

ROADMAPS TO NEW NUCLEAR 2024

Brief for Ministers
and CEOs



NUCLEAR ENERGY AGENCY

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Nuclear Technology Development and Economics

Roadmaps to New Nuclear Conference 2024

Brief for Ministers and CEOs

19-20 September, 2024



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A forum for governments and industry to
succeed with nuclear new build.



Save the date
Roadmaps to New Nuclear 2025

OECD Conference Centre

Paris, France

18-19 September 2025

Contact: roadmapstonewnuclear@oecd-neo.org

In this brief

This *Roadmaps to New Nuclear 2024 Brief for Ministers and CEOs* focuses on efforts by like-minded countries to rebuild leadership and strengthen capacities for successful nuclear energy new build projects. The Brief sets out how governments and industry can advance international collaboration, foster strategic partnerships, share best practices and learn from each other's experiences to deliver on their national priorities more effectively.

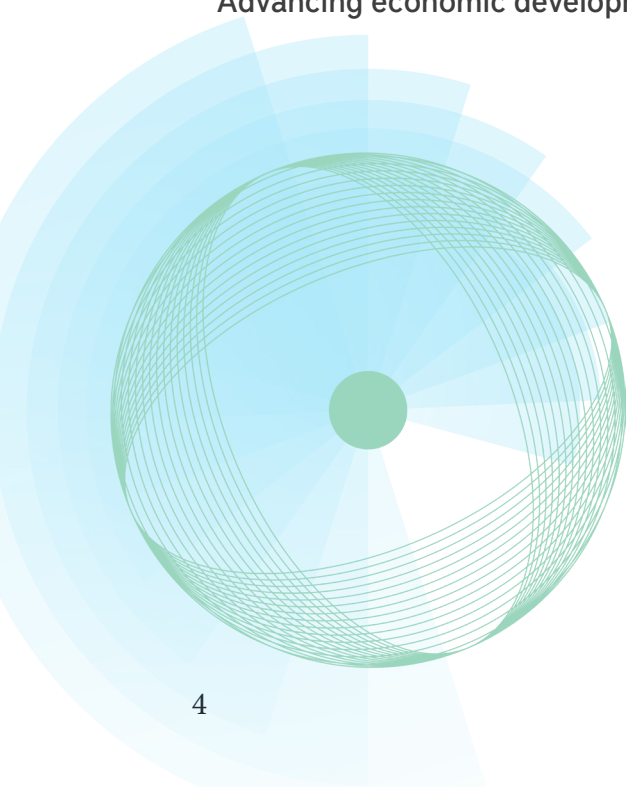
As part of the initiative, co-operative activities focusing on analyses, recommendations, and actions to help inform policy and investment decisions will be fostered. This includes efforts to finance new nuclear power plants in OECD as well as countries in the Global South, nuclear supply chain readiness, and nuclear workforce and skills development to feed the talent pipeline.

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Highlights from *Roadmaps to New Nuclear 2023*



Setting the scene

Opportunities for advancing nuclear energy to solve global issues

At the inaugural Roadmaps to New Nuclear conference, energy ministers and the heads of delegations of 20 countries issued a call to action and they developed guiding principles to chart a path forward for nuclear as a key contributor to achieving net zero carbon emissions by 2050.

The Nuclear Energy Imperative

- Address the climate crisis
- Strengthen energy security
- Support economic prosperity
- Lift billions out of energy poverty

Strategic Priorities

1. Financing new nuclear
2. Supply chain readiness
3. Talent pipeline

The Government Communiqué resulting from *Roadmaps to New Nuclear 2023* outlines guiding principles for nuclear finance, policy and regulation, research and development, supply chains, fuel supply, skills, public engagement, energy systems innovation, and international collaboration.

Three strategic priority areas were identified: financing new nuclear, supply chain readiness and the talent pipeline, and NEA was given a call to action to create a “practical, solutions-oriented approach.”

NEA has also initiated three flagship initiatives (page 53) to support member countries in their efforts. With the December 2023 commitment to triple nuclear energy by 2050 taken by more than 20 countries at the time of writing, action on these priorities and guiding principles takes on additional urgency.

Beginning a collaborative journey

The NEA and the Ministry of Energy Transition of France hosted the inaugural *Roadmaps to New Nuclear* conference at the OECD Conference Centre in Paris, France, on 28-29 September 2023.

The two days of discussions focused on opportunities to advance the construction of new nuclear power plants and to create the conditions for success in rebuilding leadership in nuclear new build. Participants explored solutions to deliver new nuclear construction at the scale and pace required to meet their energy needs.

Ministers provided guidance for the new initiative's focus, identifying three strategic priorities for co-operative work: financing new nuclear, supply chain readiness, and talent pipeline.

Participants



Sector Participants

Ansaldo
French Nuclear Safety Authority
Atomic Energy of Canada Ltd.
Barclays
Bruce Power
Canadian Nuclear Safety Commission
Cameco Corporation
Canadian Nuclear Association
CANDU Owners Group
Centrus Energy Corp
EDF

EDF-CSFN
Emirates Nuclear Energy Corporation
Energy Northwest
Electric Power Research Institute
First Nations Power Authority, Canada
Nuclear Energy Institute, United States
Nuclear Industry Association, United Kingdom
Framatome
Guggenheim Securities LLC
Japan Atomic Industrial Forum

Korea Hydro Nuclear Power
Meridiam
Mitsubishi Heavy Industries
Nuclearelectrica
Nucleareurope
Ontario Power Generation
Orano
Slovenske elektrarne a.s.
Urenco Ltd.
Vattenfall AB
Westinghouse
World Nuclear Association

View photos from Roadmaps to New Nuclear 2023:



“...we call on the NEA to co-ordinate with stakeholders in our countries to develop and support a network of industry leaders, government officials, researchers and experts as a practical, solutions-oriented approach to support decision makers in maximising the full potential of long-term operation of large reactors, large-reactor new build projects and development and deployment of SMRs for power generation and industrial applications.”

*Joint Government Communiqué
Roadmaps to New Nuclear 2023*

Joint Government Communiqué, Roadmaps to New Nuclear 2023

The future of nuclear energy is now.

The current global and geopolitical context has underlined more than ever the importance of ensuring resilient, stable, decarbonised and secure energy supplies. Security of energy supplies and affordable prices for people and businesses are top priorities on the agenda of leaders around the world as well as reaching the climate objectives established by the Paris Agreement.

Nuclear energy already plays a significant role in meeting climate goals and can play an even larger role in achieving global net zero emissions by 2050, consistent with the 1.5°C scenario and with the Paris Agreement. This ambitious objective can be realised through continued operation of existing nuclear power plants under the highest safety standards and large-scale deployment of new nuclear power plants. Achieving global net zero will require a significant increase in efforts in energy efficiency and energy savings, and the maximum use of all zero and low emissions energy sources towards achieving net zero outcomes, including both nuclear energy and renewable energy, to deliver both energy security and economic prosperity.

Nuclear power is a safe, affordable, dispatchable, and one of the low and zero-carbon energy sources that has contributed to the decarbonisation of our economies for more than half a century and which currently supplies over 10% of global electricity consumed.

Securing the needed increase in global nuclear energy will require strategic international collaboration among like-minded governments as well as public-private partnerships and industry leadership. Governments, and industry must act now to create the best conditions for success, including enabling policy frameworks, regulatory pathways that accelerate innovation, supply chain readiness, diversified fuel availability, public engagement, and promoting financing.

Read the full communiqué:





Industry communiqué, *Roadmaps to New Nuclear 2023*

As representatives of the nuclear industry in OECD nations, we have gathered in Paris, France on September 28-29, 2023, for the inaugural Government-Industry *Roadmaps to New Nuclear* conference organized by the OECD Nuclear Energy Agency (NEA) and the Government of France. We recognize that we are at a critical juncture in terms of climate and energy security, and nuclear energy must play an essential role—alongside other clean energy technologies—if we are to meet this moment.

The urgency and magnitude of the challenge before us is real and the speed and scale of the response must match this task. Building on the collaboration in April in Sapporo, Japan, during the G7 Climate, Energy and Environment Ministers meeting and Business Forum, we stand ready to work together with policymakers to rebuild leadership in nuclear energy within OECD countries and to cooperate with other like-minded nations as they seek to meet their climate and energy security goals.

To support decarbonization at the magnitude required, the international community must work to extend the operating period of existing nuclear generation resources, develop policies and tools to enable large scale deployment of new nuclear energy generation, and accelerate the development of a new portfolio of reactor technologies.

We are ready to do our part to bolster and strengthen leadership of like-minded OECD economies. Success will require a deepening of co-operation with governments, international organizations and across the industry, including public-private partnerships, international partnerships, and partnerships across the nuclear supply chain and with other industries.

Read the full communiqué:



Taking the next step

Roadmaps to New Nuclear 2024

NEA Director-General
William D. Magwood, IV



“Nuclear energy will inevitably play an important role in achieving net zero targets and ensuring energy security. It is also one of the essential tools we have available to drive economic growth around the world and lift people out of energy poverty in emerging economies in Asia, Sub-Saharan Africa and the Middle East.

We are delighted to co-host *Roadmaps to New Nuclear 2024* with Swedish Deputy Prime Minister and Minister for Energy, Business and Industry, Ebba Busch. Following the declaration made by so many countries at COP28 to triple global nuclear energy capacity by 2050, and in the lead-up to COP29, *Roadmaps to New Nuclear 2024* will bring together like-minded countries and the private industry to identify concrete steps to advance new nuclear build in the pursuit of net zero.

The time for talk is behind us; *Roadmaps to New Nuclear* conference provides a framework for action.”

Deputy Prime Minister and Minister for
Climate, Energy, Business and Industry,
Sweden
Ebba Busch



“The electrification of transport and industry requires massive investments in a robust and stable electricity system that delivers fossil-free electricity where and when it is needed. Nuclear power will have a key role in this transition, and the expansion of the civil nuclear fleet is a top priority for my government.

Therefore, I am very pleased to co-host *Roadmaps to New Nuclear 2024* with DG Magwood. I expect that this conference will make a significant contribution to advancing the build-out of civil nuclear energy in the OECD area.”

Strategic priorities

To further build upon the work in 2023 and to meet the call for action, the Ministry for Climate and Enterprise of Sweden and the OECD Nuclear Energy Agency (NEA) host *Roadmaps to New Nuclear 2024* in Paris on 19-20 September 2024. Discussions will include further development of the strategic priorities identified during the 2023 conference.

FINANCING NEW NUCLEAR

Access to capital at competitive rates

Securing financing remains a significant challenge for new nuclear projects due to higher upfront costs, complex risk assessments, and uncertainties for returns on investment. New nuclear energy will require access to significant capital at competitive rates, likely through a combination of public and private financing to de-risk projects and build investor confidence. This includes international development finance. Currently, the exclusion of nuclear energy from financing support at multi-development banks (MDBs) and international financial institutions (IFIs) works actively against this imperative.

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SUPPLY CHAIN READINESS

Healthy and resilient supply chains

The absence of new nuclear build projects in OECD countries over the last 20 years has resulted in a loss of supply chain capacity. Rebuilding will benefit the timely availability of essential components, materials, and services required to construct and maintain nuclear facilities. Timely delivery is critical to keeping projects on track and within budget. A resilient supply chain is better equipped to handle disruptions such as natural disasters, geopolitical tensions or pandemics. Diversifying suppliers and establishing contingency plans can mitigate risks and ensure that projects remain on track despite unforeseen challenges.

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TALENT PIPELINE

A skilled and prepared workforce

Meeting the scale and speed necessary to support a new wave of nuclear projects will require significant re-investment in the nuclear workforce. Promising indicators suggest that younger generations are showing increased interest in nuclear energy, with many universities reporting a surge in enrolment in nuclear engineering programmes. However, significant gaps remain in critical areas such as trade professions and skilled labour. Options to be explored include enhancing vocational training programmes, expanding apprenticeships, and integrating advanced technologies and hands-on experience into educational curricula.

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Flagship initiatives

This year's event includes a new high-level *Accelerating SMRs for Net Zero Summit* as part of the proceedings. This follows the initiative's launch at the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) hosted by the United Arab Emirates (UAE) in December 2023. Three recent NEA Flagship initiatives will also be discussed.

Stronger through collaboration

To support its members in achieving their nuclear energy goals, the NEA has developed three distinct initiatives to:

- accelerate development of SMRs for decarbonisation
- create a diverse, inclusive and gender-balanced workforce for the future
- support advancement of economic development and skills expansion in Africa.

Accelerating SMRs for Net Zero

Launched by NEA at the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) in December 2023, this collaborative initiative focuses on licensing, financing, supply chains, workforce development, fuel availability and spent fuel management. Bringing like-minded countries together on these topics will both lower costs and speed up the rollout of these new technologies.

As a component of this effort, the NEA hosts an annual Summit that brings together senior government officials and SMR executives to address key sector needs.

More on p. 53

Plan 2035: Building a diverse, inclusive and gender- balanced nuclear workforce

Plan 2035 is designed to open career pathways to youth from across the socio-economic spectrum with early community outreach and engagement at the upper secondary school level.

Plan 2035's activities leverage the NEA Global Forum on Nuclear Education, Science, Technology and Policy. It engages and informs students about career opportunities, connects them and young professionals to mentors, and provides targeted networking opportunities via a digital platform.

More on p. 55

Our Common Journey: Advancing economic development and skills expansion in Africa

About one third of African countries have integrated nuclear energy into their plans to support their development aspirations by increasing electricity supply, industrialising their economies, and reducing emissions. The NEA and the OECD Development Centre (DEV) are developing an initiative to advance economic development and skills expansion in Africa.

This inclusive policy dialogue platform for nuclear energy knowledge sharing and capacity building aims to ensure a safe, secure and gender-balanced nuclear deployment to support sustainable economic development with adequate policy and regulatory frameworks.

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Setting the scene

Opportunities for advancing nuclear energy to solve global issues

Reducing carbon emissions to meet the threat of climate change is the defining challenge for this generation. To date, the world has failed to meet it with the necessary urgency or scale of response.

Countries are not nearly on track to meet the IPCC 1.5°C scenario and the window for action is narrowing rapidly. NEA analysis highlights that tripling global installed nuclear capacity provides a realistic and practical path to meet net zero goals by 2050.

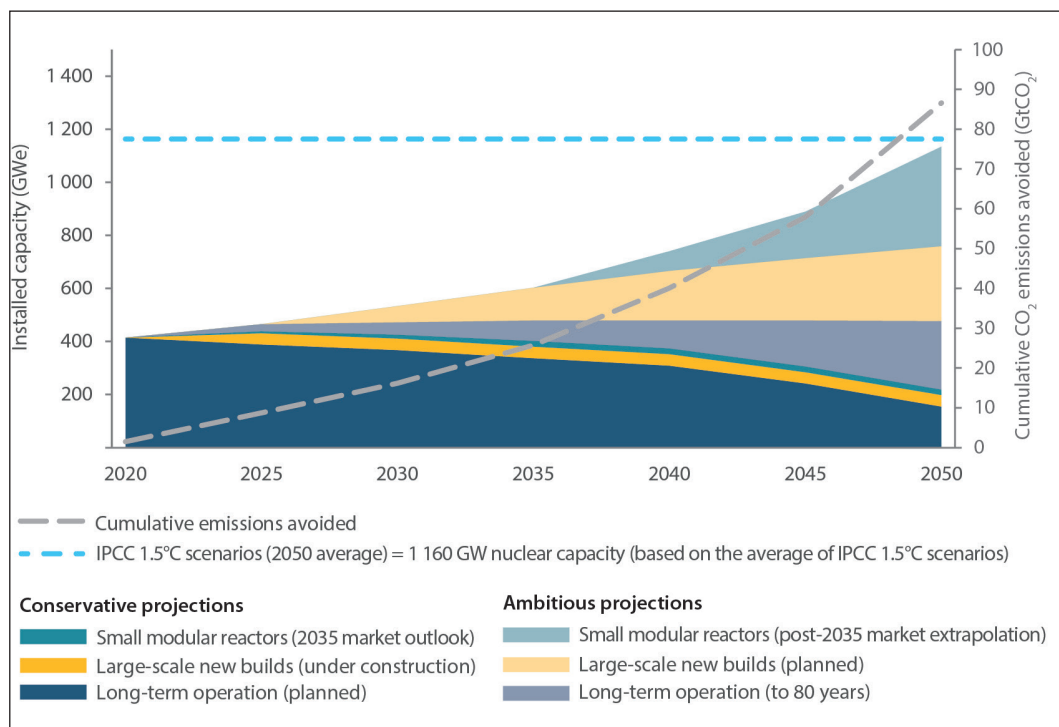
The world could avoid 87 gigatonnes of cumulative emissions between 2020 and 2050 with a combination of long-term operation (LTO) of existing reactors,

new large-scale reactor builds, and the deployment of small modular reactors (SMRs) (NEA, 2022a).

By 2050, nuclear energy could displace five gigatonnes of emissions each year, which is more than the last recorded annual emissions of the entire US economy, in 2022.

In achieving this alongside other climate and economic measures, a climate crisis can be avoided while lifting billions of people out of energy poverty and into a modern economy. At the same time, secure low-carbon energy can be secured for countries that must decarbonise their economies and infrastructure.

Figure 1: The Nuclear energy opportunity: Conservative and ambitious projections to 2050



Source: NEA (2022a), Meeting Climate Change Targets: The Role of Nuclear Energy, www.oecd-nea.org/nea-7628.

Tripling nuclear energy by 2050

Reaching net zero by 2050 will require comprehensive policy changes globally; substantial investments in innovation and infrastructure; and the large-scale deployment of non-emitting energy resources. Electricity grids must be decarbonised; vehicle fleets must be electrified or transitioned to non-emitting fuels; and industries must be transformed across sectors, including off-grid mining, buildings, and the production of chemicals, iron, steel and cement.

All credible models show that nuclear energy has an important role to play in global climate change mitigation. In 2022, the NEA reviewed the role of nuclear energy in meeting climate change targets and concluded that reaching net zero will require installed nuclear energy capacity to triple between 2022 and 2050.

This is an ambitious target for nuclear energy, but it is not beyond reach.

Considering the magnitude of global emissions reduction targets, both long-term operation of existing nuclear power plants as well as new builds of Generation III gigawatt-scale reactors have important roles to play. In addition, a wave of innovation in small modular reactors (SMRs) could unlock even further emission reductions by reaching into hard-to-abate parts of the economy, providing off-grid options and options for sites that do not require (or cannot support) gigawatt-scale power generation.

In December 2023, the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) saw more than 20 world leaders sign a Declaration to make efforts to triple nuclear energy by 2050. The Declaration referenced the 2022 NEA analysis, further recognising the key role of nuclear energy in achieving global net zero greenhouse gas emissions by 2050 and keeping the objectives of the Paris Agreement within reach.

NEA Committee on Nuclear Regulatory Activities (CNRA) statement reaffirming good regulatory principles

31 July 2024

“Recognising the Declaration by 22 Nations during the World Climate Action Summit of the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) on the need to triple nuclear energy to achieve global net zero greenhouse emissions and carbon neutrality by or around mid-century;

Recognising that while some nations plan to maintain or expand nuclear energy production, others intend to phase out their currently operating nuclear power plants;

Recognising that within specific national frameworks the licence holder has the main responsibility for safely using nuclear technology for peaceful purposes, which is also reflected in the nuclear industry’s Pledge;

Highlighting the regulators’ role to establish a framework that enables the safe use of nuclear technology requires considerable time and effort;

Recognising that nuclear regulators make decisions consistent with their commitment to nuclear safety that are independent of their governments and national energy policies;

.....”

The CNRA will align its work with the principles set out in the statement and work with other international organisations to support regulatory readiness for the safe use of nuclear technology.

Read more at the QR code.



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Nuclear energy: Clean power for the world

Nuclear energy has been a reliable producer of non-emitting, clean-air electricity for well over half a century. It powers the economies, of over 30 countries, providing the reliable electricity needed to keep people cool on the hottest days of the year and illuminating hospital emergency rooms through the darkest of nights. Its performance has steadily improved over the years through incremental innovation in the use of technology, equipment reliability and processes and through collaborative global efforts to strengthen workforce and supply chain skills and knowledge.

Some 415 operating nuclear power reactors in more than 30 countries provide over 370 gigawatts of electric capacity, worldwide. Some of the 25 additional licensed, non-operating stations offer an opportunity for further capacity with investment to leverage the initial capital cost.

Nuclear energy is the largest source of non-emitting electricity generation in OECD countries and the second largest source worldwide after hydropower, displacing 1.6 gigatonnes of carbon dioxide emissions annually (NEA, 2020a).

Recent and historical experiences show that nuclear energy can be a low-carbon technology with rapid delivery times under the right policy frameworks and a robust programmatic approach.

This was the case historically for countries such as Canada, France and Sweden, which decarbonised their electricity mix in less than two decades with hydropower and rapid deployment of nuclear energy.

Today, countries with established nuclear energy programmes, such as the People's Republic of China (China) and Korea, have demonstrated construction lead times of five to six years or less for large-scale reactor designs with high safety standards. Newcomer countries, such as the United Arab Emirates with the Barakah project, have demonstrated the ability to deliver new nuclear on a timeline and cost.

Other countries are moving towards long term operations of their assets and reducing their levelised unit cost of electricity, sometimes for decades more than originally anticipated, thanks to advancements in knowledge, technology and human performance, supported by modern, effective regulation.

Fast facts

A nuclear-powered world: Past, present, future

Second largest non-emitter, today

Nuclear energy leads after hydro power

Nuclear energy is currently the second largest non-emitting electricity source in the world and the second largest in OECD countries. Its supply is not nature dependent for wind and sun. To date, more than two years of total global emissions have been displaced by the use of nuclear power. With nuclear plant new builds already under construction and planned and for more diverse uses, this contribution is set to grow in an even more powerful way.

Two in one: Medicine and energy

Producing life-saving medicine while generating nuclear energy

For decades, nuclear reactors have been producing life-saving isotopes used for medical diagnostics and treatments and used for sterilisation of medical equipment and food production. Some electricity generation reactors even do double duty, producing megawatts while also producing isotopes like cobalt-60 and lutetium-177, which is particularly effective in some targeted cancer treatments.

Nuclear energy today

The capacity of conventional power plants worldwide is illustrated below, along with Table 1 indicating which countries are included within the regions.

Figure 2: Existing capacity of large-scale nuclear energy



What about the waste?

Managed and counted

All of the waste produced from nuclear energy is accounted for and safely managed under the oversight of national nuclear safety regulators. This is supported by international standards and best practices and safeguards monitoring by the International Atomic Energy Agency.

Transparent, upfront costs

Funds and financing to pay for decommissioning and radioactive waste disposal are well established in most countries, often included in the cost of electricity.

A technology solution

The international consensus is that deep geological repositories (DGR) are the best solution for spent fuel long-term storage. Finland is the first country to implement a DGR. Other countries are well advanced in this process.

Building a clean energy future

New nuclear energy options offer a diversity of designs and sizes

The commitment to triple nuclear energy capacity by 2050 by a growing number of countries underscores recognition that low-carbon energy needs demand an all-hands-on-deck approach.

The need for new capacity is a singular challenge with two, sometimes competing, requirements: speed and scale. Globally, there is rapid demand growth just to satisfy growing need for traditional electricity uses, especially as low and middle income countries look to leverage increased electricity access for economic prosperity and to achieve sustainable development goals. But the world doesn't just need more electricity for traditional uses.

There is rapid transformation towards electrification of other sectors, such as transportation including mass transit and personal vehicles, the need to power data centres and artificial intelligence, as well as to curb emissions in industrial and resource sectors. It is turning more decision makers

to look at both traditional large-scale nuclear power plants and SMRs in combination.

The latter is particularly attractive for non-electric applications, including decarbonising hard-to-abate sectors; for heating buildings; for producing synthetic fuels, or as a load-follower of variable renewable energy sources. SMRs can support water desalination and supply heat and power to remote and rural regions where traditional-scale reactors may have been unattainable or impractical.

With the commitment to triple nuclear energy by 2050, many countries now see a two-pronged strategy that could involve several designs and sizes to meet diverse decarbonisation and electrification needs. A resurgence of large-scale new build is in progress, in parallel with development of new pathways to achieve mass production and the deployment of SMRs and micro-SMRs. This is critical path. The future, and climate change, is now.

Ready, set, operate

Visible progress has been made in a few short years on adoption of plans, actions to construct, and successful operation of nuclear power plants globally.

Planned and proposed nuclear reactors

Near-term plans: Many countries have announced plans to build new reactors, with over 100 in various planning stages.

Emerging markets: Preparations are underway in 13 European countries for the deployment of large-scale nuclear energy capacity. Countries such as Bangladesh, Poland and Türkiye are entering the nuclear energy market for the first time.

Nuclear reactors under construction

Total reactors: 62 nuclear reactors in 17 countries

Key regions: Asia, particularly in China and India, followed by Russia and countries in Europe and the Middle East.

Capacity addition: 74 GW(e) of capacity.

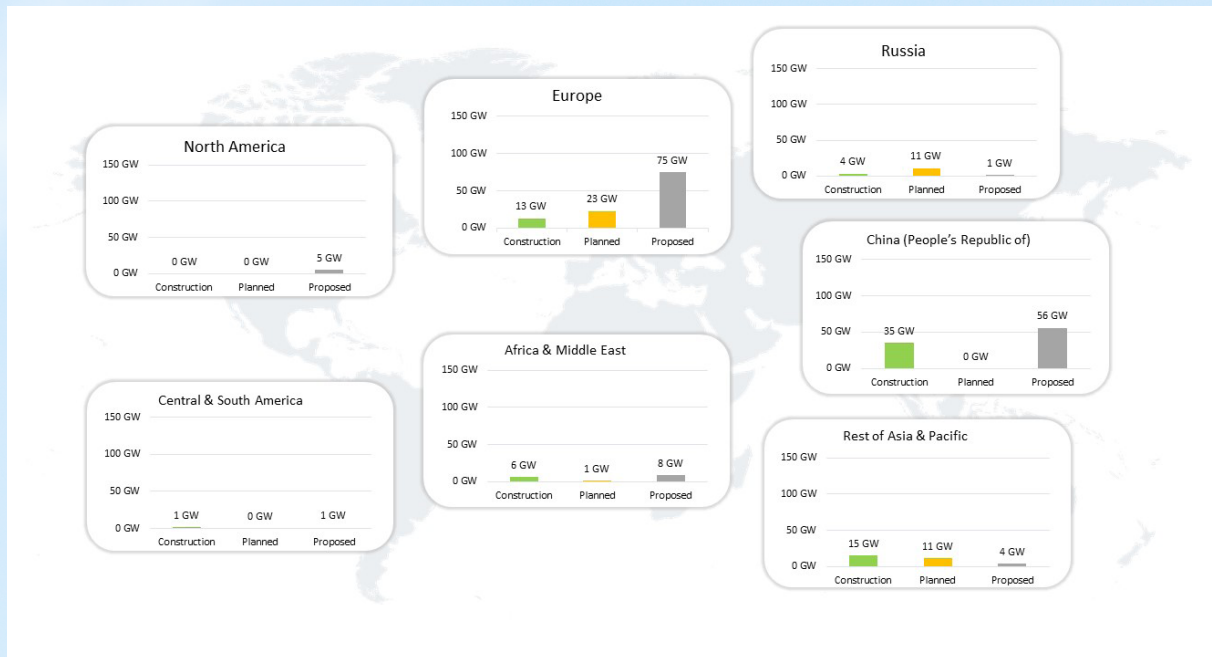
Operational nuclear reactors

Total reactors: There are 415 operating nuclear reactors in over 30 countries (IAEA, 2024).

Installed capacity: Approximately 370 gigawatts electric, GW(e).

Countries with the largest installed nuclear capacity: The United States, France, China, Russia, Korea, Canada and Japan.

Figure 3: Large-scale nuclear new build



Under construction:

Nuclear new build projects are considered 'under construction' after construction has started on site and before the plant is commissioned.

Planned:

Nuclear new build projects are considered as 'planned' once the decision has been taken by either the government or the utility, including selection of the site and the reactor technology.

Proposed:

Nuclear new build projects are considered as 'proposed' based on policy or industry statements of intention.

Fast fact

25 out of 62 reactors (over one third) under construction globally are Russian VVER reactors

Figure 4: Nuclear reactors planned and under construction by design, 2024

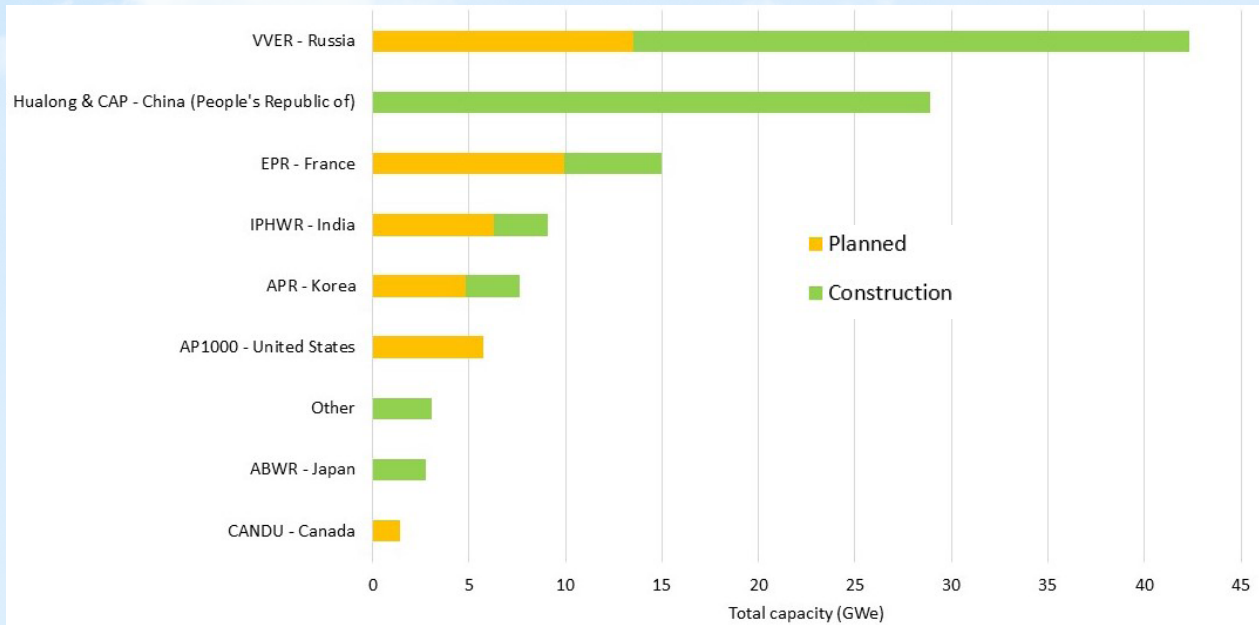


Table 1: Large-scale reactors under construction, planned and proposed by country (as of 31 July 2024)

Area	Country	Construction (GWe)	Planned (GWe)	Proposed (GWe)
Europe	Bulgaria	0	2	0
	Czechia	0	2	2
	France	1.65	9.9	12.8
	Hungary	2.53	0	0
	Netherlands	0	0	2.4
	Poland	0	3.75	6.15
	Romania	0	1.44	0
	Slovak Republic	0.47	0	2.4
	Slovenia	0	0	1.1
	Sweden	0	0	7.6
	Türkiye	4.8	0	14.4
	Ukraine	0	0	9
Africa & Middle East	United Kingdom	3.44	3.44	17.12
	Egypt	4.8	0	0
	Iran	1.06	1.057	0
	Saudi Arabia	0	0	2.8
	United Arab Emirates	0	0	5.6
Russia	Russia	3.68	11.24	1.2
China	China (People's Republic of)	35.16	0	55.5
Rest of Asia & Pacific	Bangladesh	2.4	0	0
	India	7.29	6.3	0
	Japan	2.76	0	0
	Korea	2.8	4.9	0
	Pakistan	0	0	1.2
	Uzbekistan	0	0	2.4
North America	Canada	0	0	4.8
Central & South America	Argentina	0	0	1.15
	Brazil	1.4	0	0



The arrival of SMRs

Beyond current nuclear power plants and traditional-scale plants under construction, the last decade has seen the emergence of planning and deployment for small modular reactors (SMRs). SMRs bring design flexibility to address variety of applications for electrification and decarbonisation.

As stated, the world faces a two-factor challenge in its efforts to push back climate change while also meeting humanitarian and economic necessities: scale and speed. To achieve the first, it is necessary to tackle the challenge of the second.

Nuclear technology, in its many forms, can be a powerful tool to support these goals but employing it to full effect requires that it be more accessible. Nuclear energy must achieve a state of readiness that makes it a practical energy choice for more uses, in more geographies, for more people. It must achieve greater scale, lower capital cost and better financing options, shorter deployment time, and greater efficiencies in its operations and safety and security systems, as well as simpler fuel and waste management.

The idea of nuclear energy as long-lead, complex projects must shift to include options for consumer-oriented, pre-fabricated, rapidly-deployed, and purpose-built products that offer high-confidence, defined cost and schedule.

It requires a major reimagining of the industry

business model and how innovation is deployed to enable it. The *NEA Small Modular Reactor Dashboard: Second Edition* (NEA, 2024b) reveals that China and Russia are leading on first-of-a-kind (FOAK) deployment, but rapid and real progress is under way in Europe and North America.

SMRs have already been deployed and are operating in China and Russia, with others under construction. Japan has one test reactor and Argentina has an additional reactor under construction.

SMR design vendors headquartered globally

Europe and North America are home to the headquarters of many SMR designers. The United States is home to the largest number of SMR design organisations, with nearly 35% of the field located there. Different editions of *The NEA SMR Dashboard* also reveals significant progress on siting, with SMRs operating and/or under construction in Argentina, China, Japan and Russia. A large number of earlier stage siting discussions and negotiations are advancing in Europe and North America. In Canada, site preparation is underway just east of Toronto at Ontario Power Generation's Darlington site, following clearance of the environmental assessment. A decision on construction licensing is expected in mid-2025.

Additional SMRs clear regulatory hurdles

Three additional SMR designs have received regulatory approval:

- **VOYGR** by NuScale in the United States
- **SMART** by KAERI in Korea
- **Hermes** by Kairos Power in the United States.



Taking stock

SMR and advanced nuclear reactor projects

Across the globe, SMR development is at various stages.

China and Russia are leading with all of their commercial SMRs in operation or under construction. Within OECD and NEA countries, progress towards SMR deployment is accelerating.

North America is characterised by a high number of different SMR projects. The NEA has identified 18 SMR designs at different licensing stages with the US Nuclear Regulatory Commission (NRC) or the Canadian Nuclear Safety Commission.

Over 25 sites are being investigated for potential deployment in Canada and the United States. In the rest of the world, the NEA has identified at least 23 active SMR developers, particularly in France, Korea and the United Kingdom.

Significant progress is being made on innovative technologies such as Generation IV reactors. Construction of the lead-cooled fast reactor BREST-OD-300 has been ongoing since 2021 in Russia. In 2023, China started commercial operation of its high-temperature gas reactor the HTR-PM, and the US NRC approved Kairos Power's Construction

Permit Application (CPA) for its Hermes non-power high-temperature molten salt-cooled demonstration reactor. Notably, this is the NRC's first-ever CPA approval for a Generation IV reactor. Also in 2023, DOW Chemical announced that it had selected the Xe-100 high temperature gas-cooled SMR by X-Energy to provide power and steam to its manufacturing facility in Seadrift, Texas, United States. In 2024, Bechtel began civil works in Wyoming, also in the United States, to prepare the site for the Advanced Nuclear Project by TerraPower.

SMRs in planning and construction come from vendors spread across the globe

SMR technology is gaining traction globally, the result of increased interest from the private sector and recognition at the policy level of their potential to support deep decarbonisation.

There were 63 SMR designs under active development in mid-2024. These designs come from a geographically diverse industry of SMR design vendors that include 18 design organisations headquartered in North America, 16 in Europe, and 7 in Asia. By country, 15 SMR design organisations are headquartered in the United States, seven in France, four in China, three in Canada, two in Japan, and two in Russia (NEA, 2024b).

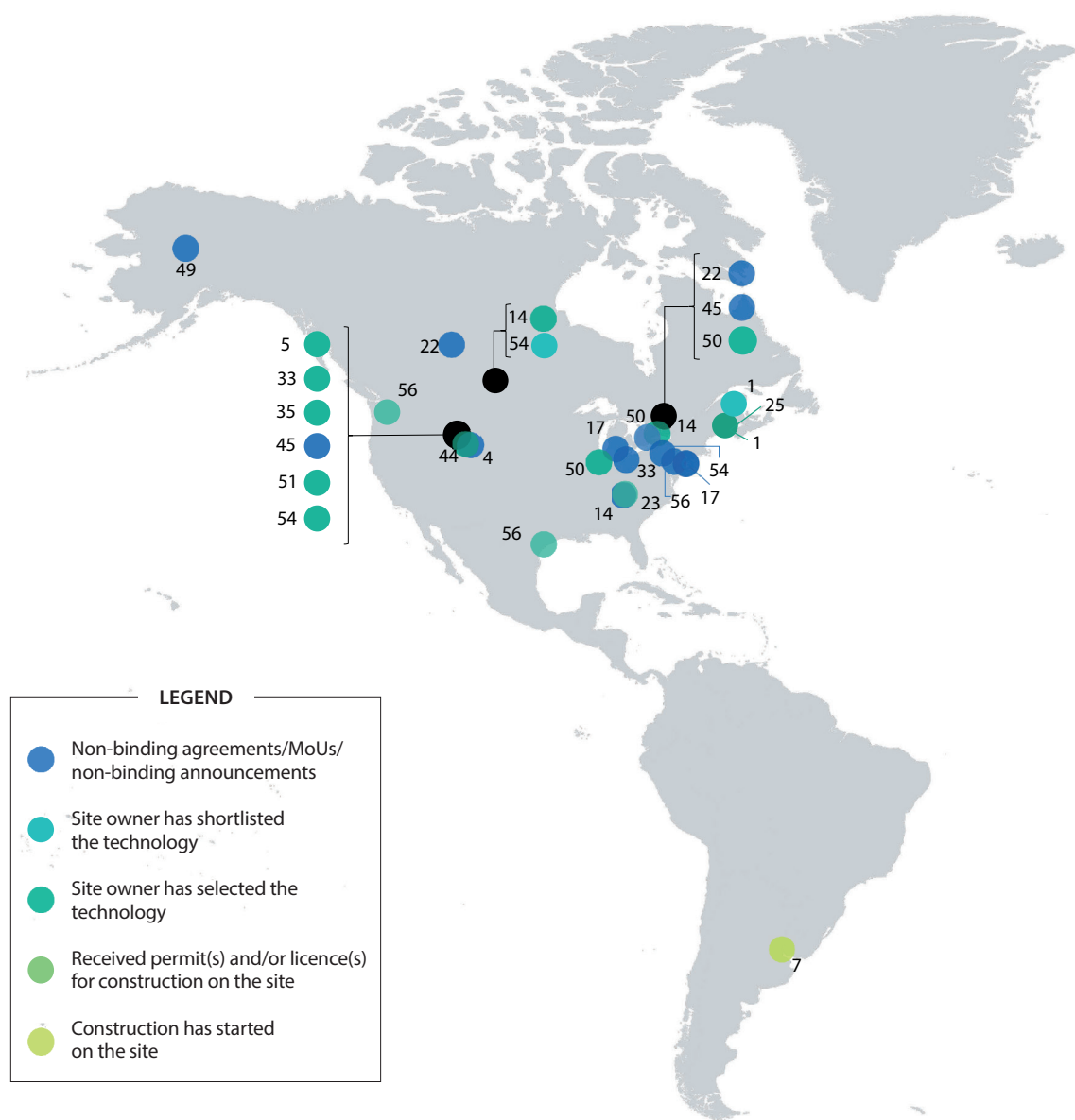
NEA and members provide thought leadership on nuclear energy development

The NEA has published and contributed to several reports and initiatives on the economics of SMRs. This work led to the formation of a new NEA Working Group on SMR Economics in 2024.

The Working Group held a workshop on the economics of SMRs in Ottawa, Canada, in February 2024. The workshop brought together experts to assess recent progress in SMR deployment and discuss how different policy frameworks, deployment strategies, and delivery models will influence the overall

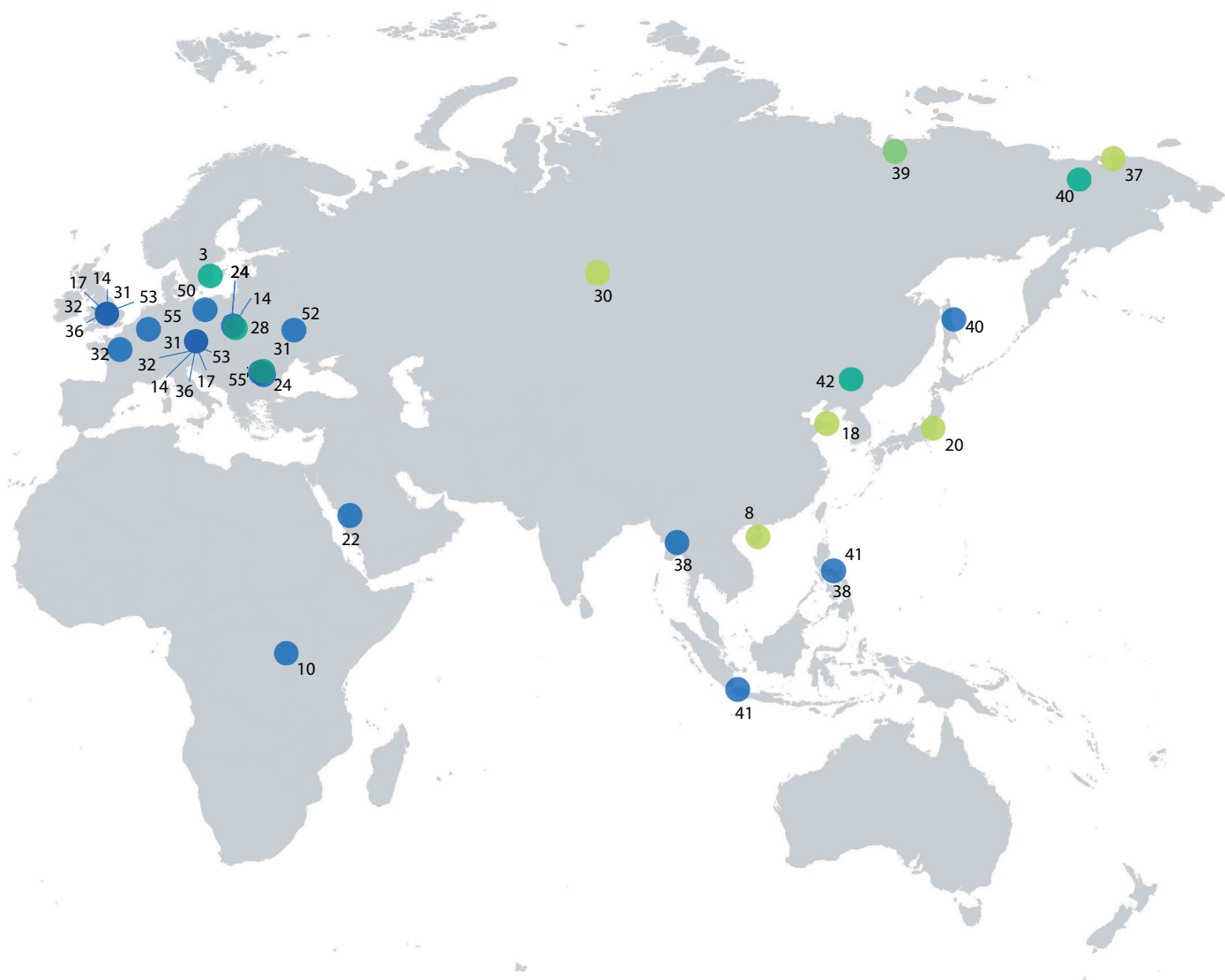
economics of SMRs. Additionally, the event drew insights from comparable industries that have achieved cost reductions through serial construction, identifying potential approaches for SMR projects. The second edition of the NEA Small Modular Reactor Dashboard was launched at the event.

Figure 5: Global map of SMR sites



1	ARC-100	ARC Clean Technology	15	Calogena	Gorgé
2	Blue Capsule	Blue Capsule Technology	16	HEXANA	Hexana
3	SEALER-55	Blykalla	17	SMR-300	Holtec International
4	BANR	BWXT	18	HTR-PM	INET
5	Project Pele	BWXT	19	GTHTR300	JAEA
6	ACPR50S	CGN	20	HTTR	JAEA
7	CAREM	CNEA	21	Jimmy SMR	Jimmy
8	ACP100	CNNC	22	SMART	KAERI
9	Energy Well	CVŘ	23	Hermes	Kairos Power
10	DF300	Dual Fluid Energy	24	PWR-20	Last Energy
11	A-HTR-100	Eskom	25	SSR-W	Moltex Energy
12	LFTR	Flibe Energy	26	FLEX	MoltexFLEX
13	SC-HTGR	Framatome	27	XAMR	NAAREA
14	BWRX-300	GE Hitachi Nuclear Energy	28	HTGR-POLA	NCBJ

NEA (2024b), The NEA Small Modular Reactor Dashboard: Second Edition, OECD Publishing, Paris, www.oecd-nea.org/smr-dashboard-2nd-edition



29	LFR-AS-200	newcleo
30	BREST-OD-300	NIKIET
31	VOYGR	NuScale Power
32	NUWARD SMR	NUWARD
33	Aurora Powerhouse	Oklo
34	Otrera 300	Otrera Nuclear Energy
35	Kaleidos	Radiant Industries
36	RR SMR	Rolls-Royce SMR
37	KLT-40S	ROSATOM
38	RITM-200M	ROSATOM
39	RITM-200N	ROSATOM
40	RITM-200S	ROSATOM
41	CMSR	Seaborg Technologies
42	HAPPY200	SPIC

43	HTMR-100	Stratek Global
44	Sodium Reactor Plant	TerraPower
45	IMSR	Terrestrial Energy
46	ThorCon 500	ThorCon International
47	Thorizon One	Thorizon
48	MoveluX	Toshiba Energy Systems & Solutions Corporation
49	4S	Toshiba Energy Systems & Solutions Corporation
50	MMR	USNC
51	Pylon D1	USNC
52	TEPLATOR	UWB and CIIRC CTU
53	AP300™ SMR	Westinghouse Electric Company
54	eVinci microreactor	Westinghouse Electric Company
55	Westinghouse LFR	Westinghouse Electric Company
56	Xe-100	X-energy

Spotlight feature

Waste Integration for Small and Advanced Reactor Designs (WISARD)

The innovative features of Generation IV reactors and SMRs that enable their promised benefits have an inherent effect on their spent fuel characteristics and waste streams. New fuel, moderator, or coolant materials lead to waste with different chemical, physical, and radioactive characteristics. Consequently, the irradiation behaviour of these materials throughout the plant life cycle must be considered, and changing the size of the reactor may change the volume and type of waste produced.

There are also potential issues with used fuel transportation due to higher burn-ups or end-of-cycle reactivity, higher decay heat, and different fuel sizes for cask storage. The waste from the next generation of nuclear power plants will have some significant differences to that currently processed in national programmes. These differences must be understood, evaluated, and anticipated to provide a long-term, sustainable waste management solution.

The NEA Joint Project on Waste Integration for Small and Advanced Reactor Designs (WISARD) aims to take advantage of the unique window of opportunity to integrate

waste management from the beginning of the SMR and advanced reactors' design life cycle. Early consideration of the logistics and constraints of future waste streams will allow waste management concerns to be actively considered when taking decisions on technology deployment and fuel cycle options. Some issues may be identified and 'designed away,' while the awareness and understanding of others will improve preparation for future disposal efforts. This early consideration also provides the opportunity to co-ordinate with the multiple stakeholders involved in bringing a new reactor design to completion.

SMRs and advanced reactors represent a diverse field with an active start-up culture and close collaboration with academia and independent research organisations worldwide. With a wide range of potential stakeholders, care must be taken to involve all parties in the process to minimise disconnects between the design, operation, and decommissioning phases. The dedicated NEA WISARD platform will facilitate the collaboration and understanding between stakeholders throughout the plant life cycle. This will be the key to building a successful, sustainable programme.

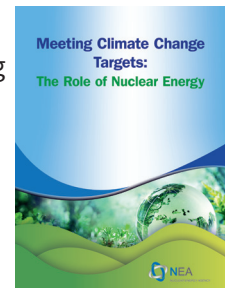
The NEA joint project, WISARD aims to integrate waste management from the beginning of the SMR and Advanced reactor design life cycle. Early consideration of the logistics and constraints of future waste streams will allow waste management concerns to be actively considered when taking decisions on technology deployment and fuel cycle options.

Three NEA publications chart nuclear energy's contribution to low-carbon energy

Meeting Climate Change Targets: The Role of Nuclear Energy (2022)

The nuclear sector supports climate change mitigation in many ways. Existing global installed nuclear capacity already plays an important role, and long-term operation (LTO) will continue to contribute for decades, displacing 1.6 gigatonnes of carbon dioxide emissions annually (NEA, 2020a). Much more is needed.

This report considered 90 IPCC pathways consistent with a 1.5°C scenario. It found that, on average, the pathways require nuclear energy to reach 1160 gigawatts of electricity by 2050, up from 394 GW(e) in 2020. Ambitious, but not beyond reach, with a combination of LTO of existing assets, large-scale new builds, and deployment of SMRs, as shown in Figure 1 on page 14.

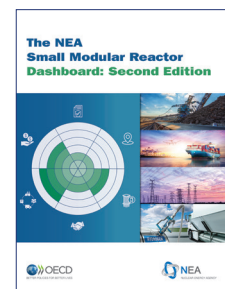


Read more at QR code



The NEA Small Modular Reactor Dashboard: Second Edition (2024)

The *NEA Small Modular Reactor Dashboard* looks beyond technology readiness levels and assesses progress across six additional enabling conditions: licensing readiness, siting, financing, supply chain, engagement, and fuel. It reveals substantial progress towards SMR deployment and commercialisation in NEA and non-NEA countries, with much of this progress occurring during the past two years. The second edition is the first comprehensive worldwide progress assessment of SMRs.



Read more at QR code

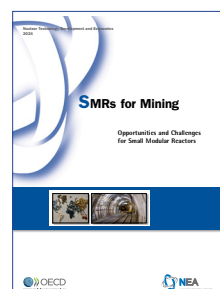


SMRs for Mining: Opportunities and Challenges for Small Modular Reactors

To be launched at Roadmaps to New Nuclear 2024

As industries transition from fossil fuels to clean energy alternatives, the mining sector - which is particularly challenging to decarbonise - stands at a crossroads. Critical minerals such as rare earth elements, niobium, lithium, cobalt, and copper are commonly located in remote areas, underscoring the importance of off-grid mining to support a secure supply chain in support of the clean energy transition. The sector faces increasing pressure to decarbonise while simultaneously expanding to meet growing demand for metals and minerals. SMRs have emerged as a promising energy option to help decarbonise off-grid and remote mining.

This report is part of an NEA series of case studies to assess the opportunities and challenges for SMRs across industrial applications. This case study considers the opportunity for small, off-grid mines that currently rely on diesel or heavy fuel oil for their energy demands and typically target high-value commodities. The report presents a conservative global assessment of existing and future market potential of micro-SMRs for off-grid mining, setting out the drivers, characteristics, and timelines for deployment in these markets.



Read more at QR code



Financing New Nuclear



Financing: A critical priority to triple nuclear energy by 2050	28
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Financing: A critical priority to triple nuclear energy by 2050

Securing financing remains a significant challenge for new nuclear energy projects due to high upfront costs, complex risk assessments, and uncertainties surrounding returns on investment.

The cost of building reactors, safety systems, and associated infrastructure can strain the financial resources of both private investors and public entities—even as system cost analyses demonstrate conclusively that nuclear energy is cost competitive.

Construction and regulatory approval processes for nuclear plants often extend over a decade, leading to prolonged periods of capital commitment. Countries will also need to put the necessary regulatory and political frameworks into place, decide on appropriate electricity market designs, ensure the societal trade-offs required in different allocations of financial risks, and step in themselves in cases where large-scale failures of private markets can be identified.

The cost of building reactors, safety systems, and associated infrastructure can strain the financial resources of both private investors and public entities—even as system cost analyses demonstrate conclusively that nuclear energy is cost competitive.

Cracking the code of nuclear finance

Scaling up investment flows in nuclear energy requires immediate action as it is one of the major challenges for countries that have decided to construct new nuclear power plants – or are considering doing so.

Tripling of installed nuclear capacity by 2050 would imply the rate of annual new builds to at least quadruple from about 7 GW(e) on average in 2024, to 25-30 GW(e) over the coming decades. Investment flows in the nuclear sector will need to increase similarly to meet this target.

Financing conditions are central for the competitiveness of new nuclear power plants as the cost of capital significantly impacts the levelised cost of electricity (LCOE). This is a central feature of new nuclear projects compared to other sources of energy, and particularly combined cycle gas turbines, due to two key factors:

- The importance of initial investment costs during construction relative to variable costs during operation, and;
- The long construction period that can last for the better part of a decade or more in case of construction delays.

Levelised costs of nuclear electricity are very sensitive to the cost of capital.

Financial costs can represent two thirds of the cost of nuclear electricity when the cost of capital reaches 9%. However, financial costs would drop to less than one third of the cost of nuclear electricity if the cost of capital is lowered to 3%.

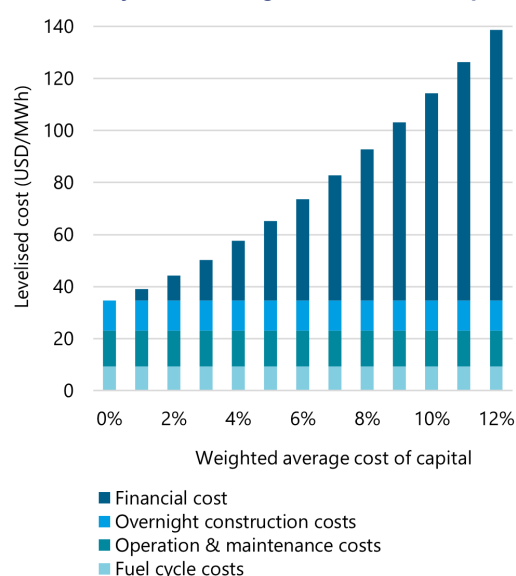
The management of project risks will directly affect financing conditions. Today, most OECD countries are emerging from more than two decades without significant construction of new nuclear power plants. This has resulted in a loss of supply chain and workforce capabilities which, in turn, have contributed to significant cost overruns and delays for recent first-of-a-kind (FOAK) projects. Whilst lessons are being learned from those FOAK projects, they also lead to new nuclear being currently associated with significant construction risks

(both real and perceived), which directly impact financing conditions as most private investors require a higher return before they are willing to accept a higher level of risk.

The challenge of mobilising investments in nuclear energy is further compounded by the structural transformation in OECD countries, since the last wave of nuclear constructions in the 1970s and 1980s. The liberalisation of energy markets combined with restructuring and, in some cases, privatisation of power utilities affects how nuclear new build financing frameworks can be devised.

This is of particular importance to the respective roles of public and private stakeholders. By comparison, in China and Russia, domestic and international investment decisions remain within government control which provides them with a systemic advantage compared to OECD countries when supporting embarking nuclear countries, particularly emerging economies.

Figure 6: Levelised costs of nuclear electricity for a range of cost of capital



Source: NEA (2020a), Unlocking Reductions in the Construction Costs of Nuclear: A Practical Guide for Stakeholders, www.oecd-nea.org/unlock2020.

Governments must do more to work with the financial sector on financing models

All capital-intensive infrastructure projects – including nuclear energy projects – depend to some extent on direct or indirect support and risk sharing from governments. This can include direct funding, but also enabling policy frameworks that recognise the role of nuclear energy for climate change mitigation and energy security, as well as risk sharing measures to allow nuclear energy projects to compete on equal footing with other non-emitting energy options.

Public-private partnerships underway

Czechia

In Czechia, a Power Purchase Agreement proposed for the Dukovany project was recently approved by the European Commission under State Aid rules as an approach to enable long-term contracts that would support investments new nuclear capacity.

United Kingdom

In the United Kingdom, the Regulated Asset Base (RAB) model under discussion will enable investors to share some of the project's construction risks with consumers and taxpayers, significantly lowering the cost of capital.

United States

In the United States, the Inflation Reduction Act (IRA) introduces several measures to support new nuclear energy projects, including tax credits on zero-carbon electricity generation and loan guarantees from the Department of Energy.

These examples illustrate how government can continue to play a role to enable the private sector to advance new nuclear projects in OECD countries.

A number of financing frameworks can be considered for nuclear new build projects where governments contribute to mitigate risks and support financing as part of public-private partnerships.

A growing role for the private sector in financing new nuclear projects

Nuclear power plants exhibit unique risk profiles, lead time and cash flows at different stages of the project life cycle, making them attractive to different investor types at different stages. Under the right approach to managing and sharing risks, governments in OECD countries can expect the private sector to play a growing role for the financing of new nuclear projects.

Additional sources of financing can be expected once projects reach final investment decision. This could include:

- **Equity financing** from institutions such as pension and infrastructure funds for which the lifetime of nuclear assets will be a source of value as it would match their own long-term financial commitments.
- **Debt financing** in cases where governments or export credit agencies provide guarantees to the lenders.
- **Green bonds** could further catalyse additional debt financing from the private sector in jurisdictions that include nuclear in ESG and other related taxonomies.

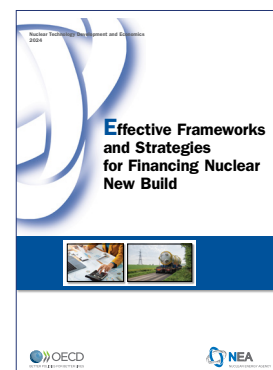
The interest of the private sector is expected to further increase once a nuclear power plant enters commercial operation as the completion of construction significantly reduces the project risk profile. This could lead to sizeable opportunities for refinancing nuclear projects once in operation with additional private capital.

NEA takes action on financing new nuclear energy

New report–*Nuclear Financing: Effective Frameworks and Strategies for Financing New Build*

Given the high priority of nuclear financing, the NEA is working to strengthen knowledge and identify opportunities to support its member countries. This includes the report *Nuclear Financing: Effective Frameworks and Strategies for Financing Nuclear New Build*, which examines eight financing models across three continents and seven countries.

The eight case studies provide a practical understanding of the financing frameworks and policy measures implemented to support the project. These include the sources of equity and debt financing, revenue streams, the role of different policy agents as well as policy support measures. These studies provide a comparative analysis for countries moving forward with new nuclear energy projects to consider in weighing the relative merits of different models for their financing.



Read more at QR code



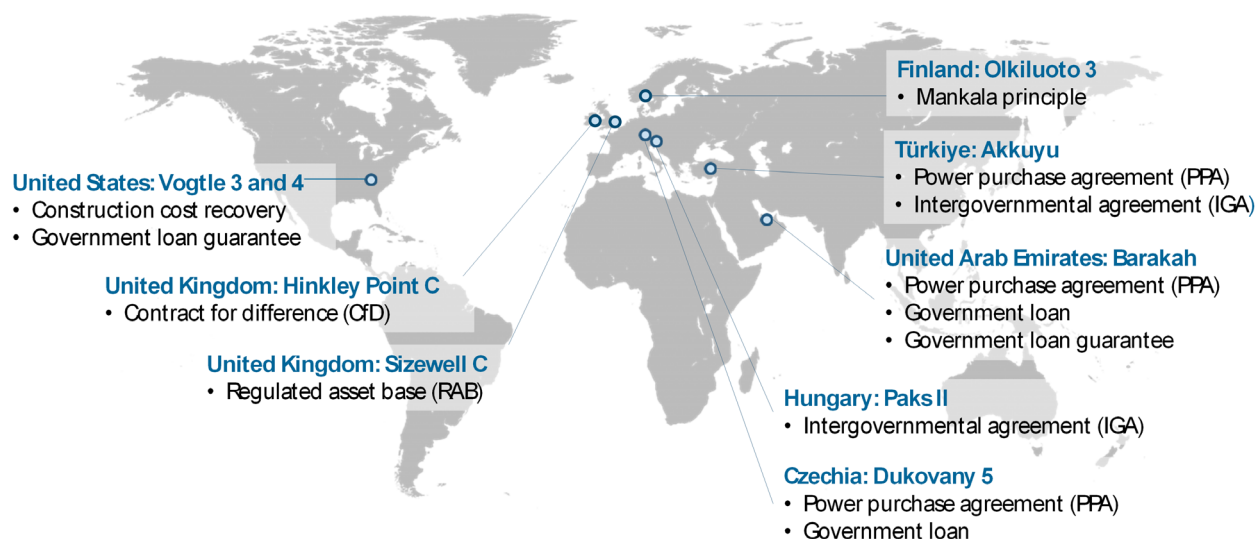
Figure 7 on page 32 and Table 2 below summarise some of the key information regarding the projects in this publication.

Table 2: Key summary information on nuclear new build financing

	Olkiluoto 3	Vogtle 3 and 4	Barakah	Akkuyu	HPC	Sizewell C	Paks II	Dukovany
Country	Finland	United States	United Arab Emirates	Türkiye	United Kingdom	United Kingdom	Hungary	Czechia
Status	Operational	Operational (partial)	Operational	Under construction	Under construction	Pending final investment	First concrete planned 2024	Preferred bidder selected
Construction year	2005	2013	2012	2018	2016	2025 (expected)	2024 (expected)	2025 (expected)
Reactor technology	EPR	AP-1000	APR-1400	VVER-1200	EPR	EPR	VVER-1200	APR-1000 (expected)
Capacity	1.6 GWe	2.2 Gwe (2 units)	5.6 Gwe (4 units)	4.8 Gwe (4 units)	3.2 Gwe (2 units)	3.2 Gwe (2 units)	2.4 Gwe (2 units)	22 GWe (2 units – expected)
Owner(s)	TVO	Georgia Power	ENEC	Rosatom	EDF	EDF, UK Gov., TBD	Hungarian Gov.	ČEZ
Financing model	Mankala principle	Construction cost recovery, loan guarantee	PPA, government loan and guarantee	PPA, inter-governmental agreement	Contract for difference (CfD)	Regulated asset base (RAB)	Inter-governmental agreement	PPA, government loan
Debt-to-equity ratio	75:25	0:100	80:20	n/a	0:100	TBD	80:20	98:2 (expected)

Source : NEA (2024a), *Nuclear Financing: Effective Frameworks and Strategies for Financing Nuclear New Build*, OECD Publishing, Paris, www.oecd-neo.org/financing2024.

Figure 7: New build financing case studies



Source : NEA (2024a), Nuclear Financing: Effective Frameworks and Strategies for Financing Nuclear New Build, OECD Publishing, Paris, www.oecd-nea.org/financing2024.

Four models emerge from case studies of nuclear new build

REGULATED REVENUES

Akkuyu, Barakah, Dukovany 5, and Hinkley Point C are projects whose financing is underpinned primarily by mechanisms to regulate revenues through power purchase agreements (for the first three projects) or a contract for difference (for the fourth project).

COST RECOVERY REGULATION

Vogtle 3&4 and Sizewell C are based on specific regulated frameworks for cost recovery. Vogtle 3&4 are financed primarily under a construction costs recovery regulation. Sizewell C is expected to implement a Regulated Asset Base (RAB) model.

CO-OPERATIVE MODEL

Olkiluoto 3 in Finland is based on the Mankala model, whereby the power utility sells the electricity it produces to its shareholders at production costs.

VENDOR FINANCING

For the Paks II project in Hungary, the financing framework relies primarily on vendor financing, with debt financing from the vendor country, Russia, covering 80% of the financing needs.

SMR finance: Key findings

Key findings on financing SMRs from *The NEA Small Modular Reactor Dashboard: Second Edition*

Of 98 SMR designs reviewed, only 63 have human and financial resources allocated to them, while the remainder are currently paper reactors or cancelled. Outside those 63 under development, 11 have their first-of-a-kind (FOAK) reactors fully financed and only one shows progress towards financing an Nth-of-a-kind (NOAK) deployment.

Non-OECD countries continue to lead

While the 12 financed designs (11 FOAK plus one NOAK) represent positive progress, much to date has been outside of OECD countries.

The NOAK reactor is Russian (RITM-200S) and of the 11 FOAK that have secured financing, three are Russian SMRs (KLT-40S, BREST-OD-300 and RITM-200N), three are Chinese (HTR-PM, ACP100 and ACPR50S), one is a US Department of Defence SMR (Project Pele), one is a US demonstration reactor (Hermes), one is a Japanese research reactor (HTTR); another is Argentina's CAREM, a PWR 25 MW prototype.

There is only one example of an OECD commercial SMR deployment, the BWRX-300 at Darlington, Ontario, that presents a model that could be replicated commercially more widely in OECD markets. This project is notable for its diverse financing sources that draw from private sector equity investments, public grants, loan guarantees, and measures to recoup costs from the rate base.

Learn more about the report on page 27 or follow the QR code.



Also coming in Q4, 2024:

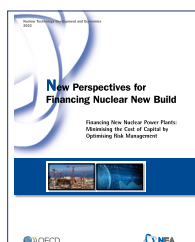
NEA Report: *Financing, Market Design and Project Management in Nuclear New Build*

New report covers financing, market design and project management in nuclear new build.

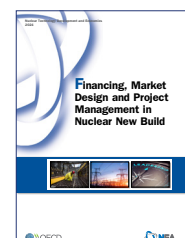
An earlier report *New Perspectives for Financing Nuclear New Build. Financing New Nuclear Power Plants: Minimising the Cost of Capital by Optimising Risk Management* (NEA, 2022b),

showed how optimising management of risks that arise during the preparation, construction and operation of a new nuclear power plant affects its capital cost.

This second report identifies forms of financing, market design and project management (and their interactions) for new, large-scale nuclear power plants and highlights opportunities from emerging industrial policies internationally. It will offer concrete proposals and a checklist to guide financing decisions.



Read the 2022 and 2024 reports



Exclusion of nuclear energy projects in international development finance

Added roadblocks for low and middle income countries

The World Bank's present exclusion of nuclear energy from financing support works actively against the imperatives of energy access in low and middle income countries. Beyond denying access to World Bank financial instruments, the exclusion has cascading impacts on international development finance and private lending more broadly.

Institutional impacts

All international financial institutions but one (the European Investment Bank, which has not financed nuclear new build projects since 1987) either formally exclude, or omit nuclear energy entirely from their lists of eligible projects. Additional policy impacts of the exclusion include:

Exclusion of nuclear energy from policy advice and support for capacity building under the World Bank development finance instruments. This inhibits emerging a country's ability to consider the potential of nuclear energy to contribute to their energy and climate strategies.

Direct influence on the availability of private financing due to the influence of the World Bank Group in supporting public-private partnerships for infrastructure projects in emerging countries. This carries cascading impacts considering the traditional alignment MDBs, IFIs, and private lenders to join with each as project sponsors as part of risk mitigation strategies and capital raising efforts.

Indirect influence on the availability of private financing through international taxonomies that define uniform criteria for determining whether an economic activity qualifies as "sustainable". This leads to additional impacts on additional asset classes, such as the issuance of climate and green bonds. The normative role of the World Bank on climate finance is expected to increase in the coming years as the Bank moves forward with its Approach to Paris Alignment. This will have a further impact on climate finance more broadly as many organisations continue to be voluntary "policy takers" from the World Bank, even when not required by statute.

Competitive disadvantage for nuclear suppliers in OECD countries. Exporters continue to lose ground to Chinese and Russian build-own-operate (BOO) export models with Russia's Rosatom, an active nuclear exporter with projects in Bangladesh, Egypt, Hungary, India and Türkiye, and the China's CGN and CNNC active in Argentina and Pakistan. Both countries are increasingly active across Africa and South-East Asia. The advent of small modular reactors (SMR) in emerging economies will likely serve to further highlight the distortive impacts of the exclusion of nuclear energy in international development finance as countries move forward with technology choices for nuclear new builds.

A call to action

In December 2023, more than 20 countries at the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) issued a declaration on tripling nuclear energy, specifically calling on "...shareholders of the World Bank, international financial institutions (IFIs), and multinational development banks (MDBs) to encourage the inclusion of nuclear energy in energy lending policies".

These countries called on multinational development banks and international financial institutions to prioritise the inclusion of nuclear energy in green taxonomies and lending policies.

Supply Chain Readiness



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INSIGHT

Healthy nuclear energy ecosystems create a virtuous circle for supply chain management

Like any organism, supply chains thrive when they have a balanced diet of the right ingredients and a nurturing environment

The three strategic priorities, financing, supply chain and talent, identified at *Roadmaps to New Nuclear 2023* share a symbiotic relationship. For each, the greatest likelihood to attract the right resources is dependent on the health of the other two.

In the case of supply chain, financing mechanisms and highly skilled, plentiful talent are feed stock that will attract and nourish businesses, inclining them to choose investment in the nuclear energy sector over alternative opportunities.

Public policy is another feed source to the supply chain. When countries create an imbalance through policies that favour tax credits and funding incentives to non-nuclear low-carbon options, especially in absence of a price on carbon, the predictable effect is a chill on businesses willing to risk investment in nuclear energy enterprise.

Until recently in some jurisdictions this specific scenario of price imbalances resulted in a moratorium on new build and refurbishment, in practice if not policy, and even a shuttering of nuclear energy assets, including high performers. Where once that may have been considered merely a justified business decision, the public interest consequences are much clearer today.

In other jurisdictions, neglect of social licence created the same result. A shift in political winds driven by grassroots sentiment can set back years of progress in nuclear energy programmes, and, with it, supply chain development.

Political winds have shifted again in nuclear energy's favour. This was precipitated in large part by the combination of climate change and a surge in energy demand, as well as renewed concerns about energy security, torquing the need for reliable low-carbon energy. But, due to past policies, in some jurisdictions, nuclear energy's ability to answer the call is hampered by the deterioration of supply chains. New networks need to form and ramp up. As importantly, knowledge transfer needs to be re-established.

Where there is not evidence of a robust supply chain to point to, it also becomes more difficult to pass the litmus test for investment and financing.

The challenge is not only for new builds. When supply chains are left to atrophy, the ability to procure parts and maintain operations becomes more complex. Plant refurbishments increase in cost, further impacting the safety, efficiency and affordability necessary to earn the political capital necessary for the nuclear energy programme.

Fortunately, there are solutions to these challenges. In jurisdictions that made conscious decisions to rebuild the supply chain there are success stories. Where efforts have been made to proactively build, train and nurture supply chains to the expectations of nuclear-grade safety and quality, the industry is thriving. In some countries, industry conferences are seeing record numbers of attendees as the list of interested suppliers grows. But it is not a numbers game alone.

Success requires a commitment to supply chain health that includes government and private sector investment in strategies that

create a talent pool for those businesses to draw from. As well, collaboration between design vendors, utilities and supply chain can ensure those unique requirements of safety and quality

assurance standards and monitoring are well understood at all supply tiers.

The application of robust standards, regulation and import/export controls, that ensure safety and quality without stifling the ability to get work done in a timely manner is required. And it requires leadership, including supportive government policies that help assure markets of a long-term predictable, consistent commitment to nuclear energy programmes.

In building and nurturing a healthy supply chain ecosystem, the ultimate winners are ratepayers and citizens who benefit from energy that safely, affordably and effectively keeps the air free of smog, helps cool the planet, and powers the potential for economic prosperity.

Financing, supply chain and talent share a symbiotic relationship. Where there is not evidence of a robust supply chain, it becomes more difficult to pass the litmus test for investment and financing.

A new world supply chain

**The world is facing two unprecedented types of change:
Technological and climate.**

The first may save the world from the second.

Historically, the nuclear industry has required diverse, highly skilled and sometimes specialised businesses across many disciplines of its supply chain in sectors ranging from mining, engineering, construction, operations and waste management. These businesses ensure safe, effective and affordable end-to-end nuclear energy programme management.

This remains true. But in addition, today, the demands, and necessary diversification, within the supply chain are increasingly complex. To meet the speed and scale of need for low-carbon energy requires a significant disruption to the contemporary business model. Innovation needs to be harnessed to hit the right price points for affordable energy, to strengthen efficiency in production capacity and to develop, deploy and construct on a vastly accelerated timeline.

Where once design diversity meant different technologies of similarly sized and functioning nuclear plants, today it means diverse design specifications for different purposes, sizes, geographies and even operating models.

Advanced manufacturing, artificial intelligence, robotics, data management, additive (3D) manufacturing and other digitalisation techniques are creating new areas of nuclear supply chain previously untapped, unregulated and even unconsidered as part of the nuclear energy landscape.

In today's geopolitical and global market ecosystem, disruption includes the necessity to manage cyber and physical security as well as counterfeit, fraudulent and suspect items. In a world where components of parts could be sourced from myriad locations, the global supply chain is in fact, not a chain at all but a labyrinth.

At a time when climate change is on the doorstep, urgent action is required. The nuclear energy sector, for some obvious reasons, as a highly regulated industry with the potential for high consequence events, has been slower than others to adapt to new technologies.

The inherent reasons for delayed adoption were further exacerbated by jurisdictional policies that put nuclear construction and long-term maintenance on the back burner, effectively cutting the oxygen supply to traditional supply chains and further dampening likelihood of innovation.

But things are changing, and in some jurisdictions, at speed.

With new policy and market signals, the industry is recognising the need and opportunity of disruption and market leaders are integrating the technologies into their operations and construction.

Without advancing technology, the world would be at an extreme disadvantage against meeting the challenges of climate change. The task, and the opportunity, is to harness it.

Boulogne-Billancourt, France, 5-6 March 2024



NEA Workshop on Nuclear Supply Chains

Assurance Today, Confidence Tomorrow

Suppliers play a critical role in the construction and operation of nuclear power plants. With a declining number of nuclear grade suppliers and a loss of skills in some regions, supply chain oversight raises specific challenges that require regulators to adopt new practices and increase co-operation. In this context, the NEA organised a workshop to address the latest challenges related to supply chain oversight practices and to examine potential risks that the nuclear industry will need to consider how to ensure safe and reliable nuclear operations. This two-day workshop was organised by the NEA Committee on Nuclear Regulatory Activities, which works to provide a mechanism for nuclear safety regulators and technical support organisations to share their knowledge in making policy and licensing decisions, as well as oversight practices related to the supply chain. The workshop brought together more than 130 participants from 22 countries.

Workshop participants highlighted the importance of collaboration among regulators, utilities, and suppliers in nuclear supply chains and took note that new technologies, such as SMRs, will bring new challenges. Discussions focused on readiness and strategic planning to meet potential challenges. Industry representatives and regulators also addressed opportunities and risks associated with small modular reactors. A session on quality delivery explored how industry standards (e.g., ISO 19443) could improve quality delivery and mitigate future burdens in a changing supply environment. The workshop participants also examined how developing a strong organisational culture could support safe and reliable delivery. Workshop participants shared perspectives and reached the following recommendations during the discussions:

- Non-compliance is often caused by complexity and (schedule) pressure, which could be mitigated through simplification and early involvement.
- Lack of trust and staff turnover are symptoms of a poor safety culture, highlighting the need for strong leadership, better communication and comprehensive training.

Key outcomes and lessons learnt will be shared in a forthcoming NEA report, marking a significant milestone in enhancing operational efficiency and resilience in the nuclear supply chain. The report will include critical messages and 12 recommendations to fortify the supply chain for regulators and key stakeholders – including licensees and suppliers.

Read more about the workshop using the QR code.



Taking the pulse of global supply chain readiness

NEA global survey of more than 20 countries reveals key needs and drivers for a robust nuclear energy supply chain

Understanding the readiness of the nuclear supply chains in OECD countries for nuclear new build is key to inform decisions by policymakers and industry leaders. In response to this need, the NEA carried out the first global survey of OECD nuclear supply chain readiness for nuclear new build. Working with 17 industry associations the NEA surveyed utilities and supply chain companies across more than 20 countries.

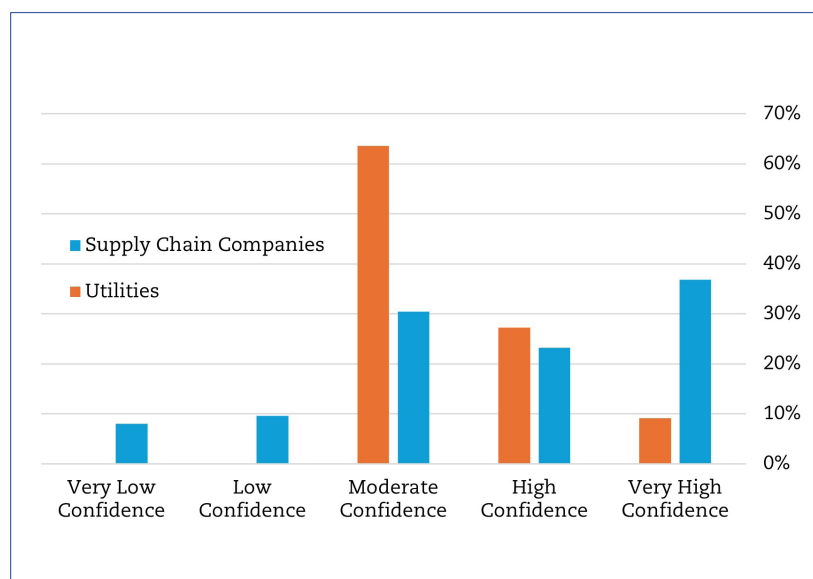
The survey focuses on various aspects of the nuclear supply chain, such as confidence in and visibility along the supply chain as a whole, bottlenecks and challenges to nuclear new build, priority areas for collaboration, as well as conditions for investment.

Industry associations engaged

Bulgarian Atomic Forum
Canadian Nuclear Association
CANDU Owners Group
French Nuclear Industry Association
Hungarian Nuclear Forum
Italian Nuclear Association
Japan Atomic Industrial Forum
Korea Atomic Industrial Forum
Nuclear Energy Institute

Nuclear Industry Association
Nucleareurope
Nucleair Nederland
Organization of Canadian Nuclear Industries
Slovenian Nuclear Forum
Spanish Nuclear Industry Forum
Swedish Atomic Forum
World Nuclear Association

Figure 8: Confidence in the supply chain to deliver on nuclear new build



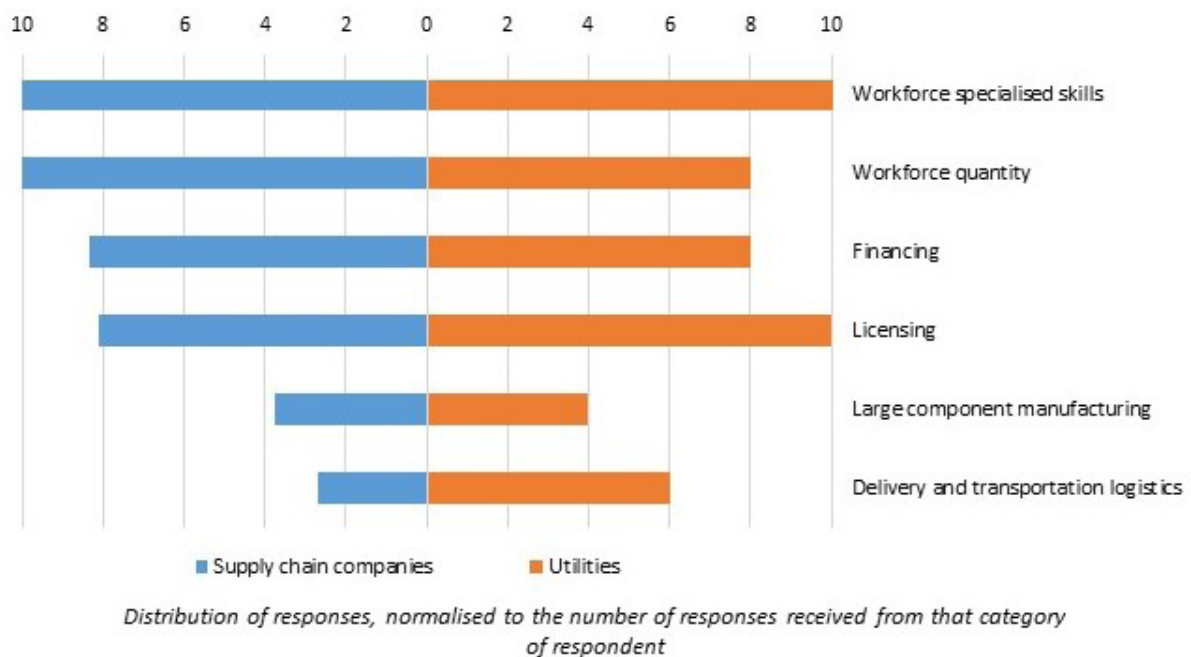
Key insight

Supply chain companies express higher degrees of confidence in the ability of the supply chain to deliver nuclear new build compared to utilities.

These results suggest that individual supply chain companies may be confident in their own abilities to deliver but, in aggregate, the utilities are less confident. This could be the result of different tolerances for risk or different degrees of visibility along the length of the supply chain.

This demonstrates strong agreement on the importance of enabling financing and strengthening the talent pipeline. It also reveals the greater exposure of utilities to regulatory risks.

Figure 9: Key domestic bottlenecks to nuclear new build projects according to utilities and supply chain companies

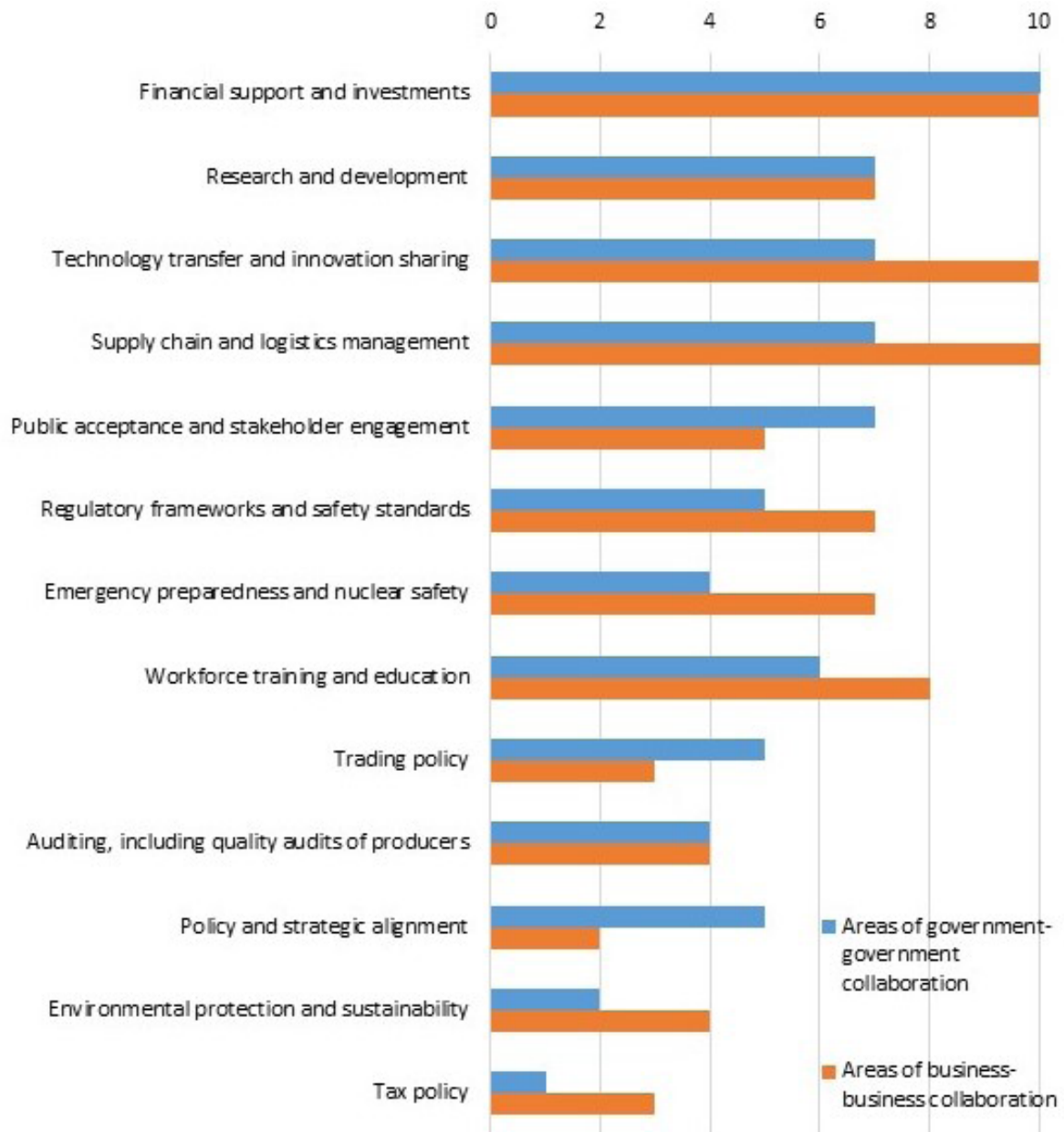


Key insights

(Graph above): The top three bottlenecks for both utilities and supply chain companies are workforce, financing, and licensing - although utilities rank licensing first.

(Graph at right): The top three priorities identified by utilities for government-to-government collaboration are financial support and investment, research and development, and technology transfer and innovation sharing, and for business-business collaboration are financial support and investments, supply chain and logistics management, and research and development.

Figure 10: Utilities' perspectives - Priorities for government-government and business-business collaboration



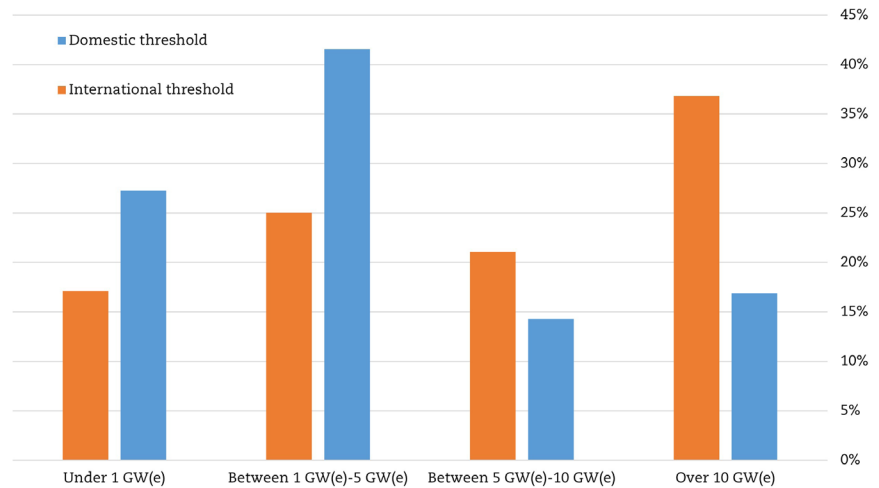
Distribution of responses, normalised to the number of responses received from that category of respondent

These survey results reconfirm the importance of enabling financial frameworks as a top priority for both government-government and business-business collaboration. Technology transfer and innovation sharing as well as supply chain and logistics management are identified as top priorities for business-business collaboration suggesting that these areas are seen as strong determinants of success in nuclear new build.

Figure 11: Supply chain companies' perspectives: What threshold of anticipated growth in the nuclear sector is necessary for significant supply chain capacity investment?

Key insight

The threshold for supply chain companies to invest in expanding their capacities is higher if the demand comes from the international market instead of the domestic market.



A stronger demand signal, potentially corresponding to a more robust order book, is required from the international market to catalyse investment in the supply chain. This suggests that supply chain companies are more confident in domestic announcements and projections for nuclear new build. It further suggests that supply chain companies may be less confident about their ability to compete on the international market.

Competition and collaboration are necessary to move forward

Competition is an important driver of efficiency in global markets for nuclear new build. Nevertheless, there are important areas where greater co-operation is needed amongst governments and industry to enable the supply chain to meet growing demand, in particular:

1. Enabling financial frameworks
2. Greater visibility up and down supply chains
3. Supporting and de-risking domestic supply chain companies connecting to international markets
4. Strengthening the talent pipeline.

Fuel supply update

The NEA has several resources to support decision makers with data and projections on the nuclear energy fuel supply chain.

Uranium resources, production and demand

The “Red Book” is a long-trusted source for the status of the global uranium market.

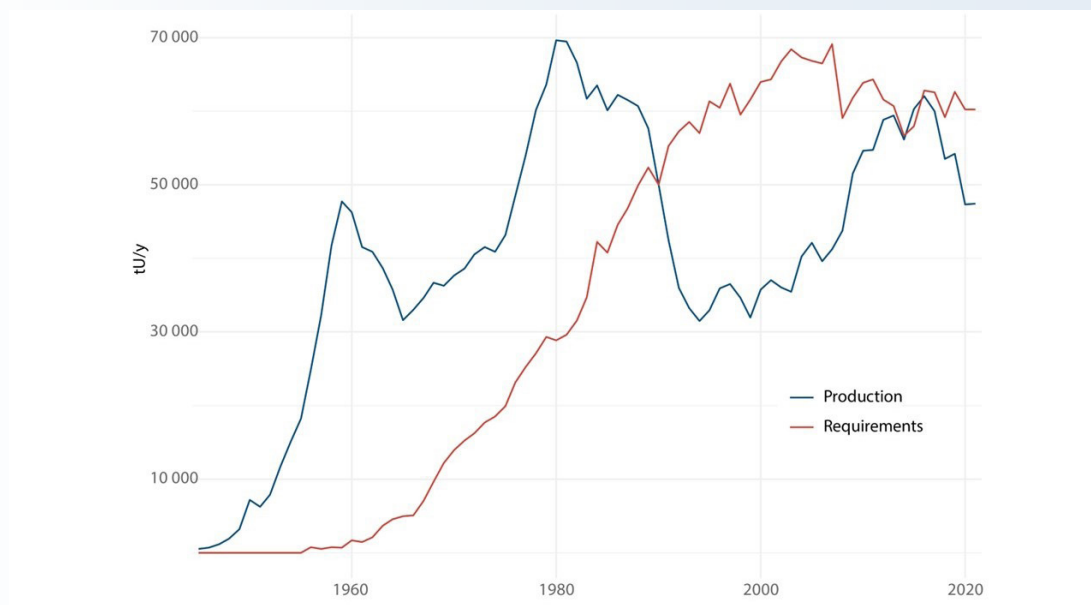
With 29 editions published between 1965 and 2024, the joint NEA-IAEA report *Uranium Resources, Production and Demand*, commonly known as the “Red Book”, is a trusted source of uranium market data and analysis. The Red Book compiles official government information from over 50 countries, presenting comprehensive data and analysis.

The 2022 edition of the Red Book concluded that sufficient uranium resources exist to support ongoing nuclear energy use and significant growth in nuclear capacity for electricity generation and other uses in the long term, but also emphasised that enabling frameworks for exploration, mining and transport are necessary.

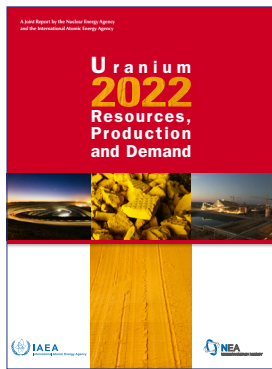
Key data from the 2022 Red Book:

- Global uranium mine production decreased in the years leading up to 2022 due to a depressed global uranium market.
- World nuclear capacity expected to rise as global energy demand increases, with East Asia projected to have the largest capacity by 2040.
- Global identified recoverable uranium resources, in the highest cost category (<USD 260/kgU), totaled 7 917 500 tU.

Figure 12: Global uranium production and requirements (1950-present)



Source: NEA (2023a), *Uranium 2022: Resources, Production and Demand*,
www.oecd-neo.org/uranium-22.



With the exception of Canada, all nations with plans to expand nuclear power presently depend on imported natural uranium. As Figure 13, below shows, there is a clear distinction between major uranium producing and consuming countries.

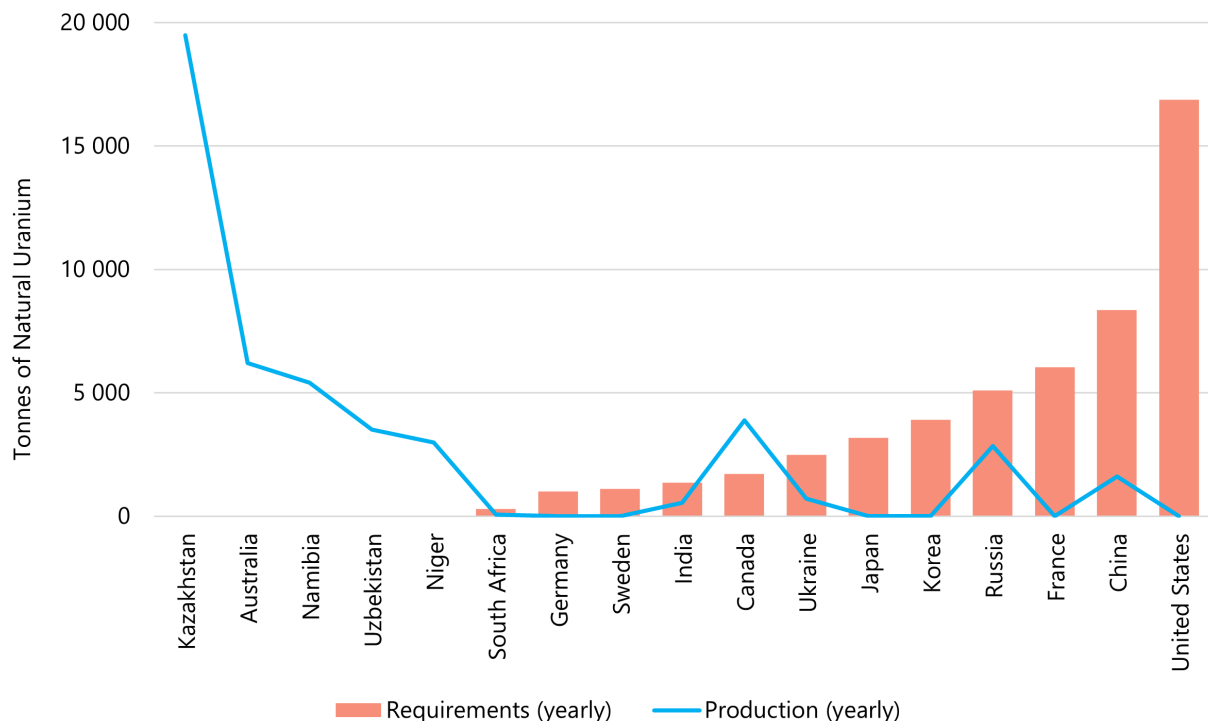
Figure 13 also highlights how, notably, most major uranium producers do not rely on nuclear energy themselves. This establishes a fundamental geographical reality: production of uranium is, in general, located in different locations far from where it will be consumed. Consequently, the international trade of uranium is an essential dimension of the uranium market. International shipping requirements and transfers to international ports are, for this reason, also consistently a matter of strategic interest.

In 2023 and 2024, the world witnessed a shift in many countries that was driven by the need for reliable energy sources amid growing geopolitical uncertainty and the urgency of addressing climate change. The 2024 Red Book (NEA, forthcoming) will detail the impact of these developments on uranium demand and supply and project nuclear production and reactor requirements through 2050.



Read the full 2022 Red Book at the QR code.

Figure 13: Uranium production and requirements in 2021 by country



Source: NEA, (2023a), Uranium 2022: Resources, Production and Demand, www.oecd-neo.org/uranium-22.

NEA Report – *High-Assay Low-Enriched Uranium (HALEU): Drivers, Implications and Security of Supply*

To be launched at Roadmaps to New Nuclear 2024

Many of the current SMR concepts that incorporate advanced nuclear technology, particularly Generation IV technologies, propose to use high-assay low-enriched uranium (HALEU), which is defined as enriched uranium with a proportion of the fissile isotope uranium-235 (U-235) that is higher than current commercial fuel but below 20%. Securing a stable fuel supply for advanced nuclear technologies is a significant yet often underestimated challenge that has emerged as a strategic priority.

Securing a stable fuel supply for advanced nuclear technologies is a significant yet often underestimated challenge that has emerged as a strategic priority.

Up to and including 2023, there was no commercial supply of HALEU from providers in OECD countries. Some limited commercial supply began being produced in 2024. In some countries, there is another short-term method for producing HALEU fuels: down-blending existing HEU stocks in countries where they are available.

The nuclear energy industry has historically operated with commercial enrichment of up to 5%, with the associated industrial supply chain and the legal and regulatory frameworks designed accordingly. Moving to higher than 5% enrichment will have implications along the entire fuel cycle, from uranium mining, conversion and enrichment markets, as well as fuel cycle strategies, transportation and infrastructure, and management of the back end of the fuel cycle. These implications are even more pronounced if the enrichment levels are above 10%.

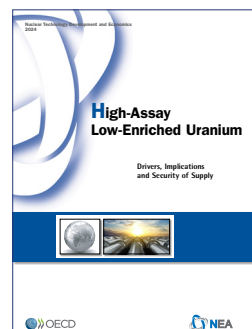
This new report by NEA examines these issues and offers an understanding of the

role and implications of HALEU. To support policymakers, the report:

- Identifies the advantages and challenges associated with HALEU fuel adoption;
- Fosters a strategic vision about the role of HALEU in achieving energy priorities, optimising nuclear power operations from a fuel-cycle perspective, ensuring safety and security, and addressing environmental concerns, including resource utilisation and final waste considerations; and
- Recommends areas for future consideration to assist policymakers looking to facilitate the emergence of a HALEU-based and/or HALEU-ready fuel cycle, including with respect to research and development support, regulatory frameworks, international collaboration and public engagement.

Tripling nuclear target has significant implications for fuel requirements

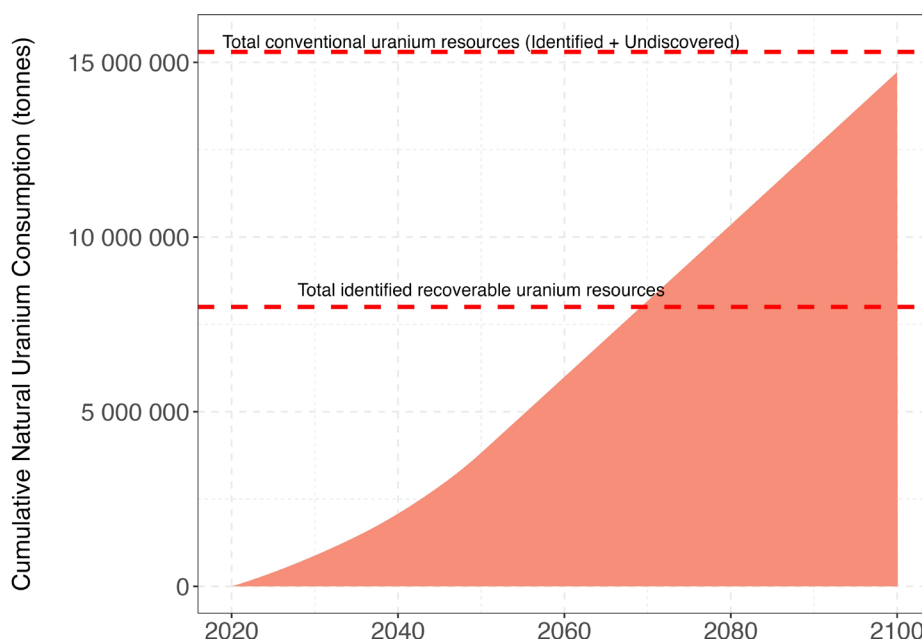
One key finding of the report is that tripling global nuclear energy by 2050, through a combination of refurbishments and long term operations of existing reactors, new builds of large scale nuclear power plants that utilise mainly low-enriched uranium (LEU) fuels, plus deployment of Generation IV reactors and SMRs including some using HALEU fuels, will have significant implications on requirements for the front end of the fuel cycle, transportation and infrastructure requirements, and the back end of the fuel cycle.



Read the report:



Figure 14: Cumulative natural uranium requirements to support tripling nuclear energy by 2050



Source: NEA, (2023a), Uranium 2022: Resources, Production and Demand, www.oecd-neo.org/uranium-22

With a once-through fuel cycle, currently identified recoverable uranium resources would be fully consumed by 2070, and conventional uranium resources (identified and undiscovered) would be fully consumed by 2100. Demand for natural uranium would exceed 200 000 tonnes per year by 2050. This would necessitate significant investment in exploration for new uranium resources, optimal use of secondary resources of uranium, as well as consideration of fuel recycle options.

Enrichment and conversion services, production and demand

NEA “Orange Book” to inform investments and ensure secure and resilient nuclear fuel supply chains.

Looking beyond uranium mineral markets, which is the primary focus of the Joint NEA-IAEA Red Book, the NEA is preparing to launch a new publication series starting in 2025 taking stock of supply and demand for fuel cycle services, with a focus on enrichment and

conversion. The “Orange Book” will integrate national and regional data to create a clear picture of existing and projected nuclear fuel supply chains, identifying risks and vulnerabilities, to support decision-makers seeking to guide investments and ensure secure and resilient nuclear fuel supply chains.

Leveraging the NEA’s unique access to data and insights about emerging global markets for small modular reactors and large scale nuclear new builds, the Orange Book will present demand scenarios for nuclear fuel and fuel services, with a focus on the enrichment and conversion services required to produce LEU and HALEU fuels.

Supply and demand projections will be complemented with insights for policymakers and private sector decision-makers to support the development of the necessary capacities in the front end of the fuel cycle for countries to succeed in their plans for nuclear new builds.

Talent pipeline



Attract, train and retain: The nuclear energy industry's greatest growth challenge may not be technical at all

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Spotlight feature: Women in the nuclear workforce

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NEA training and education activities

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Attract, train and retain: The nuclear energy industry's greatest growth challenge may not be technical at all

Ask any nuclear energy sector leader and they will tell you that even more than the technology business, they are in the people business. People, highly skilled, often specialised, and with a large training investment are the lifeblood of the nuclear energy industry. Even as the industry ramps up SMRs, with less requirement for on-site staff in operation, an entire new set of skills and qualifications will be needed across the value chain and for mass, global construction.

That new construction need is coming at a time when companies and jurisdictions will be competing for nuclear talent. They'll also be competing with other sectors, given the level of broader multi-sectoral transition activity required to achieve net zero by 2050.

There is a time for competition and a time for collaboration. While companies across the sector may compete to attract talent to individual projects and companies, collectively, there is an imperative to collaborate in building the frameworks and systems that broaden and nurture the pool everyone must draw from.

The need to scale nuclear energy (and every other decarbonising infrastructure) falls at precisely the time of declining birth rates, baby boomer retirements, and a wide range of attractive and diverse career choices.

Consequently, the industry needs a shift in how it thinks about its talent pipeline. People to fill the jobs and deliver the services are not just the product; they're the audience. Attracting them means courting them. In a world of mass communication and shifting educational pathways, the job of effectively attracting, training and retaining skilled people is another area where the industry must create new models.



People to fill the jobs and deliver the services are not just the product; they're the audience.

Today's talent needs to start with the traditional knowledge and skillsets that have been the staple of the nuclear industry in science and technology. Cultivating an interest in science, technology, engineering and mathematics (STEM) and then encouraging its application in nuclear energy remains a high priority. In addition, new plans are needed to attract people with new skillsets in data management, artificial intelligence, robotics, IT and cyber security, as well as advanced manufacturing trades, and specialised forms of engineering.

Expertise in finance and investment, engagement and communications, change and project management, and human resources among others will also be required.

Attracting the talent

“What do you want to be when you grow up?” It is an age-old question that typically spurred answers like doctor, teacher, farmer or veterinarian. Depending on culture, the answers may also have varied by gender.

Today, ‘game developer’ may be higher on the list than a generation ago, but chances are that nuclear scientist, engineer or welder may not have risen up in the ranking much. It is not entirely surprising, as children may find inspiration in what they see within their environment.

And yet, this is just the kind of visibility required to build a healthy, long-term talent pipeline. The traditional education route to engineering, science and trade jobs is one of the primary feeder channels into the nuclear industry. The earlier young people understand the opportunities a career in nuclear energy can offer, the more likely they are to consider applying their engineering or science degree or their welding or electrical skills to it.

The NEA, working with its members, has developed several programmes to raise visibility and access to education for youth, to increase visibility and access to the concepts, knowledge and skills that will broaden awareness and strengthen the youths’ capacity to pursue the opportunities of a nuclear energy career. Read more about these initiatives, starting on page 55.

A people-centred transition

It's also critical to consider other pipelines to talent. As a shift to low-carbon energy displaces jobs in other forms of energy and as technology advancements eliminate other types of jobs, there will be people looking for opportunities to retrain and retool their skills and to apply them in new careers.

Today, workers can expect to have multiple jobs over the span of their career. In an industry with well-established knowledge and training frameworks, through both post-secondary institution partnerships and within industry, this is an area where nuclear energy has an advantage. The well-developed training programmes provide an opportunity to take mid-career workers and provide nuclear sector wrap-around training and upskilling that will allow them to turn existing education and experience into a new career in nuclear energy.

Read more about NEA initiatives to provide reskilling and upskilling to workers through multiple pathways on page 51.

Leaning into diversity to grow the talent pool

The traditional energy sector, including nuclear, is still comprised of more than 80% men. Many of the work environments and systems have been geared to male workers, given their predominance in the sector. To ensure women can join the diverse areas of the workforce fully and successfully, from the trades to the boardroom, will require rethinking the systems in place to not only recruit but to retain women.

The NEA has been working on initiatives to provide access to nuclear energy careers to women. Read more about these initiatives on page 50.



A checklist to attract and train modern knowledge workers

Strategies to attract talent	Strategies to retain talent
✓ Improved communication, including via better use of social media, more role models ✓ Engagement with upper secondary schools ✓ Increased political acceptance ✓ Clear national roadmaps, systems and resources for training and workforce development ✓ Comprehensive, innovative and multidisciplinary curricula ✓ Improved gender balance and inclusiveness ✓ International collaboration and networking	✓ Enhanced partnerships with industry: • expanded traineeships, internships, scholarships, summer programmes, job fairs, etc. ✓ Innovative curricula adapted to future needs, project-based education, hands-on training ✓ University support: • sufficient faculty to replace vacant posts due to retirements and address growing needs • modernised universities' infrastructure and equipment • co-operation with other universities in a country and in other countries • flexible education schemes to make cross-training and career transitions to nuclear easier ✓ More efficient nuclear knowledge management, cross-organisational and international co-operation ✓ Students' access to experimental infrastructure and career development, including internationally ✓ Flexible education schemes to make cross-training and career transitions to nuclear easier

Spotlight feature

Women in the nuclear workforce

Growth in nuclear energy capacity to meet global demand relies on growing the workforce capacity with it

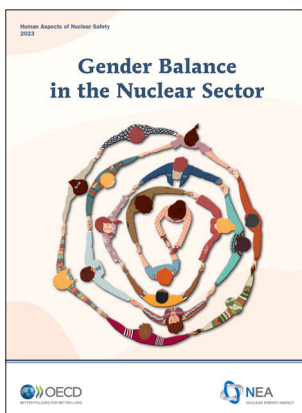


The nuclear sector will need to grow and diversify its workforce to meet projections for new nuclear capacity additions, a difficult task without recruiting women. A NEA report *Gender Balance in the Nuclear Sector* provides the first publicly available international data on gender balance in the nuclear sector and is based on data collected from over 8 000 women in the nuclear workforce in 32 countries, as well as human resources data from 96 nuclear organisations in 17 countries.

Released on 8 March 2023 to mark International Women's Day,

the report reveals that nearly half the women surveyed in the nuclear energy sector have experienced or heard accounts of gender bias and sexual harassment at work. The publication also highlights that women are paid less and feel as though they lack female role models, which makes it harder for the sector to attract more female talent. Visibility and numbers remain low with women making up only 24.9% of the nuclear sector workforce in NEA countries at the time of publication.

This NEA report led to the formulation of a new OECD Recommendation in 2023 to help governments to attract more women into the nuclear sector and develop more female leaders, ensuring its sustainability and contribution to net zero.



This led to the formulation of new OECD Recommendation in 2023 to help governments to attract more women into the nuclear sector and develop more female leaders, ensuring its sustainability and contribution to net zero. The 38 OECD countries agreed upon a new, focused approach to improve the gender balance in the nuclear sector, calling on national authorities and the industry to take action to increase the representation of women in the sector and enhance their contributions –especially in science, technology, engineering and mathematics (STEM) roles and leadership positions.

Read the full report:



NEA creates Global Forum on Nuclear Education, Science, Technology and Policy



The NEA established a Global Forum on Nuclear Education, Science, Technology and Policy on 28 January 2021 in partnership with academia to provide a platform for sustained co-operation amongst academic institutions, policymakers and key stakeholders in the nuclear energy sector and civil society. This first-ever international standing body of nuclear science and technology academics is governed by the Council of Advisors comprised of representatives from NEA member countries' universities. The work of the Global Forum on Nuclear Education, Science, Technology and Policy is focused on the following areas:

- Achieving gender equity in the nuclear engineering and technology as well as in academic workforces
- Building the future of nuclear engineering education
- Rethinking the relationship between nuclear energy and society
- Fostering innovations in the nuclear sector
- Re-establishing nuclear law education programmes
- Building a pipeline of STEM professionals
- Developing an international curriculum for the back end of the nuclear fuel cycle.

As part of this framework, NEA has developed several initiatives that include the following three workshop series:

Rising Stars workshops

Launched in 2023, the Rising Stars workshops aim to increase gender diversity in the nuclear sector by helping integrate female rising stars into the global nuclear community. The annual multi-day workshop is designed for female undergraduate, graduate and postgraduates in the nuclear and nuclear-adjacent fields and offers the opportunity to attend career panel sessions with inspiring female leaders, present their own work and network with international peers.

National nuclear education workshops

National nuclear education workshops examine how to enhance the nuclear education and workforce development within a specific country. Successful workshops have so far taken place in 2022-2023 in Japan, Korea and Romania. These events have brought together stakeholders from the governmental, academic and industrial sectors to discuss a particular issue related to nuclear education and produced a clear set of actions to address the challenges identified.

Additionally, NEA offers a broad suite of online and in-person courses and initiatives for professionals, researchers and university and secondary school students.

International mentoring workshops

The NEA has organised mentoring workshops that enable open dialogue and discussion between highly accomplished scientists and engineers and young women who are at an important decision point for their futures. These workshops encourage female students' interest in STEM studies and nuclear careers. Since 2017, the NEA has reached over 500 high-school and university students in multiple countries.

International School of Nuclear Law (ISNL)

Established in 2001 by the NEA in co-operation with the University of Montpellier, ISNL is designed to provide participants with a comprehensive understanding of the interrelated legal issues pertinent to the safe, efficient and secure use of nuclear energy. The course is designed for professionals and graduate students in a relevant discipline.

International Nuclear Law Essentials (INLE)

The INLE five-day course addresses the needs and interests of lawyers in government or the private sector. The curriculum is also designed to interest scientists, engineers, policymakers, managers and other professionals working in the nuclear field.

Fundamentals of International Nuclear Law (FINL)

The NEA has designed the course to provide a high-level, introductory review of the central aspects of international nuclear law in a condensed online programme of three hours per day. The course is designed for both professionals and graduate students.

International Radiological Protection School (IRPS)

The IRPS, organised in co-operation with the Swedish regulator, the Swedish Radiation Safety Authority (SSM), and Stockholm University, addresses developments in radiological protection recommendations, standards and related implementation and practices. It includes presentations and illustrative case study discussions to explore the practical aspects of implementing radiological protection.

Nuclear Risk Communication Training Course (RCTC)

The RCTC aims to improve the effectiveness of risk communication to enhance public understanding. Over four days, participants interact with communication experts and technical professionals working in nuclear energy organisations to learn the fundamentals of risk communication.

International School on Simulation of Nuclear Reactor Systems (SINUS)

SINUS provides training in multiphysics modelling and simulation and associated validation, verification and uncertainty qualification. The course leverages the comprehensive expertise of the NEA Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems and the software distribution capabilities of the NEA Data Bank. Participants meet online and in person for a dynamic, hands-on, self-paced program.

The NEA Data Bank Computer Program Service (CPS)

For more than 30 years, CPS courses have provided a unique opportunity to unite code users worldwide, facilitating computer program exchanges among users and with code developers. Online and in-person courses on the most widely used computer programs are organised year-round.

Transfer of Thermal-Hydraulic and Severe Accident Knowledge Gained Through CSNI Activities (THICKET)

Disseminating thermal-hydraulic and severe accident knowledge, competence, and experience acquired through CSNI activities during the last three decades to newcomers working in the area of nuclear installation safety and have entered the workforce among member countries recently as technical specialists.

NEA flagship initiatives

Three new NEA flagship initiatives turn goals into action for participating member countries

As described on page 13, the NEA continues to assist its member countries in maintaining and further developing their efforts toward new nuclear capacity. This work is being achieved through international co-operation to progress the scientific, technological, and legal bases required for a safe, environmentally sound, and economical use of nuclear energy for peaceful purposes. This includes a focus on everything from assessments of new supply chain needs and promoting an inclusive new generation of the nuclear workforce, to encouraging adequate regulation that accounts for the safe use of innovative reactor designs, advanced materials, and new accident-tolerant fuels.

1. Accelerating SMRs for Net Zero

Overview

The NEA launched Accelerating SMRs for Net Zero during the 28th Conference of Parties to the United Nations Framework Convention on Climate Change (COP28) hosted by the United Arab Emirates (UAE) in December 2023. Accelerating SMRs for Net Zero leverages NEA's network of industry leaders, government officials, researchers, and experts to establish a practical, solutions-oriented platform with a defined plan of work for collaboration and knowledge exchange to support decision-makers in maximising the full potential of SMRs. As a component of this effort, the NEA will host an annual Summit to bring together senior government officials and SMR executives to address key sector needs.

Background

Many NEA countries wish to keep pace with innovation in the private sector for the commercialisation of SMR designs and deployment opportunities, in support of decarbonisation. Keeping pace with private sector innovation on SMRs for power generation and industrial applications will require both government-to-government co-operation and public-private partnerships.

Significant international co-operation will be required to lay the groundwork for substantive progress in six core areas: licensing readiness, financing, supply chain, workforce development, fuel availability and spent fuel management. Harmonisation and strategic partnerships in these areas can help lower both costs and barriers to first-of-a-kind SMR deployment.

Beyond on-grid power to replace fossil fuel generation, market signals indicate the potential for significant SMR demand in hard-to-abate sectors: off-grid heat and power to replace diesel generators in remote regions for mining operations; high-temperature heat to replace fossil fuel cogeneration in heavy industries such as chemicals processing and potash production for the fertiliser industry; and marine propulsion to replace heavy-fuel oil for merchant shipping. Determining the suite of applicable SMR technologies, identifying the right enabling condition, and better understanding potential applications and markets can help accelerate the deployment of economy-wide SMR decarbonisation solutions.

Plan of Work

Accelerating SMRs for Net Zero's plan of work focuses on analyses, recommendations, and actions to help inform policy and investment decisions by governments, industry and the financial sector.

Plan of work areas include:

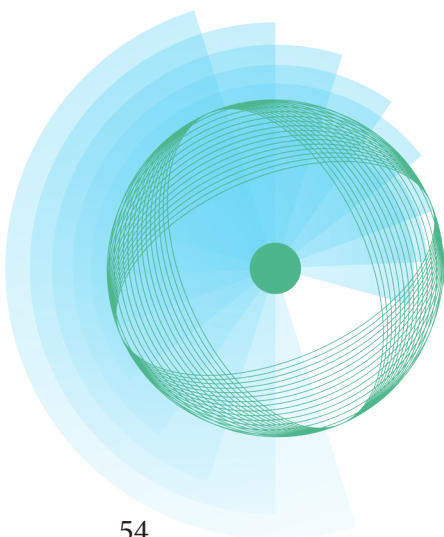
- System costs studies
- Market sizing
- Radioactive waste management and decommissioning
- Industrial applications
- International nuclear liability framework
- Nuclear science and advanced materials
- Opportunities for regulatory harmonisation
- Gap analyses
- SMR Dashboard
- Data sharing
- Outlook for nuclear fuel supply
- Nuclear safety demonstration and licensing of SMRs

Accelerating SMRs for Net Zero Summit, September 2024

Paired with Roadmaps to New Nuclear 2024, the first SMRs for Net Zero Summit will bring together senior officials and private sector executives to discuss technological impacts, potential financial support frameworks, and licensing and regulatory issues that can affect timely and cost-effective SMR deployment.

High-level discussions will be designed to identify and implement the industrial policies, regulatory readiness and leadership focus necessary for ensuring the success of SMR technologies. Summit goals include identifying key policy choices and decision points across the core areas of the work plan to support decision makers in industry and government in the following areas:

- Unlocking public and private financing for SMR innovation and commercialisation
- Strategies to ensure a secure supply of high-assay low-enriched uranium (HALEU) in volumes significant enough to meet a 2027 timeline for first movers
- Technological and market challenges associated with sector coupling
- Legal, logistical and regulatory challenges related to the mobility and transportability of SMRs
- New market opportunities with authoritative assessments of SMR power requirements, temperature ranges, and operational specifications to meet end use decision-making criteria and timelines.



2. Plan 2035:

Building a diverse, inclusive and gender-balanced workforce for the next nuclear energy era



Overview

The NEA is launching a new workforce development initiative, “Plan 2035” designed to enhance, accelerate, and build upon current NEA educational activities as part of the Global Forum on Nuclear Education, Science, Technology and Policy with early outreach to upper secondary schools.

Founded on the core pillars of diversity, inclusivity, and gender balance, the project seeks to open career pathways to good, well-paying jobs for youth across the socio-economic spectrum.

Engaging underrepresented communities in this effort provides a vehicle for workforce recruitment and a pathway to secure good, well-paying jobs supporting economic growth and prosperity. Plan 2035’s objectives include:

- Providing innovative and impactful strategies and programs to support member country efforts to enhance student participation in STEM fields and implement recommendations from NEA bodies on encouraging STEM education and improving gender balance.
- Accelerating existing NEA education and training activities that aim to address the future nuclear workforce needs in a strategic, structured, consistent and efficient manner.
- Offering educational tools, outreach materials and networking opportunities in the field of nuclear energy to students beginning from the upper secondary school level through to young professional career stages.
- Driving meaningful change and creating a workforce that reflects the diversity of the communities it serves in collaboration with stakeholders from across the public and private sectors.

Plan 2035 focuses on developing and disseminating educational materials through inquiry-based learning, technology integration, real-world case studies, and cross-disciplinary approaches. Beyond educational outreach, Plan 2035 will serve as a digital global platform for networking opportunities. Plan 2035 will seek to guide and support student pipelines originating at the upper secondary school level, through university and vocational school programmes to the young professional career stage.

Focused on activities to inspire, mentor and network, Plan 2035 will provide a comprehensive suite of resources and opportunities, including:

- **Mentorship programmes:** Connecting students with industry professionals and academics who can provide guidance, career advice and personal development support.
- **Internships and apprenticeships:** Partnering with leading companies and institutions to offer hands-on experience and practical training in various fields, ensuring students and young professionals gain valuable skills and insights.
- **Workshops and seminars:** Hosting regular online and in-person events featuring experts and leaders from diverse industries, focusing on emerging trends, skill development, and career planning.
- **Networking events:** Organising virtual and physical meetups, conferences and social events to foster connections among students, educators, industry professionals and alumni, creating a supportive community for knowledge sharing and collaboration.
- **Resource library:** Providing access to a vast collection of educational materials, including articles, research papers, tutorials and case studies to support continuous learning and professional growth.
- **Global collaboration:** Facilitating international partnerships and exchanges, allowing students to gain cross-cultural experiences and broaden their professional networks.
- **Alumni network:** Creating a robust alumni network to offer ongoing support, mentorship (such as career counselling, interview preparation resources), and networking opportunities for graduates as they progress in their careers.
- **NEA International Exchange Programme:** Building an international platform for young professionals from underrepresented communities to connect, share experiences and support each other's professional growth internationally.
- **Ambassadorships for diversity, inclusivity, and gender-balance:** Working with universities to develop international student exchange programmes and a group of "Ambassadors" for upper secondary school outreach activities. University mentors will show the students what they can achieve, using their personal histories as scientists and engineers and answering questions about their studies, careers and life. By promoting the core values of diversity, inclusivity, and gender-balance, Plan 2035 will leverage the NEA's networks and conduct additional outreach to universities in North America, Europe, and Asia.
- **The NEA Awards:** Establishing a nomination and selection process for an NEA Certificate of Excellence for outstanding dedication, achievement and commitment to nuclear training and education.

Spotlight feature

Rebranding nuclear energy: AtomExplorer travelling exhibit

Plan 2035's community outreach strategy will be designed around the AtomExplorer travelling exhibit. Transforming community centres, school auditoriums and university halls into immersive learning environments, the showcase will invite students and educators on an engaging journey through the fascinating world of nuclear energy.

From interactive exhibits exploring the science behind nuclear reactions to student displays, every showcase element will be meticulously crafted to captivate audiences and spark meaningful conversations.

From the basics of atomic structure to the marvels of nuclear fission and fusion, the exhibit will transform complex theories into accessible, immersive experiences. Visitors will journey through the rich history of nuclear energy — from the dawn of the nuclear age at Stagg Field in Chicago, Illinois in 1942 and the construction of the world's first nuclear reactor in Butte County, Idaho in 1951 to its pivotal role in shaping the present and future with power and non-power applications.

Cutting-edge, interactive displays showcasing innovative technologies and hands-on activities will offer a comprehensive understanding of nuclear science, emphasising its global impact on sustainable development and energy access. The exhibit will ultimately encourage students to see themselves as part of the next generation of nuclear professionals. The AtomExplorer exhibit will also double as a platform for students to present their science and art projects related to nuclear energy. This interactive element will highlight the creative potential of young minds and foster a sense of ownership and inspiration for the future of nuclear science.

Leveraging the NEA's existing activities in nuclear science and education

Through its Global Forum on Nuclear Education, Science, Technology and Policy, the NEA offers its Rising Stars Programme. This initiative welcomes female rising stars in science, technology, education and policy into the global nuclear community through annual multi-day workshops and other activities. Plan 2035 will leverage these networks and additional activities, such as the NEA High Level Group on Gender Balance, to develop educational and outreach materials for secondary school audiences.



INSPIRE

Engage and inform students about nuclear science and technology and related STEM careers

- Design the framework and content for the “AtomExplorer” – a travelling nuclear information and careers exhibit to be deployed around the world.
- Create an online platform to support all educational outreach resources.
- Provide a library of video lectures by NEA member country experts and other educational materials that can be easily accessed by schools and education providers.

Key partner organisations

- Young Generation Network
- WiN Global

MENTOR

Connect students and young professionals to mentors who serve as outstanding role models

- “Franchise” the NEA’s successful International Mentoring Workshops into a global platform to reach many more students.
- Launch the NEA Global Internship Programme.
- Expand the NEA Global Forum Rising Stars Programme.
- Expand other NEA training programmes and provide young professionals with scholarships.

Key partner organisations

- Global Forum on Nuclear Education, Science, Technology and Policy
- National governments, private sector and foundations

NETWORK

Provide targeted networking opportunities and build global platforms

- Use the NEA networks to build a global community of role models and educators.
- Create a networking platform for alumnae of the NEA Global Forum Rising Stars Programme, which welcomes female students in science, technology, education and policy through annual workshops and other activities.
- Engage students and educators in the NEA Global Forum initiatives, a network of experts in the nuclear energy sector generating and sharing ideas.

Key partner organisations

- Global Forum on Nuclear Education, Science, Technology and Policy
- Experts from NEA member countries

3. Our Common Journey

Advancing economic development and skills expansion in Africa

Overview

The NEA and the OECD Development Centre (DEV) are advancing a framework to support the advancement of economic development and skills expansion in Africa. This initiative focuses on employing NEA methodologies to foster co-operative frameworks among ministries, universities, and businesses. The initiative will highlight the potential economic benefits of nuclear projects, such as developing broadly applicable skills and businesses. This approach, an advantage of project models commonly used in the Global North, is fully complementary with the IAEA Milestones Approach, which promotes international collaboration to share best practices, expertise, and resources. The framework is also based on the principle that NEA member and African countries have a mutual interest in using nuclear technology to improve the quality of life and respond to climate change imperatives.

Why Our Common Journey?

Developing clean technologies in Africa is essential for sustainable development worldwide. Currently 43% of Africa's population lacks access to electricity and energy demand is predicted to more than double by 2040 (IEA, 2022). While at present, many African countries rely on fossil fuels for electricity production, deploying new clean and low-carbon energy sources represents a priority for governments across Africa to support sustainable industrial development and make progress in achieving the African Union's Agenda 2063 and the Sustainable Development Goals. Africa's sustainable development depends on combining diverse technologies according to the local context, identifying the different needs and capacities among African countries and regions, and investing in state-of-the-art technological developments.

These include a focus on technologies needed to enable sustainable development while meeting the global climate challenge—such as renewables, energy efficiency and nuclear energy. Many countries worldwide are turning to nuclear technologies as a component of their plans for sustainable development.

Like many OECD and NEA countries, African countries aim to develop nuclear energy in the coming years to provide plentiful, clean energy and spur the development of high technology skills, new businesses and investment. To build successful nuclear energy programmes, African countries will need to develop the necessary capacity, policy and regulatory frameworks to address the opportunities and responsibilities associated with nuclear energy development.

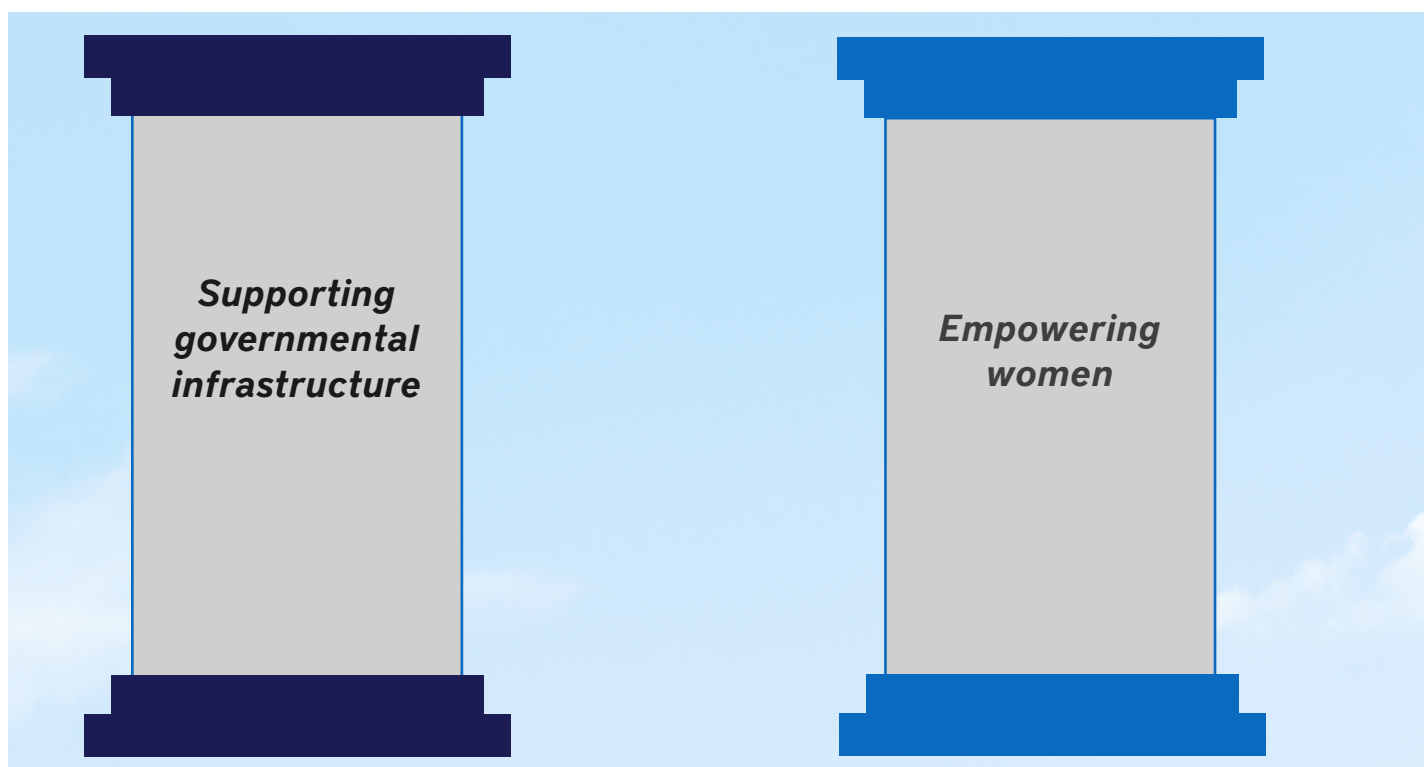


The *Common Journey* effort aims to help address these needs by establishing a policy dialogue platform for knowledge sharing and capacity building to ensure a safe, secure and gender-balanced nuclear deployment that supports Africa's sustainable economic development. In particular, this effort is designed to bring OECD practices for international co-operation and joint action to African nations interested in developing nuclear programmes by:

- Serving as a forum for sharing and analysing information among governments, universities, and businesses in interested African countries
- Creating mutually beneficial partnerships with relevant organisations in OECD and NEA countries
- Building technical skills to meet industrial and economic needs
- Facilitating communication with stakeholders and the public
- Supporting a diverse, inclusive and gender-balanced generation of experts.

This effort is designed to bring the approaches and expertise of bodies like the NEA to the support of development in Africa. The initiative is based on the principle that governments in the OECD, the NEA and Africa have a mutual interest in using nuclear technology to improve the quality of life for all people while saving the global environment.

Four pillars of the Common Journey initiative



SUPPORTING GOVERNMENTAL INFRASTRUCTURE

- Promoting open dialogue among government policy specialists, regulators and other stakeholders in the energy field
- Advising on key scientific, economic and legal development topics
- Support development of expertise in ministries and agencies to maximise the opportunities presented by nuclear development to spur capacity building and value chain development.

EMPOWERING WOMEN

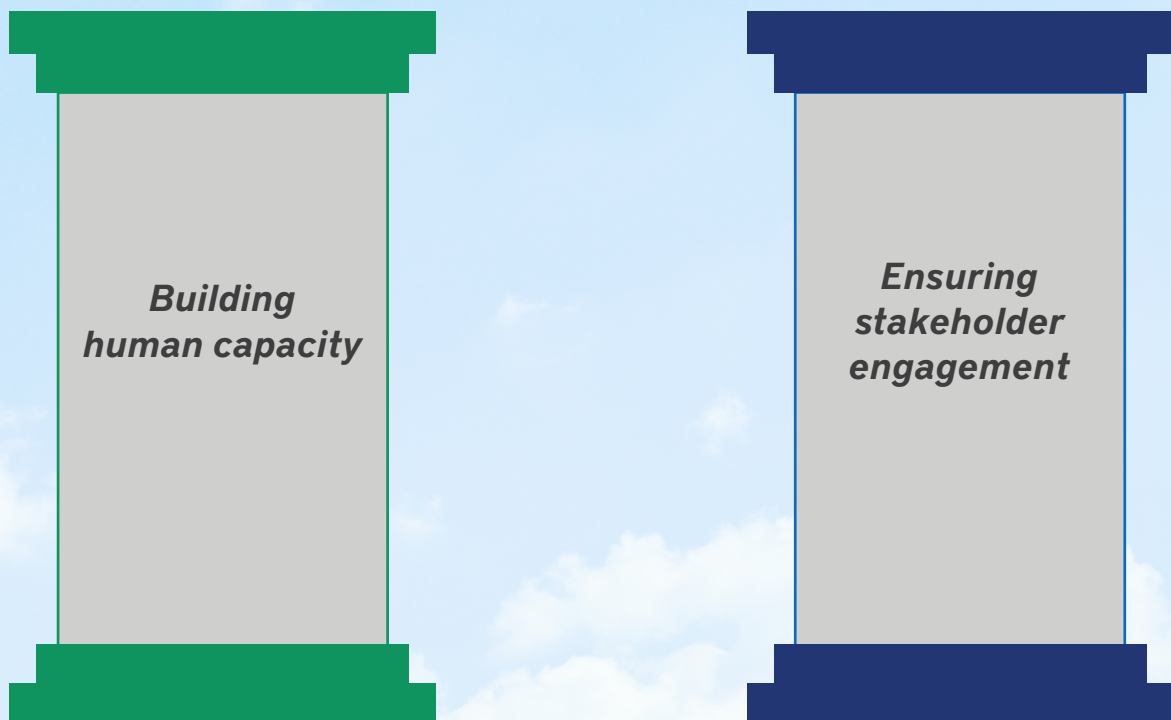
- Sharing insights and lessons learned on ways to achieve gender parity in nuclear institutions
- Creating pathways for women to take leadership roles and strengthening women's contributions in decision-making processes
- Raising awareness of the benefits of science and technology in economic development and the daily lives of women

BUILDING HUMAN CAPACITY

- Establishing collaborations within Africa to maximise investments, modelled on effective approaches used by the OECD and the NEA
- Building collaboration with universities from OECD countries in science, technology, research, and innovation
- Developing "Train the Trainer" programmes to support the expansion of essential skills.

ENSURING STAKEHOLDER ENGAGEMENT

- Disseminating information to build awareness of nuclear development across Africa
- Sharing useful experiences and approaches to involving stakeholders and the public in decisions
- Taking into account human and societal issues as well as concerns of the general public.



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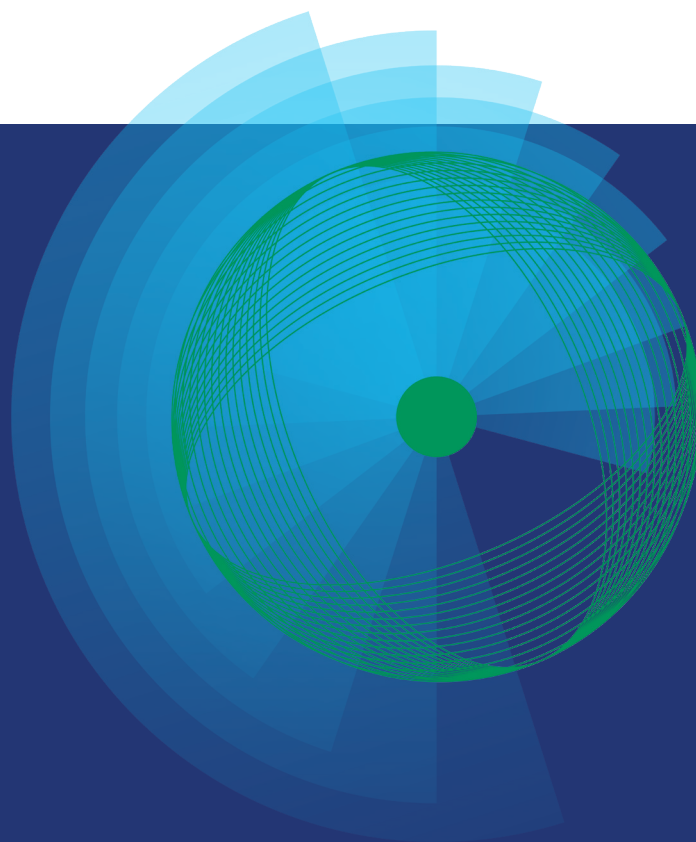


Government Offices of Sweden



**U.S. DEPARTMENT OF
ENERGY**

This *Roadmaps to New Nuclear: Brief for Ministers and CEOs* focuses on efforts to rebuild leadership and strengthen capacities for successful nuclear energy new build projects. Following on the work accomplished by delegates, including ministers and CEOs at the inaugural *Roadmaps to New Nuclear Conference 2023*, this brief provides a summary overview of identified strategic priorities and the actions taken since by the NEA. It sets the scene for discussions among this year's delegates to advance international collaboration, foster strategic partnerships, share best practices and learn from each other's experiences. The brief provides current data with insights from economic analyses and recommendations to inform policy and investment decisions. It sets out initiatives to enable the use of nuclear energy to deliver on climate and economic priorities more effectively during this crucial period of energy transition.



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