demand, demonstrating on a large scale that nuclear is very flexible and is the perfect complement for the development of Variable Renewable Energies (VRE). The French nuclear fleet can increase or decrease its production by 80% in less than 30 minutes.

The nuclear sector is the third largest industrial sector in France, behind the aerospace and automotive sectors, and accounts for 220,000 jobs, working in 3,000 companies, and 5,000 recruitments by the end of 2021, despite the Covid-19 crisis. It has launched in 2015 the "Grand Carénage", a 50 billion euros program designed to revamp the fleet for long-term operations.

"France Relance", the French roadmap for the economic, social and ecological rebuilding of the country released last September, provides a budget of 470 million euros over two years for nuclear power. 200 million euros will be devoted to skills development, 100 million euros to strengthen the equity capital of SMEs and mid-sized companies weakened by the COVID crisis and the remaining 170 million for research into Small Modular Reactors (to support the French SMR project, Nuward). Furthermore, President Macron's recent remarks on nuclear power last December during his visit to the Framatome plant in Le Creusot showed his support to the French atom and he reaffirmed that our energetic and ecological future would depend on nuclear for the decades to come.

According to the French government's request, EDF is working on the potential building of six new EPRs in France, with the purpose to start renewing the existing fleet after 2035, as most units will reach 60 years of operations. It is important to launch this new set of EPRs in order to meet the time requirements for the renewal of the fleet but also for industrial reasons: it is important to provide the French (and the European) supply chains with industrial programs that will enable them to invest in their industrial tools, technologies, and skills to build new reactors in series, in a very competitive way… This strategy was comforted by the generic positive opinion for the continuation of operation of the 900 MW fleet (32 reactors) beyond 40 years given very recently by the Nuclear Safety Authority.

The fight against global warming is an international one, and nuclear must be able to play its part, through a commitment to technology-neutral standards by the international institutions.

Sfen

Country Perspective

Chinese nuclear industry

Overview

22 nuclear power plants

49 nuclear reactors

17 nuclear reactors under construction

Generation mix

thermal	hydro	wind	nuclear	solar
71%	16%	6%	5%	2%

Nuclear facts on China

2060 Nuclear energy expected to play a significant role in reaching China's 2060 goal to be carbon neutral

70 GW China aims to have 70 GW of installed nuclear capacity by 2025

18% Over the next five years, China sets a 18% reduction target for CO_2 intensity and 13,5% for energy intensity

Viewpoint

CNEA's views on China's future energy system and nuclear energy development

China has become the world's largest energy producer and consumer, and the country that improved its energy utilization efficiency at a quickest speed. Guided by the new energy security strategy of "four revolutions and one cooperation" proposed by President Xi Jinping (to push forward energy consumption revolution, energy supply revolution, energy technology revolution, energy system revolution, and strengthen international cooperation in the field of energy all around), China is accelerating the construction of a clean, low-carbon, safe and efficient enerWWWgy system.

In September 2020, Chinese President Xi Jinping announced at the general debate of the 75th United Nations General Assembly that China will improve its self-reliance and make more effective policies as well as take the same effective measures to work towards its commitment of achieving a peak CO2 emission by 2030 and carbon neutrality by 2060. It is expected that by 2030, China's non-fossil energy will account for about 25 percent of its primary energy consumption, and the total installed capacity of wind and solar power will reach over 1.2 billion kW.

As a clean, low-carbon, high-quality energy source, nuclear power has become an important option for China to address the climate change issue and achieve its carbon neutrality goal. Chinese government proposes in its 2021 yearly work report that it will "actively develop nuclear power in a good order with safety as a prerequisite", and explicitly indicates that China will continue to promote nuclear power construction steadily during the period of the 14th Five-Year Plan and beyond. As a safe, stable energy source with high-efficiency, nuclear energy is also the only choice to replace traditional fossil energy to be the base-load power source on a large scale. It's important to promote the synergistic development of nuclear energy and renewable clean energy in order to ensure the stable operation of power grids as well as secure the stable supply of energy.

We wish that the efforts of Climate Change Conference (COP26) will enable every country to realize that nuclear energy is an important and essential option for addressing the global climate change issue in a more unanimous way, We also wish that all countries around the world will realize that we all should work together to promote the safe and efficient development of nuclear energy to make positive contributions that will help to address global climate change issue and build a clean and beautiful world.

中国核能行业协会
CHINA NUCLEAR ENERGY ASSOCIATION

Country Perspective

Russian nuclear industry

Overview

*According to PRIS

11 nuclear power plants (including the world's only floating NPP)

38 nuclear reactors

03 nuclear reactors under construction

Generation mix

thermal	nuclear	hydro	solar	wind
	20.6%	19.8%	0.2%	0.1%

Russian nuclear facts

02 commercial-scale Fast Breeder Reactors (FBR) are operating in Russia (BN-600, BN-800)

05 nuclear-powered icebreakers are operating along the Northern Sea Route

30% of the electricity produced in the European part of Russia is generated by nuclear power plants

Viewpoint

High-tech solutions at the service of people and sustainable development

The world's first nuclear power plant (NPP) to contribute to a country's electrical grid was built in the Russian city of Obninsk in 1954. Today, Russia ranks fourth in the world in terms of the number of operating nuclear power units (38). Russia's range of nuclear reactors includes pressurised water reactors in the VVER series, high power channel reactors in the RBMK class, and fast sodium reactors. The world's first lead-cooled fast reactor BREST-300-OD is currently being built in the Tomsk region, while low-power EGP-6 reactors and the world's first civilian floating nuclear power plant Akademik Lomonosov are already successfully operating beyond the Polar Circle.

Rosatom's mission is to provide "high-tech solutions for the service of people." The company works to improve the quality of people's lives and contribute to mankind's sustainable development. We build nuclear power plants not only in Russia, but also abroad, develop nuclear applications for use outside of the energy sector and advance nuclear science, and help countries master high-tech solutions and create nuclear infrastructure.

Russia has created a comprehensive programme to help develop its nuclear science and nuclear technology sector. Rosatom's priorities in the mid-term are to develop and provide two-component nuclear energy system, a closed nuclear fuel cycle, small and medium-sized nuclear power plants, plasma technologies, and thermonuclear fusion.

A separate area of our activity is hydrogen energy. In the near future, we will start the industrial production of green hydrogen at Russian NPPs both for domestic consumption and export. There are plans to build a railway communication network on the island of Sakhalin with Rosatom's participation.

We are convinced that closing the nuclear fuel cycle is the future of nuclear energy – and fast reactor technologies are an integral part of this task. Closing the nuclear fuel cycle will transform the peaceful atom into a nearly inexhaustible renewable energy source with a lifespan of many millennia. And in Russia, this is no longer some theoretical technology of the distant future – a complex product will be made available to the market within the coming 10-15 years.

In our opinion, the foundation of the world's future energy balance is the so-called "green square," which comprises nuclear, solar, wind, and hydropower. We do not see nuclear energy as a competitor to existing renewable sources, but as a partner working towards the same goal in a playing field where all sides of the square complement and reinforce each other. This is the most reliable and efficient way to build a carbon-free society of the future, one in which all tools at our disposable, including nuclear power, are harnessed for the betterment of the world.

ROSATOM

Country Perspective

Canadian nuclear industry

Overview

04 nuclear power plants

19 reactors in operation

00 nuclear reactor under construction

Generation mix

60%	15%	9%	9%	4%	2%
hydro	nuclear	natural gas	coal	wind	biomass and geothermal

Nuclear facts on Canada

91 Climate change is considered a serious issue by 91 per cent of Canadians

216 Between 2035-2050, SMRs could reduce GHG emissions by 216 megatonnes (Mt) in the heavy industrial sector

14 SMRs could contribute to getting to net zero by reducing GHG emissions by 14 Mt per year on average, the equivalent of taking over 3 million cars off the road per year

YES TO NUCLEAR PERSPECTIVES I COUNTRY PERSPECTIVE

Viewpoint

Net zero needs nuclear in Canada and the world

Canada is a Tier 1 nuclear nation, with a full spectrum of capabilities and resources in nuclear technology such as uranium mining, research, power and medical isotopes.

Nuclear is the second largest source of electricity in Canada at 15 per cent of total generation. In Ontario and New Brunswick, nuclear energy represents 60 per cent and 36 per cent of generation, respectively.

Among the largest clean energy projects currently under way in Canada are the multibillion-dollar refurbishments at Ontario's Bruce and Darlington nuclear plants, which will provide the province with clean and affordable electricity into the 2060s and strengthen Canada's nuclear supply chain and ecosystem.

Canada, like other countries, has pledged to phase out coal-fired electricity by 2030, exceed its 2030 Paris Agreement emissions target and to reach net-zero emissions by 2050.But Canada is not going to get to net zero by just cleaning up our electricity system, which is already 82 per cent non-emitting nationally. We have to look to other sectors of our economy.

We're dependent on natural resources extraction and heavy industry and it's in these places we have to look for greenhouse gas (GHG) reductions. Canada's industrial sectors – such as oil sands, chemical manufacturing and mining – currently contribute more than 30 per cent of Canada's greenhouse gas emissions.

We cannot afford to abandon these industries that form the backbone of our economy. For Canada to reach our goal of net-zero emissions by 2050, we must decarbonize heat and power in the industrial sector in an environmentally and economically advantageous way.

SMRs are particularly well-suited to the industrial sector given their ability to generate reliable, carbon-free electricity and heat.

Research conducted by EnviroEconomics and Navius Research and commissioned by the Canadian Nuclear Association (CNA), shows the economic and climate benefits and implications of employing SMRs in Canada's high-emitting industrial sectors. Across all scenarios, SMRs delivered low-cost emission reductions, driving down the cost of getting to net-zero as a nation while contributing significantly to Canada's annual GDP. Between 2035 to 2050, SMRs could reduce GHG emissions in the industrial sector by 216 megatonnes – the equivalent of taking more than three million cars off the road each year in Canada.

With deployments set to begin as early as 2026, SMRs could be widespread by 2035 to meet the rapidly growing demand for emission reductions in the industrial sector.

Canada has an incredible collaboration between the federal and four provincial governments, four provincial utilities and our regulator.

This year, the province of Alberta formally joined Ontario, New Brunswick and Saskatchewan in signing a memorandum of understanding to explore developing and deploying SMRs. And nuclear has been recognized in the federal government's definition of clean energy and its climate and hydrogen plan.

While Canada continues to move positively on nuclear, the global community also has a role to play in recognizing the role nuclear can play as a clean source of energy.

The next COP26 in Glasgow, Scotland, needs a firm commitment by global leaders of a realistic, science-based approach that includes more nuclear power because net zero needs nuclear.

by John Gorman
President and CEO
Canadian Nuclear Association

Country Perspective

Ukrainian nuclear industry

Overview

04 nuclear power plants

15 reactors in operation

02 nuclear reactors under construction

Generation mix

50%	27%	8%	5%	4%	4%
nuclear	coal	natural gas	hydro	wind	solar

Nuclear facts on Ukraine

- Zaporizhzhia Nuclear Power Plant is the largest power plant in Europe and among the 10 largest in the world
- Nuclear energy allows Ukraine to ensure sustainable economic development, decent work, and high scientific and technological potential
- Nuclear energy is a guarantor of Ukraine's energy security, providing more than half of the total electricity production

YES TO NUCLEAR PERSPECTIVES I COUNTRY PERSPECTIVE

Viewpoint

Nuclear Energy remains the most cost-effective low-carbon energy source for developing countries

The impact of the nuclear energy sector on economic and energy security is difficult to overestimate, since nuclear power plants provide about 50% of all electricity in Ukraine. In terms of the share of nuclear generation in the total volume of electricity production, Ukraine is the second-largest player in the world after France, where the share of nuclear power plants exceeds 70%. Thus, environmentally friendly and cheap nuclear energy is one of the key elements of energy security of the state and a powerful factor to increase the competitiveness of the Ukrainian economy.

Globally about 10% of electricity among low-carbon sources in 2020 came from nuclear power and the Low-Carbon Development Strategy of Ukraine until 2050 emphasizes the importance of nuclear energy in the context of preventing climate change and achieving Ukraine's goals of the Paris Agreement.

In order to mitigate the impact of energy production on the environment, the search for alternatives to carbon energy sources shows that none of the types of generation can compete with nuclear energy in terms of both production capacity and the minimum level of impact on the climate. Nuclear energy is characterized by lower marginal costs than traditional energy, does not contribute to increasing CO2 emissions and ensures uninterrupted energy supply. Today, nuclear energy remains the unalterable source of energy with the lowest greenhouse gas emissions.

According to the Energy Strategy of Ukraine for the period up to 2035, an important role as one of the most cost-effective low-carbon energy sources is given to nuclear energy and its further development requires the study of new types of reactors to replace decommissioned power units.

Given the trends in the electricity supply market in the world, Ukraine plans to replace the existing water-water energetic reactor units with more economical and safer next-generation small modular reactors. On June 10, 2019, Ukraine's major national nuclear operator Energoatom, the nation's State Scientific and Technology Center, and Holtec International ratified a trilateral agreement on establishment of the international consortium to support activities for implementation in Ukraine of small modular reactor technology. As part of the expansion of the cooperation on the introduction of small modular reactors technology in Ukraine, a Memorandum of Understanding signed between the Energoatom and Studsvik Scandpower GmbH (Sweden) on July 17, 2019. Studsvik provides methodological support and transfer of computer codes for safety analysis.

Thus, maintaining the share of nuclear generation together with the gradual introduction of renewable energy sources remains as the key solution for Ukraine in facilitating the transition to a low-carbon economy. This will help not only to mitigate the effects of climate change, but also to achieve other goals, such as economic growth, infrastructure development and sustainable urban and community evolution.

Country Perspective

V4: Czech Republic, Hungary, Poland and Slovakia

Nuclear sector overview of V4 countries

05 nuclear power plants

14 reactors in operation

02 nuclear reactors under construction

Generation mix in Hungary

49%	23%	15%	8%	2%	2%
nuclear	natural gas	coal	biofuels & waste	solar	wind

Nuclear facts on V4

Czech utility ČEZ plans to construct two new reactors at its Dukovany nuclear power plant

2033 Poland plans to build the country's first nuclear plant by 2033, and five more are due to follow by 2043

Slovenské elektrárne is a leading heat supplier utility in Slovakia, and the only in Europe to supply heat from nuclear reactors directly to homes

Viewpoint

Nuclear power is the key factor for the security of electricity supply

Ensuring energy sovereignty, secure energy supply at reasonable costs and the decarbonization of energy production are the three main pillars of the Hungarian energy policy.

According to the National Energy and Climate Plan most of the electric power generated in Hungary will originate from nuclear energy and renewable sources –mainly from solar installations. These carbon free technologies do not replace or exclude each other but are complementary and mutually supportive. The operational lifetime of the existing four units of Paks NPP has been extended by 20 years, so they will operate till the mid of 2030s. To maintain the current high share of nuclear energy in the domestic electricity production for longer period two new NPP units are under construction.

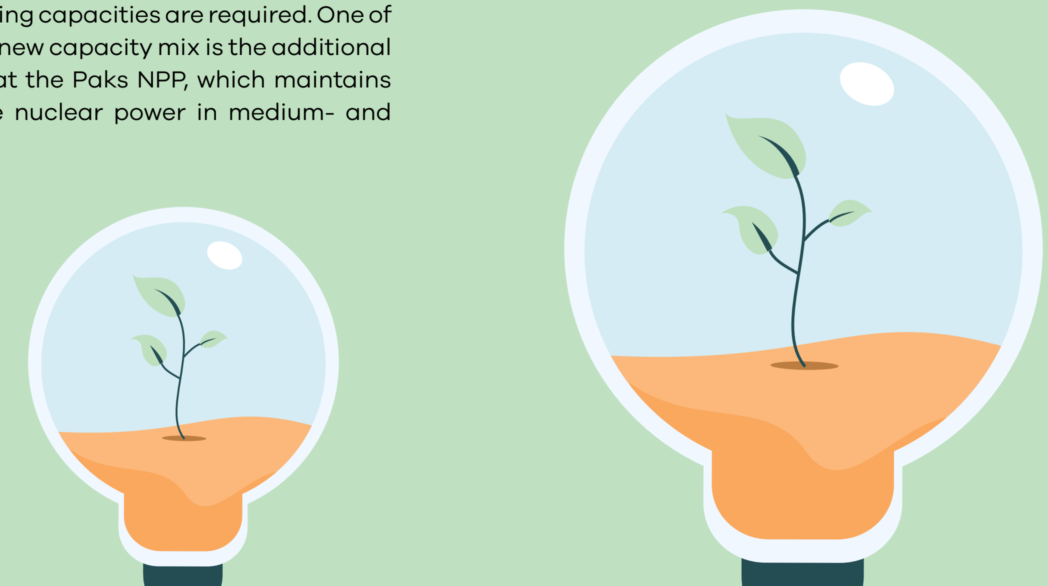
Nuclear power is the largest source in Hungarian energy mix, its share around 50% in the domestic production. Further decarbonization of the energy sector is inconceivable and unfeasible without nuclear energy. The country's climate protection policies are realistic and based on the current international environmental protection trends in line with Paris Agreement on Climate Change. The implementation of these policies relies on feasible measures with expected results afforded by current available technologies. The measures focus on the carbon neutral power generation and transport electrification.

According to the forecasts the need for electric energy will steadily increase in the next decades, some old power stations on fossil fuel will retire and the currently high electricity import dependency should be reduced. Therefore, new generating capacities are required. One of the components of the new capacity mix is the additional two units of 1200 MW at the Paks NPP, which maintains the current role of the nuclear power in medium- and long-term perspective. The design solutions of the new units meet all the up-to-date safety requirements and has all the features of the generation 3+ units.

In climate change context the nuclear electricity has several advantages, it emits, during the whole fuel cycle, very limited green-house gases and other air pollutants, the land required to produce electricity is significantly lower than other energy sources, nuclear is responsible for a very small amount of the total hazardous waste that is produced by society across.

The excellent operation results of the existing four units show the high nuclear safety culture in Hungary. The implemented safety enhancement programs, the capacity uprate, and the implementation of the 15 months fuel cycle are the good examples to demonstrate the high technical level and innovation capabilities of Hungarian nuclear engineering experts. The technical culture and specific knowledge in nuclear field will be maintained and transferred to the next generation of experts by implementing comprehensive training and educational programs with participation of leading universities and scientific centers.

by Hungarian Nuclear Forum



Country Perspective

Nuclear Industry in the Middle East

Overview

02 operating nuclear power plants

02 nuclear power plants under construction

15 nuclear reactors operating and under construction

Generation mix

gas	oil	others	nuclear
56,5%	42,1%	1,1%	0,3%

Nuclear facts on Middle East

04 countries of the region have operating NPPs or are building them

1961 Egypt's first reactor, the Experimental Training Research Reactor-1 (ETRR-1), achieved its initial criticality in 1961

10% 10% of Turkey's power consumption will produce Akkuyu NPP once fully operational

YES TO NUCLEAR PERSPECTIVES I COUNTRY PERSPECTIVE

Viewpoint

by Egyptian Atomic Energy Authority

Today, the world is facing an unprecedented tipping point where climate change poses a real and imminent threat to the prosperity that so many enjoy today and what millions aspire to and work towards tomorrow. Climate continues to change due to emissions from burning fossil fuels, although many other important factors contribute to it. To mitigate climate change, we must reduce our consumption of these carbon-intensive fuels; as for renewable energies, they can and should be an essential part of this plan.

It is quietly known and noticeable in the Middle East in general that green and renewable energies are spreading and invading the fields of their non-renewable counterparts. We read this as an indicator of the growth of individual and institutional awareness at the different levels of Arab societies, and despite the multiplicity of issues that look apparently more urgent, energy crises have resurfaced again in the arenas of discussions and decision-making.

We find countries harnessing their deserts by planting solar cells with extended surfaces. Some countries have designated cities for the production of solar energy. We also see cells on the roofs of various homes and even car park canopies in a steadily increasing growth to harvest the sun's energy. At many sites throughout the region, there exists what is also known as wind farms, cylinders with turbines of carefully considered heights and sizes, welcoming air to pass through them to generate electricity.

And of course, we should mention nuclear energy that is the heart of the life of the future, though it is still unincluded in the list of the main energy resources in the Middle East countries for many reasons, foremost of which is the bad conception concerning the capabilities of this type of energy.

It is a continuous renewable energy which can reduce any negative impact on the environment, opening new horizons for life in all its fields by raising the capacity of energy supply for homes, reducing the gaps between supply and demand for energy, and enabling industries at unprecedented levels.

We are thrilled to see that more and more Middle East countries choose nuclear to diversify and decarbonize their energy supplies. UAE are putting into operation one after another units of its Barakah plant. Russian nuclear giant Rosatom is preparing to build 4 units at El- Dabaa in Egypt. Saudi Arabia, Jordan, and other Arab countries are considering including nuclear in their energy balance.

And it should be emphasized that power generation is not the only application of peaceful nuclear technologies in the Middle East. With the assistance of the IAEA, the region is developing programs in nuclear medicine, agricultural radiology, water desalination and other areas important for the health and prosperity of society.

Hopefully, we will see the Middle East one day, pulsing with green energy from the lowest lands to the farthest. We hope that this day will come closer, that we will participate in its coming, through people's support, as every brick contributes to construction.

by Tarek Abdel Aziz Farag,
Researcher in Nuclear Media
and Media Official at EAEA

Country Perspective

Nuclear Industry in sub-Saharan Africa

Overview

01 operating nuclear power plant

02 nuclear power plants under construction

00 under construction

Generation mix

hydro	gas	oil	coal	geothermal	others
51%	24%	15%	14%	2%	4%

Nuclear facts on sub-Saharan Africa

- 4 countries of the region are mining uranium
- a third of the almost 30 countries currently considering nuclear power are in Africa
- it will take 10 to 15 years to create the necessary nuclear infrastructure in the region

Viewpoint

Countries of sub-Saharan Africa have a growing interest in nuclear energy

One of the most monumental tasks we currently face as a global community is the need to eliminate energy poverty. According to the IEA, approximately 620 million people in Sub-Saharan Africa do not have access to electricity. An even more shocking picture emerges when we look at indicators by country: only Ghana has electrification rates of over 70%; the rate of electrification is below 5% in Malawi, Chad, the Central African Republic, Liberia, and Sierra Leone; and the 48 countries of sub-Saharan Africa have a combined installed power capacity of just under 70 GW, roughly equivalent to the installed power capacity of Spain.

At the same time, the region ironically has great potential in the field of renewable energy – hydro and solar, in particular. However, in order to use intermittent renewable sources without risks of energy shortages and blackouts, a clean and reliable backload source is needed. This is why the countries of sub-Saharan Africa have a growing interest in nuclear energy.

Russia's nuclear vendor, Rosatom, has so far signed nuclear cooperation agreements with more than 15 countries in sub-Saharan Africa, and China's state-owned CGN and France's EDF are currently in negotiations with several countries in the region. Everything indicates that the following decade will see a plethora of nuclear energy projects implemented throughout the continent.

However, building a large, conventional nuclear power plant does not seem to be a viable option in many countries in sub-Saharan Africa at this point in time. The IAEA recommends that the capacity of a country's power grid be about 10 times the capacity of a NPP in order for that NPP to be connected safely. Today, only a handful of African countries meet those requirements. Even the dynamically developing country of Kenya has an installed capacity of only 2,400MW, while the capacity of a modern Gen 3+ reactor is usually higher than 1000 MW.

For this reason, small modular reactors (SMRs) should be the technology of choice for the countries of Sub-Saharan Africa. These reactors have an average capacity of 50-100 MW per unit, can be mass produced, and can be deployed in remote areas. Even more importantly, SMRs are easier to finance and faster to build than big, conventional NPPs. One module costs significantly less in comparison with one conventional nuclear power unit.

But SMRs are a rather advanced technology and none of the countries of Sub-Saharan Africa, except for South Africa, can even be called a newcomer to the nuclear energy industry – they literally have zero experience operating commercial plants. This is why it is necessary to ensure that all required support be provided to countries along the way, from help creating a nuclear regulatory framework from scratch to help building infrastructure to help training new personnel.

An excellent option for countries wanting to study the benefits of nuclear energy before building a power plant is to install a research reactor. Such research reactors are exported by South Korea and Argentina. There is also a more complex, turnkey solution available – Rosatom's Centre for Nuclear Science and Technology (CNST). Such centres include a research reactor and scientific laboratories and can also be equipped with medical and irradiation facilities. Medicine and irradiation are amongst a wide range of other non-energy applications of nuclear technologies that can also be studied via research reactors, applications that too can contribute to the sustainable development of African countries.

by the NNWI and African Young Generation in Nuclear

YES TO NUCLEAR PERSPECTIVES
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