Nuclear Energy: The Future is Now

William D. Magwood, IV
Director-General
Nuclear Energy Agency

FGV Energia, 4 July 2024

The NEA: 34 Countries Seeking Excellence in Nuclear Safety, Technology, and Policy

- The premier international platform for cooperation in nuclear technology, policy, regulation, research, and education.
- 34 member countries + strategic partners (e.g., China and UAE).
- 8 standing committees and more than 80 working parties involving more than 3500 experts from around the world
- Global relationships with industry and universities.

Argentina	Australia	Austria	Belgium
Bulgaria	Canada	Czech Republic	Denmark
Finland	France	Germany	Greece
Hungary	Iceland	Ireland	Italy
Japan	Korea	Luxembourg	Mexico
Netherlands	Norway	Poland	Portugal
Romania	Russia	Slovak Republic	Slovenia
Spain	Sweden	Switzerland	Turkey
United Kingdom	United States		

NEA countries operate about 82% of the world's installed nuclear capacity

The NEA Committees Framework

NEA – Steering Committee for Nuclear Energy

- NEA High-level Group on Stakeholder Engagement, Trust, Transparency and Social Sciences (HLG-SET)
- NEA High-Level Group on Improving the Gender Balance in the Nuclear Sector (HLG-GB)

- **CNRA** – Committee on Nuclear Regulatory Activities
- **CSNI** – Committee on the Safety of Nuclear Installations
- **RWMC** – Radioactive Waste Management Committee
- **CDLM** – Committee on Decommissioning of Nuclear Installations and Legacy Management
- **CRPPH** – Committee on Radiological Protection and Public Health
- **NLC** – Nuclear Law Committee
- **NDC** – Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle
- **NSC** – Nuclear Science Committee
- **MBDAV** – Management Board for the Development, Application and Validation of Nuclear Data and Codes

NEA committees bring together top governmental officials from NEA member countries and strategic partners to address critical issues, establish best practices and promote international collaboration. Each committee oversees numerous expert working groups.

Major NEA International Co-operative Frameworks

NEA Serviced Bodies

- **Generation IV International Forum (GIF)** with the goal to develop new fission technologies with greater sustainability (including effective fuel utilisation and minimisation of waste), economic performance, safety and reliability, proliferation resistance and physical protection.
- **Multinational Design Evaluation Programme (MDEP) -** initiative by national safety authorities to leverage their resources and knowledge for new reactor design reviews (ABWR, AES2006, AP1000, EPR, HPR1000).
- **International Framework for Nuclear Energy Cooperation (IFNEC) –** 65-country forum for multilateral discussion and analyses of a wide array of nuclear topics involving both developed and emerging economies.

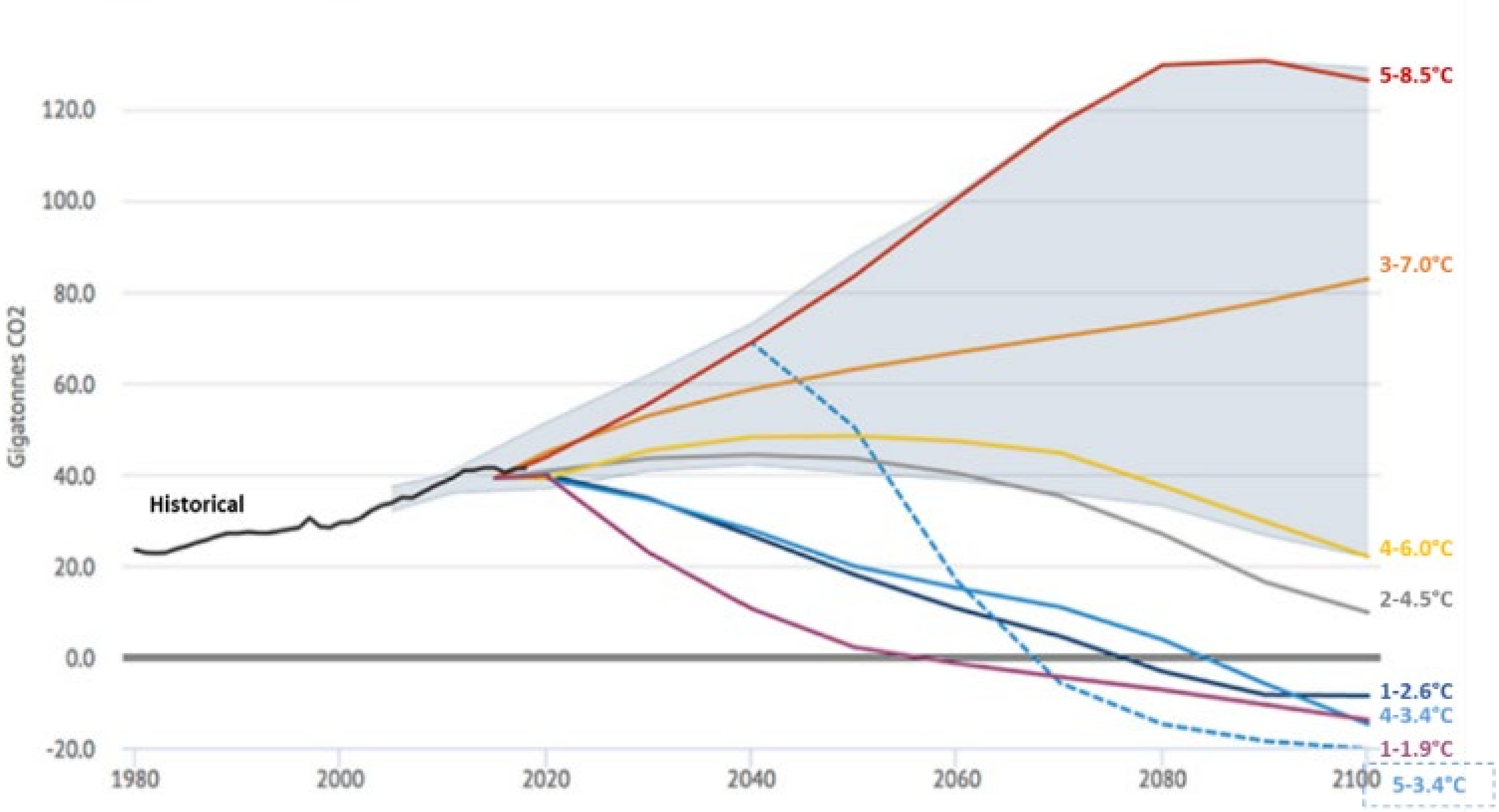
28 Major Joint Projects

- **Nuclear safety research** and experimental data (e.g., thermal-hydraulics, fuel behaviour, severe accidents).
- **Nuclear safety databases** (e.g., fire, common-cause failures).
- **Nuclear science** (e.g., thermodynamics of advanced fuels).
- **Radioactive waste management** (e.g., thermochemical database).
- **Radiological protection** (e.g., occupational exposure).
- **Nuclear Education, Skills and Technology Framework (NEST)** (promoting the development of a new generation of subject matter experts).

Global Action Is Urgently Needed to Meet Climate Targets

- The magnitude of the challenge should not be underestimated
- The planet has a “carbon budget” of 420 gigatonnes of carbon dioxide emissions for the 1.5°C scenario
- At current levels of emissions, the entire carbon budget would be consumed within 8 years
- Emissions must go to net zero, but the world is not on track

Temperature outcomes for various emissions futures



Source: Carbon Brief (2019).

Roadmaps for New Nuclear Ministerial Meeting

Paris - September 28-29, 2023

- In the lead-up to COP28, energy ministers from 20 countries issued a joint communiqué as a ***"call to action and guiding principles in support of roadmaps for nuclear energy"*** further ***"calling on the NEA to coordinate with stakeholders to develop*** *[…]* ***solutions-oriented approach to support decision-makers in maximizing the full potential of nuclear energy"***
- This call to action was also echoed in an industry communiqué

Key Observations

- **Energy security is now the driving issue in many capitals** as electricity prices rise dramatically around the world and recent geopolitical events highlight the vulnerability of fossil fuel supply chains
- **Coal use is shrinking in OECD countries** as policies, markets, and public perception turn against its use in many countries.
- **Recent focus on 2030 targets for CO_2 reductions** have forced both increased investment in energy and a much larger degree of reality.
- **Particularly in the aftermath of COP26, many OECD and emerging economies view nuclear energy as a key element in their decarbonization strategies.**

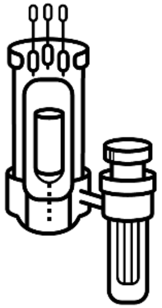
Commitment to Triple Nuclear Capacity by 2050

- 24 nations call for tripling of global nuclear capacity by 2050
- Reflects NEA analysis in "Meeting Climate Change Targets: The Role of Nuclear Energy"
- Multinational Development Banks (MDBs) and International Developmental Finance Institutions (IFIs) in focus

The Full Potential of Nuclear Energy to Contribute to Emissions Reductions

Long Term Operation

Large Gen-III Reactors



Small Modular Reactors

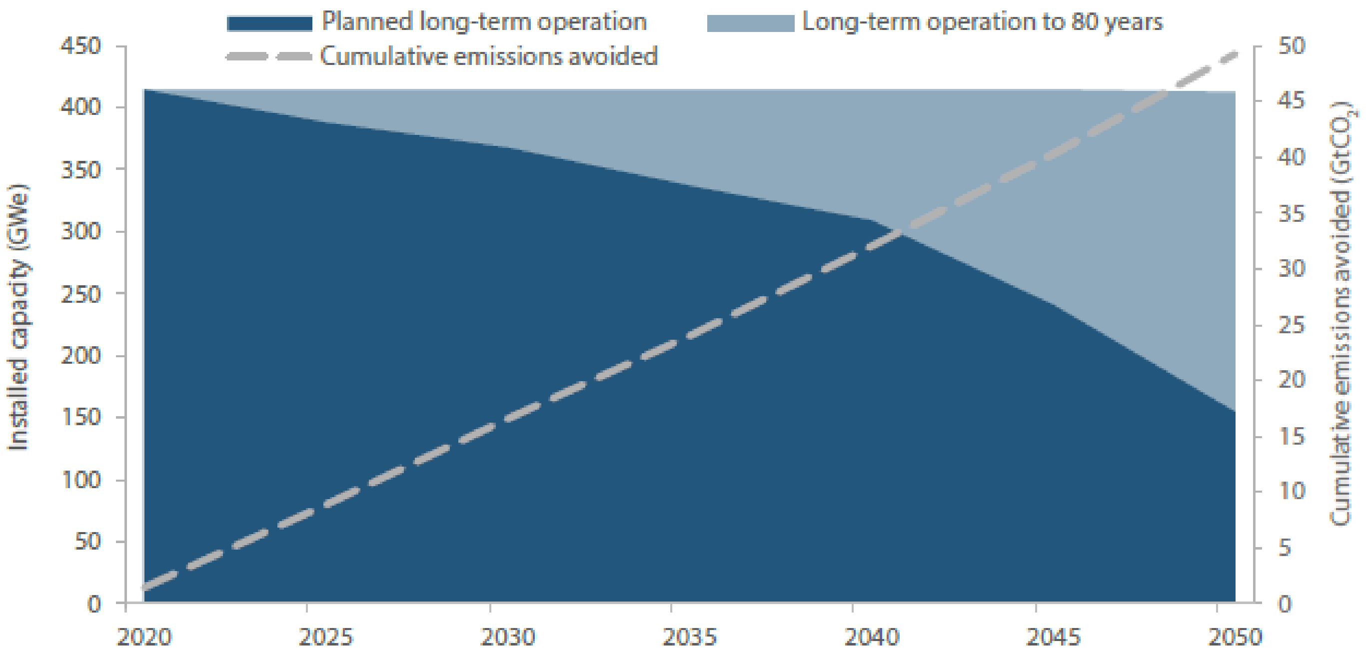
Non-Electrical applications

Complementary nuclear technologies and applications

Long-term Operation of Current Nuclear Plants

- The average age of nuclear power plants in OECD countries is nearly 40 years
- The technical potential exists in most cases for long-term operation for several more decades
- Long-term operation is one of the most cost-competitive sources of low-carbon electricity
- Adequate policy and market are key conditions of success of long-term operation
- Long-term operation could save up to 49 gigatonnes of cumulative emissions between 2020 and 2050

Long-term operation – installed capacity and cumulative emissions avoided (2020-2050)

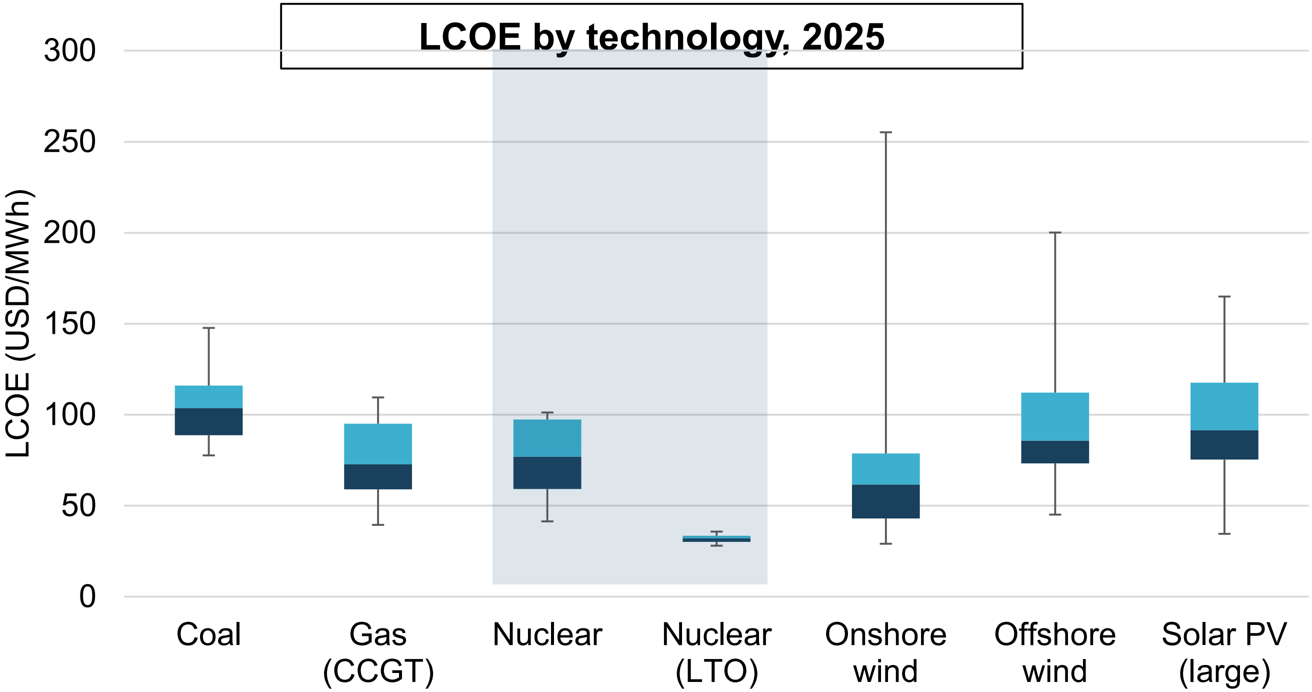


Note: Note: It is assumed that nuclear power (12 gCO_2eq/kWh) is displaced by gas with a carbon footprint of 490 gCO_2eq/kWh (Bruckner, 2014). By 2050, 25% of nuclear reactors are used for nuclear heat applications, also displacing gas. By 2050, nuclear reactors operate with a 90% availability factors with 60% of the power used to supply electricity and 30% to supply hydrogen. Hydrogen produced with nuclear power will displace steam methane reforming (10 kg CO_2 per kg of H_2).

Long-Term Operation is THE Least Cost Option

Many Countries now plan for LTO

- **Views of LTO vary around the world due to differing policy and regulatory approaches.** For example in some countries, the 40 year mark is characterized as "plant lifetime."
- Distorted, dysfunctional, and obsolete markets do not recongnise the value of existing nuclear plants to system reliability and carbon reduction.
- Some government policies were leading to the premature shut down of nuclear plants. **Many such policies have now been modified.**



Note: Coal includes lignite plants. Discount rate of 7% and carbon price of USD30/tCO2
Source: IEA/NEA (2020)

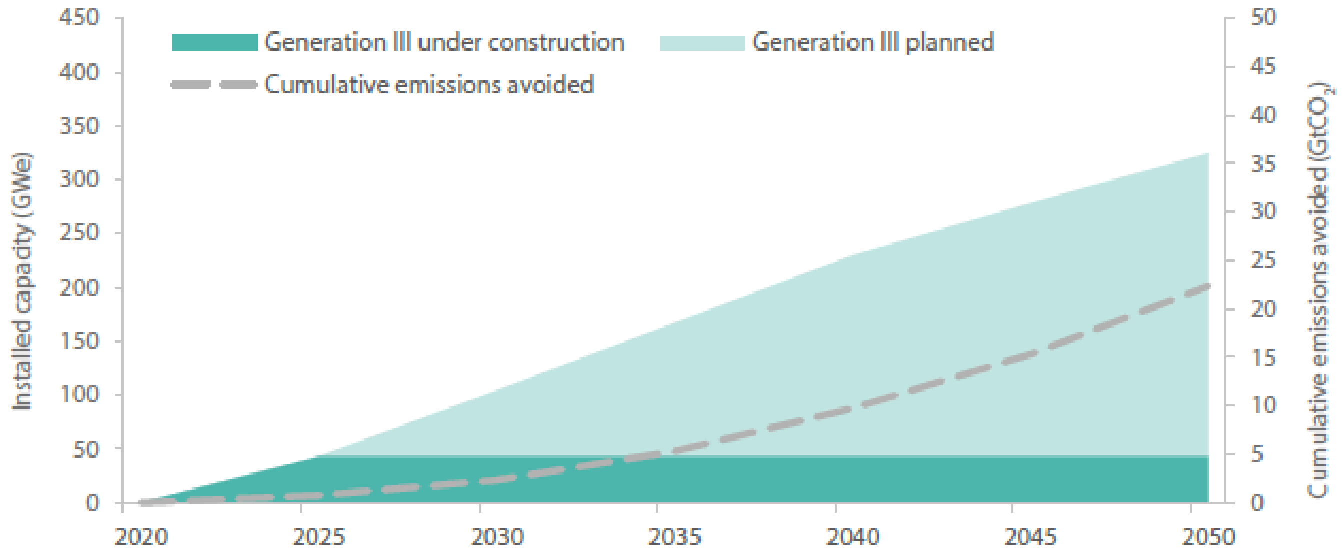
Long-term operation could save up to 49 gigatonnes of cumulative emissions between 2020 and 2050.

New Builds of Large Generation III Plants

- At the end of 2020, 55 gigawatts of new nuclear capacity in the form of large-scale Generation III reactors were under construction around the world driven largely by new builds outside the current OECD membership

- Taken together, large-scale Generation III reactors that are under construction and planned are expected to reach over 300 gigawatts of installed capacity by 2050, avoiding 23 gigatonnes of cumulative carbon emissions between 2020 and 2050

Generation III new builds – installed capacity and cumulative emissions avoided (2020-2050)

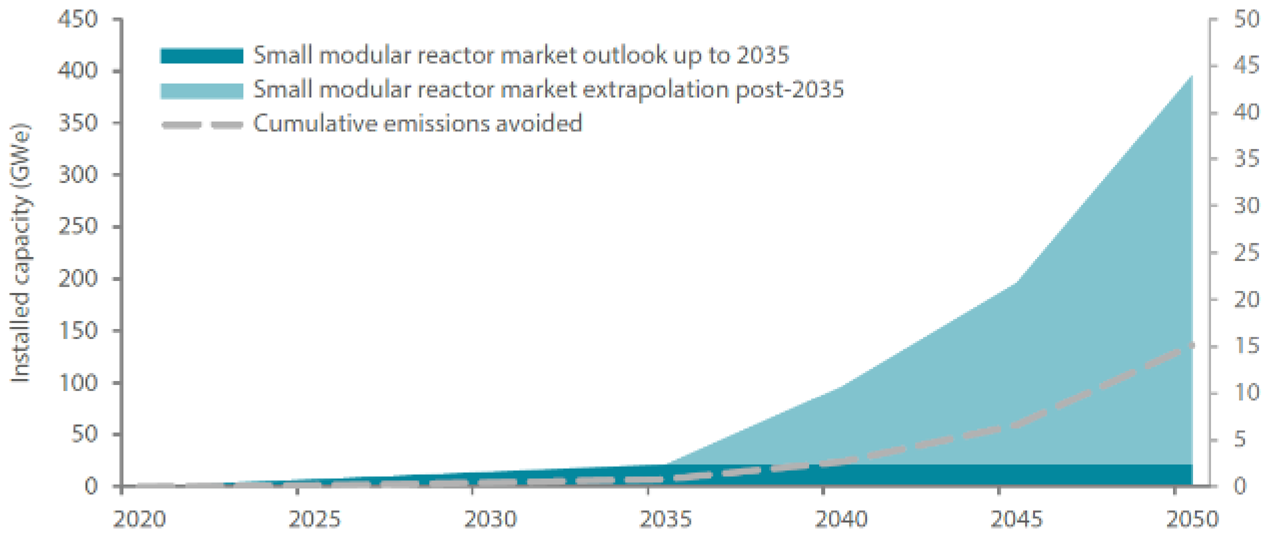


Note: Note: It is assumed that nuclear power (12 gCO_2eq/kWh) is displaced by gas with a carbon footprint of 490 gCO_2eq/kWh (Bruckner, 2014). By 2050, 25% of nuclear reactors are used for nuclear heat applications, also displacing gas. By 2050, nuclear reactors operate with a 90% availability factors with 60% of the power used to supply electricity and 30% to supply hydrogen. Hydrogen produced with nuclear power will displace steam methane reforming (10 kg CO_2 per kg of H_2).

Small Modular Reactors and Generation IV Reactors

- Several SMR designs are expected to be commercially deployed within 5-10 years and ready to contribute to near-term and medium-term emissions reductions
- SMRs could see rapidly increasing rates of construction in net zero pathways
- Up to 2035, the global SMR market could reach 21 gigawatts
- Thereafter, a rapid increase in build rate can be envisaged with construction between 15 and 150 gigawatts per year

Installed Capacity And Cumulative Emissions Avoided

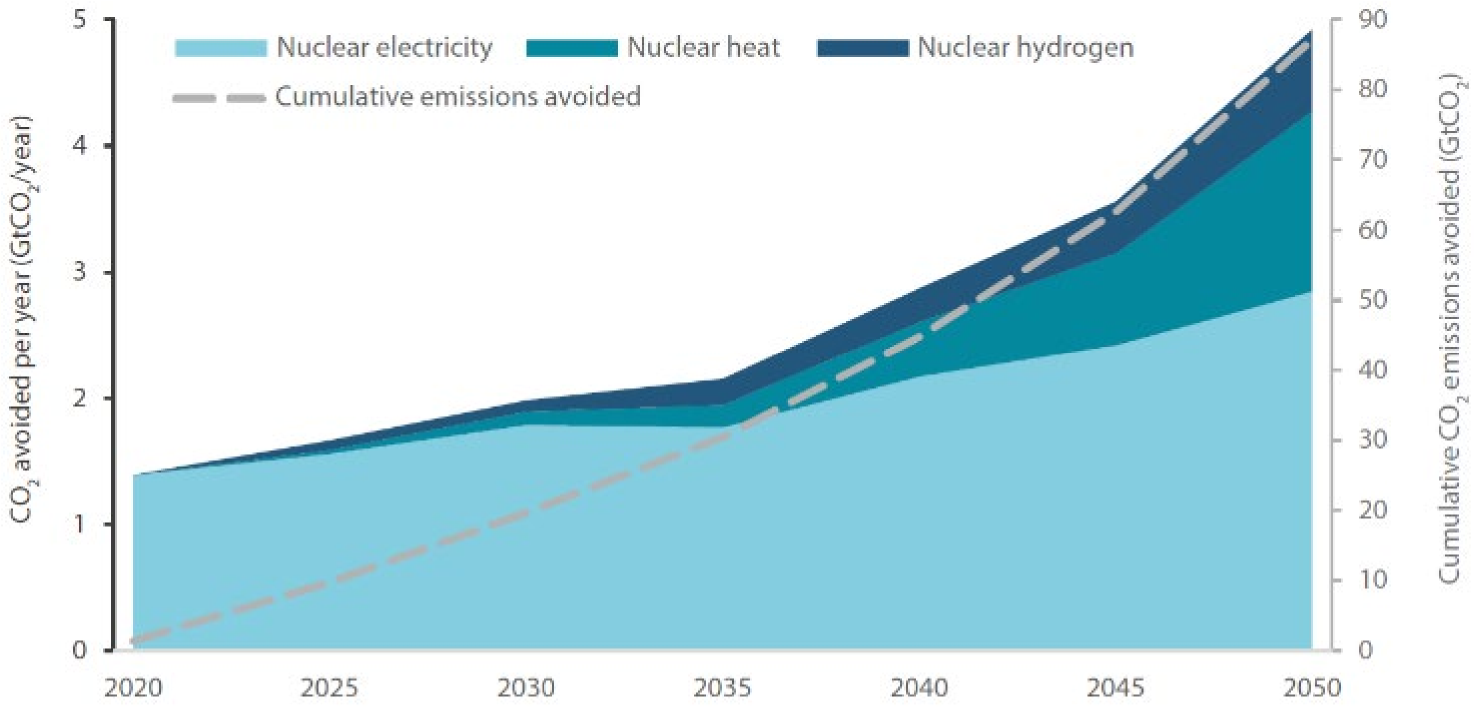


Note: Note: It is assumed that nuclear power (12 gCO_2eq/kWh) is displaced by gas with a carbon footprint of 490 gCO_2eq/kWh (Bruckner, 2014). By 2050, 25% of nuclear reactors are used for nuclear heat applications, also displacing gas. By 2050, nuclear reactors operate with a 90% availability factors with 60% of the power used to supply electricity and 30% to supply hydrogen. Hydrogen produced with nuclear power will displace steam methane reforming (10 kg CO_2 per kg of H_2).

Power and Non-power Applications of Nuclear Energy

- Taken together, nuclear hybrid systems with non-electric applications including hydrogen can contribute to avoiding nearly 23 gigatonnes of cumulative emissions between 2020 and 2050
- Further, nuclear energy enables more extensive, more rapid, and more cost-effective deployment of variable renewables, by providing much needed flexibility
- The role of nuclear energy in emissions reductions for future energy systems is therefore even greater

Carbon emissions avoided by nuclear power and non-power applications



Small Modular Reactors and Generation IV Reactors:
Enabling Pathways to Net-Zero

SMALL MODULAR REACTORS (SMRs)

Small	Modular	Reactor
• Smaller output • Small physical size • 1-300 MWe	• Factory Production • Portable • Scalable	• Nuclear Fission • Heat • Electricity

BENEFITS

Simplified Safety
- Lessons learned from 60 years of operations

Flexibility
- Adapted to complement variable renewables

APPLICATIONS

On-Grid
- 200-300 MWe
- Replace coal

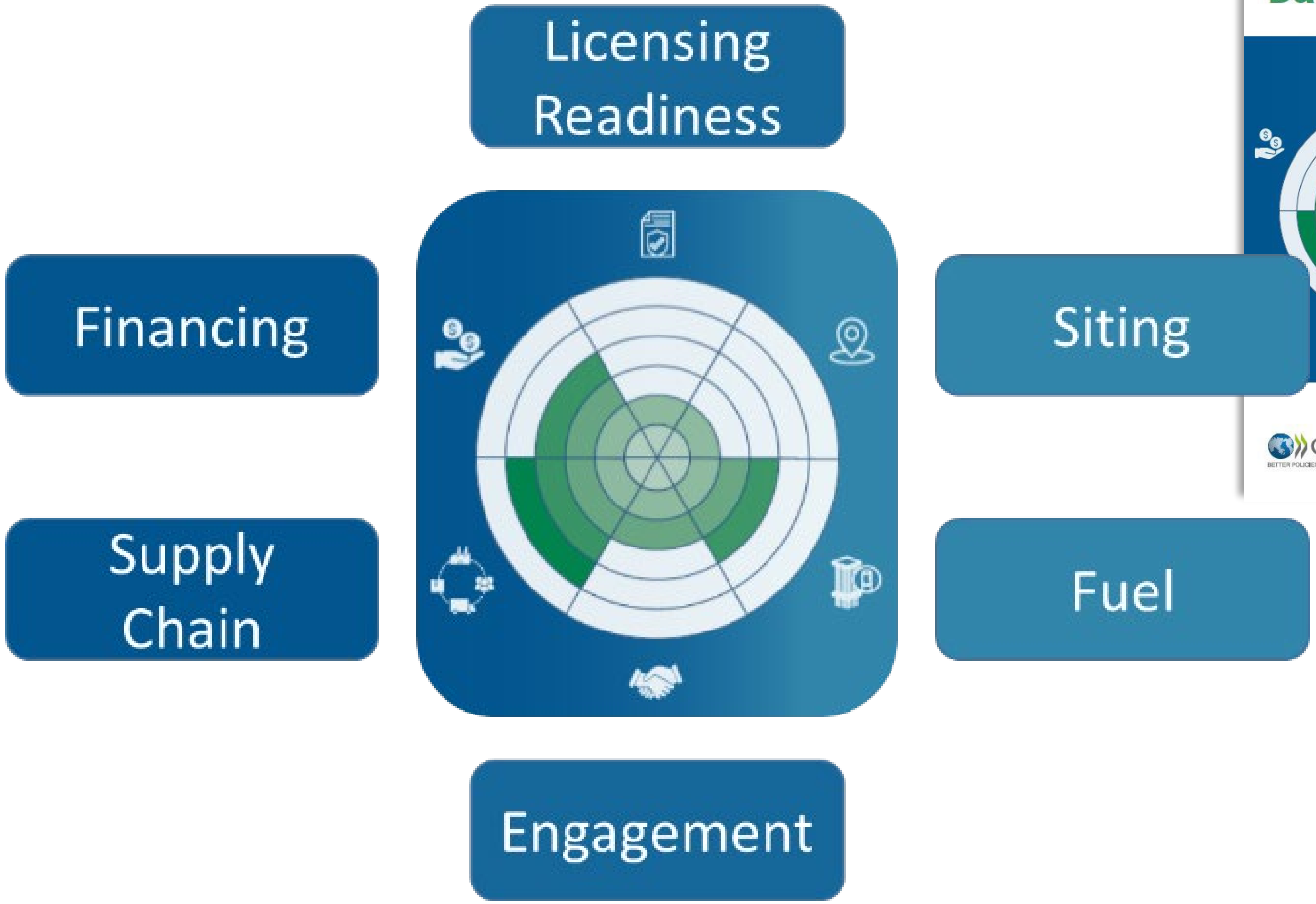
Merchant Shipping
- Marine Production
- Off bunker fuel

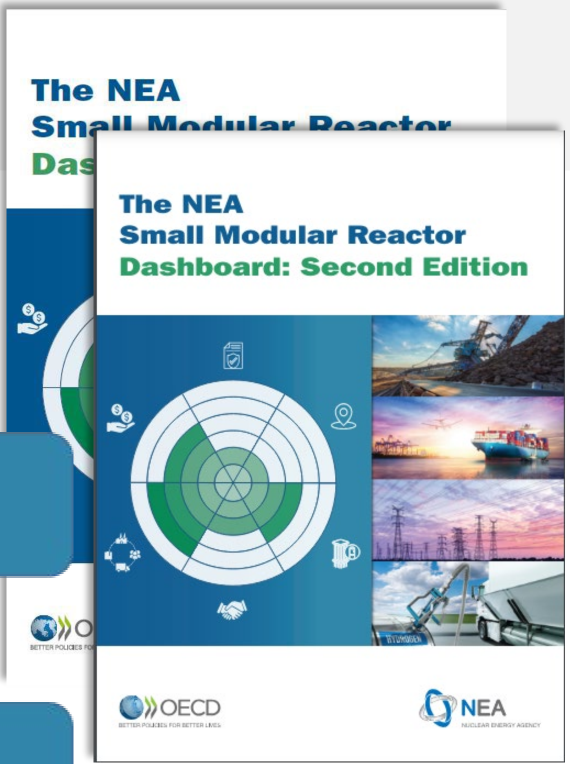
Off-Grid
- Remote sites
- Replace diesel

Heat
- 285 – 850 °C
- Industrial cogeneration

Tracking progress: *NEA SMR Dashboard*

- "Technology readiness level" is useful, but only reveals part of the picture
- **NEA defined six additional indicators of progress**
- With the NEA indicators, the picture becomes clearer





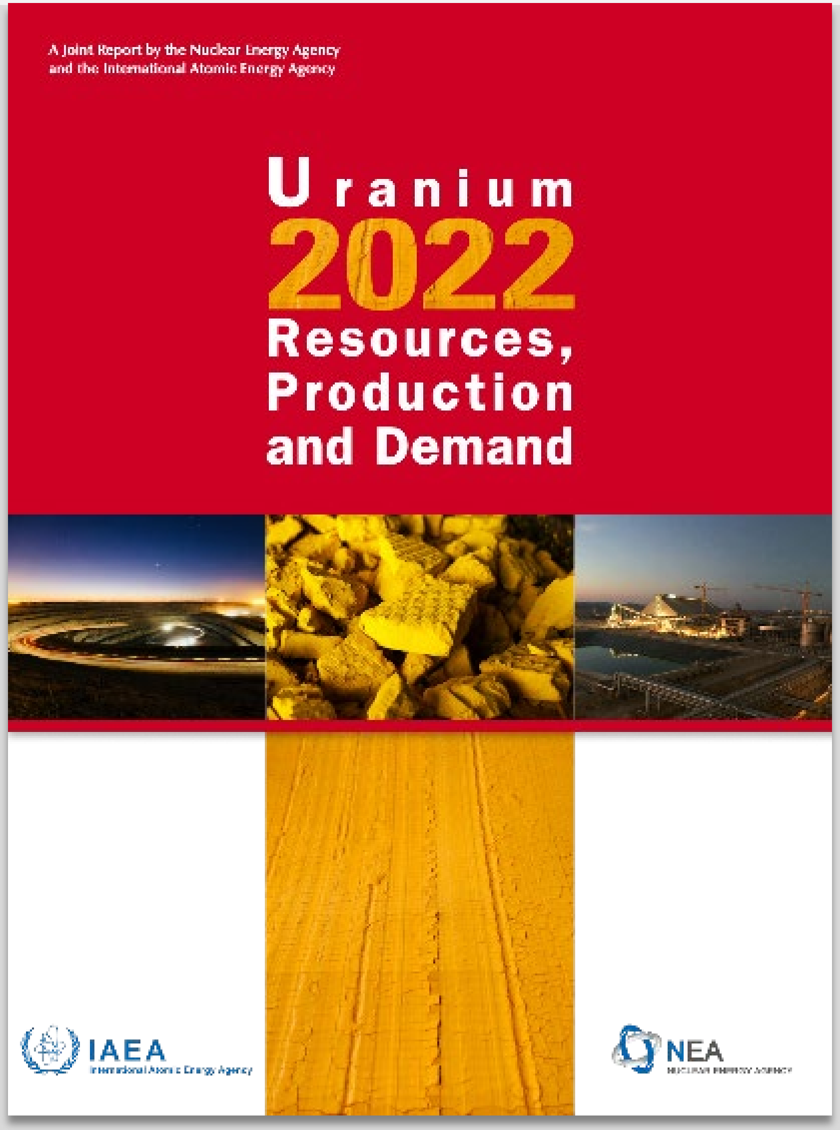
2nd Edition published in February 2024

www.oecd-nea.org/SMR-Dashboard-2nd-edition

The Red Book:
Uranium Resources, Production and Demand

A biennial Joint report of NEA and IAEA

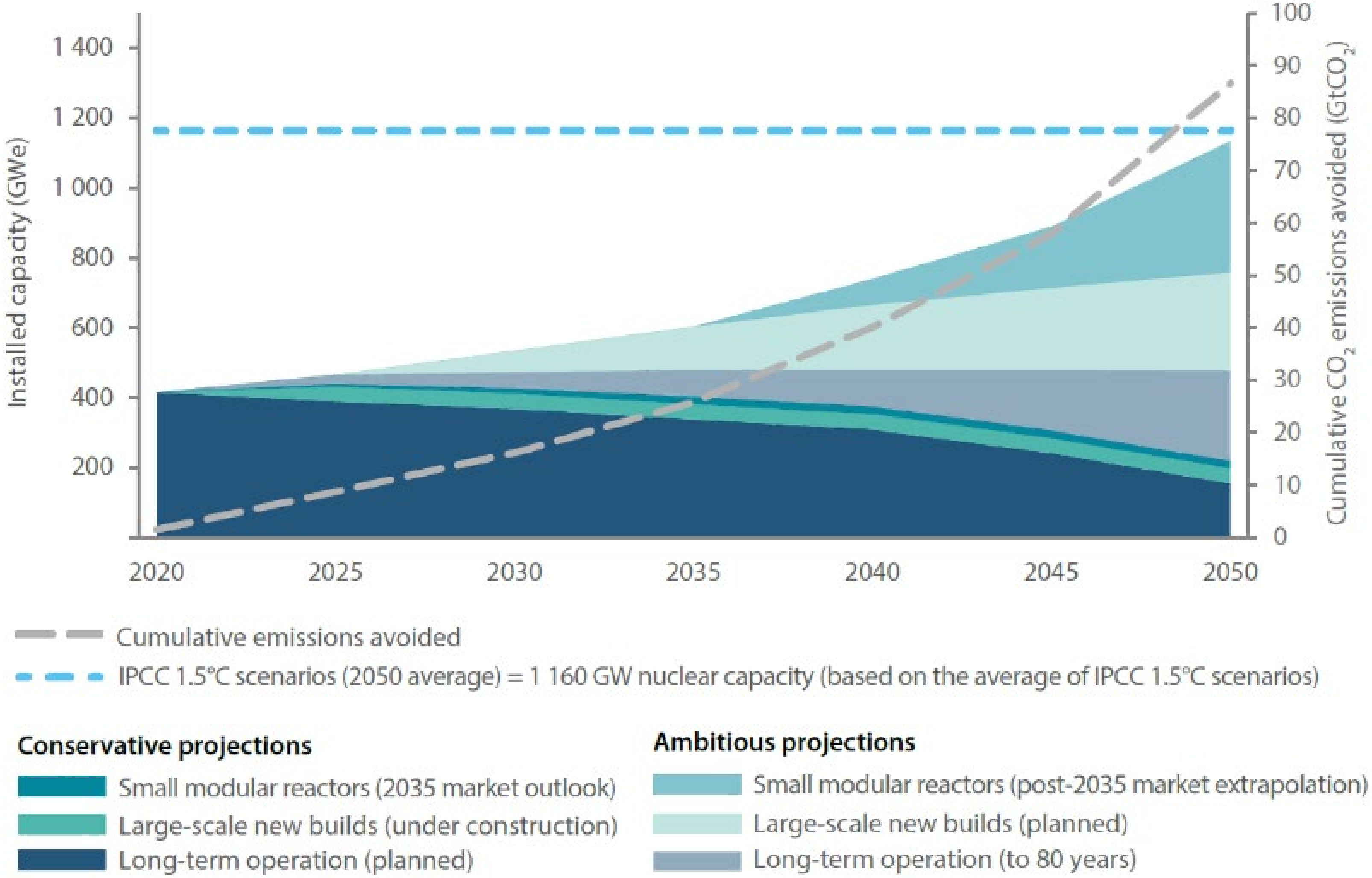
- **The world's reference on the subject of uranium resources**.
- Outlook:
  - Known resources are more than sufficient for current nuclear capacity.
  - Tripling global nuclear capacity will challenge current resources, requiring significant exploration and possibility consideration of recycling
- Red Book 2024 will be issued soon.



It *is* possible...

Reaching **the target of 1160 gigawatts** of global installed nuclear capacity by 2050 would require a combination of **long-term operation, large-scale Generation III, SMRs, and non-electric applications** such as nuclear-produced heat for desalinisation and hydrogen

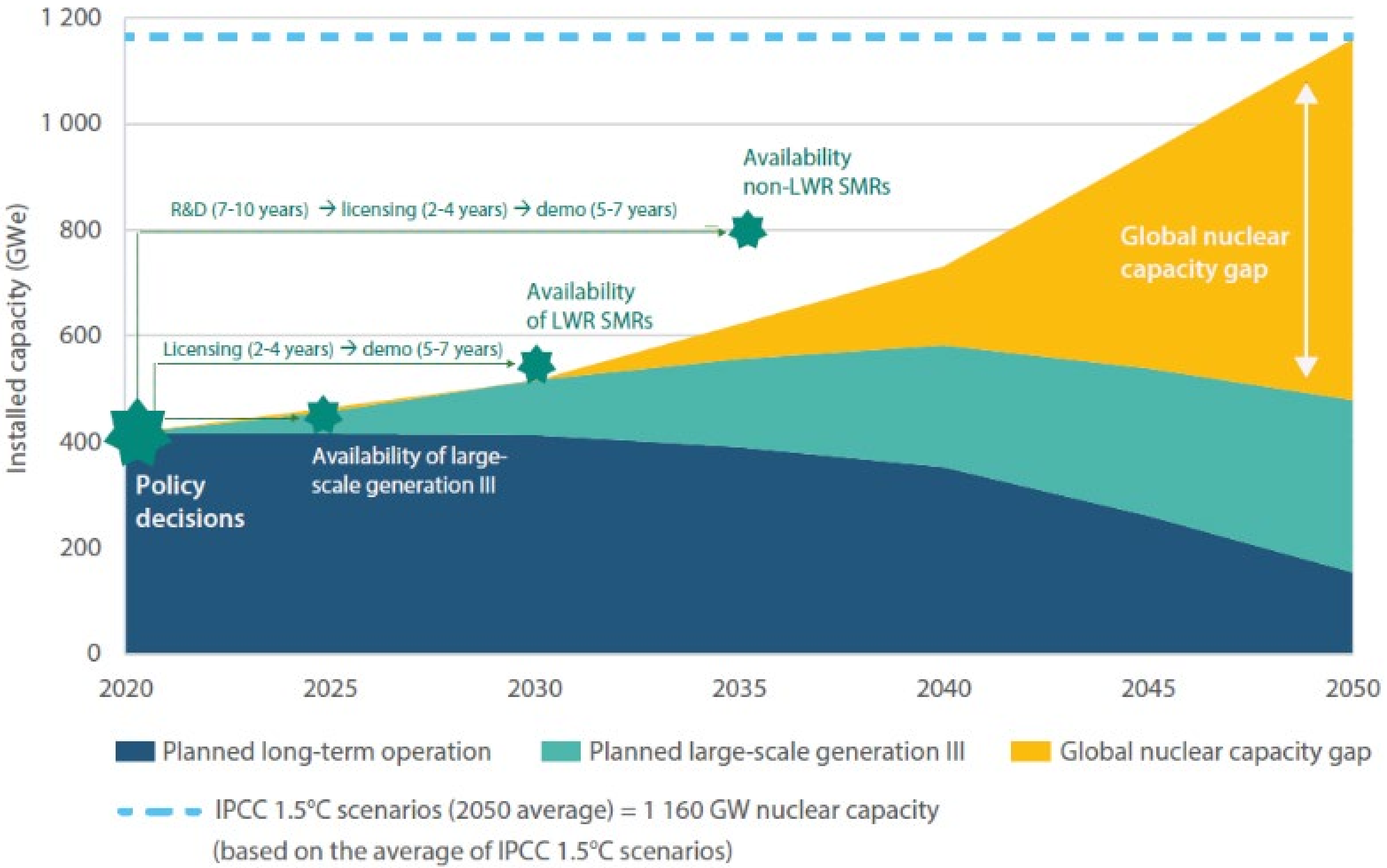
Full potential of nuclear contributions to Net Zero



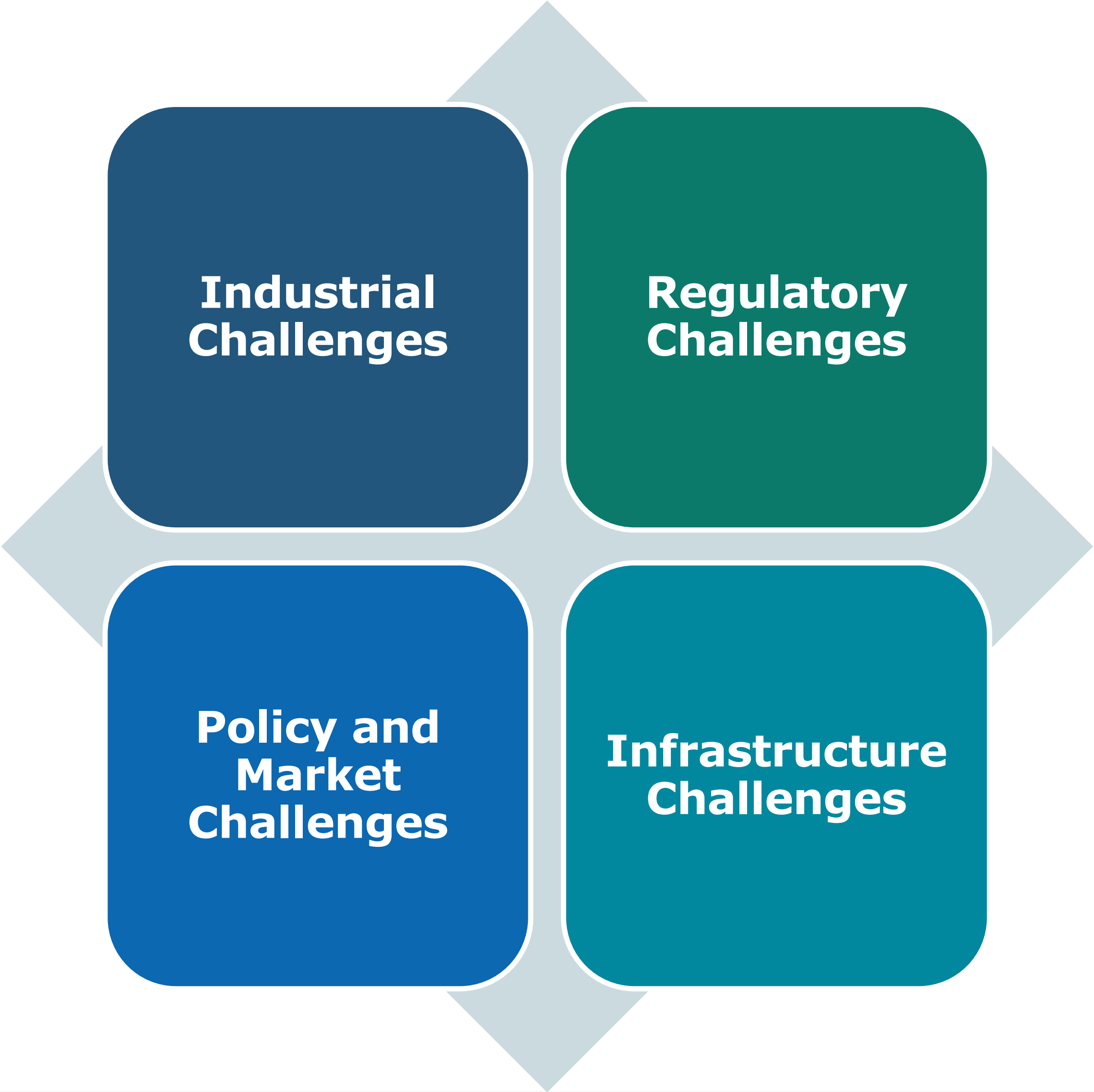
...But We are Not on Track toward Success

- Under current policy trends, nuclear capacity in 2050 is expected to reach **479 gigawatts** – well below the target of 1160 gigawatts of electricity
- Owing to the timelines for nuclear projects, there is an **urgency to action now to close the gap in 2030-2050**

Global installed nuclear capacity gap (2020-2050)



For New Nuclear Energy to be Successful, Key Challenges Must be Addressed



For New Nuclear Energy to be Successful, Key Challenges Must be Addressed

Industrial Challenges

- **Execution**—industry must take breakthrough technologies from the drawing board to commercial reality and deliver projects as promised
- **Operations Models**—industry must present realistic models to operate large numbers of SMRs and microreactors
- **Supply Chain**—past experience demonstrates that the global nuclear supply chain is neither broad nor deep and suppliers are not always as prepared as might be expected

For New Nuclear Energy to be Successful, Key Challenges Must be Addressed

Regulatory Challenges

- **Adaptation to New Technologies**—regulators must not view Gen IV technologies through a Gen II lens and must be prepared to address digital technologies
- **Accept New Paradigms**—new technologies may be game-changers in areas such as EP and security, but regulators must be truly risk-informed
- **Global Thinking**—regulators must act nationally but think globally; otherwise there cannot be a true global market for new technologies

For New Nuclear Energy to be Successful, Key Challenges Must be Addressed

Policy and Market Challenges

- **Financing**—government policies are needed to support financing of new nuclear construction and other high-capital investments needed to reach Net-Zero; change is needed in the International Financial Institutions
- **Outdated Electricity Markets**—today's markets don't support long-term environmental and energy security goals; dispatchability has value!
- **FOAK**—governments must put policies in place to address FOAK risks and costs; policymakers must recognize that first projects will be expensive and challenging

For New Nuclear Energy to be Successful, Key Challenges Must be Addressed

Infrastructure Challenges

- **HALEU—**the lack of a clear path to a reliable supply of high assay LEU is a barrier to new technologies
- **Legal Frameworks—**new technologies—especially mobile reactors—will require updates to existing legal and regulatory frameworks to address liability, safety and other considerations
- **Human Resources—**more must be done to promote a new generation of nuclear experts while promoting greater diversity and gender balance

For New Nuclear Energy to be Successful, Key Challenges Must be Addressed

Infrastructure Challenges

- **HALEU**—the lack of a clear path to a reliable supply of high assay LEU is a barrier to new technologies
- **Legal Frameworks**—new technologies—especially mobile reactors—will require updates to existing legal and regulatory frameworks to address liability, safety and other considerations
- **Human Resources—**more must be done to promote a new generation of nuclear experts while promoting greater diversity and gender balance

The Global Forum on Nuclear Education, , Science, Technology and Policy

The **NEA Global Forum on Nuclear Education, Science, Technology and Policy** was established in January 2021 to:

- Engage governments with academic institutions responsible for developing the next generation of nuclear science and technology experts.
- Provides academic institutions around the world with a framework for interaction, co-operation, and collective action.

1st Rising Stars Workshop at MIT, USA, September 2023

Council of Advisors

35 members from 20 academic institutions in 13 countries

- Working Group 1: **Gender balance in nuclear technology & academic workforces**
- Working Group 2: **Future of Nuclear Engineering Education**
- Working Group 3: **Relationship between nuclear energy & society**
- Working Group 4: **Innovations in the nuclear sector**
- Working Group 5: **Re-Establishing Nuclear Law Education Programme**
- Working Group 6: **Building a pipeline of STEM professionals** ***NEW***
- Working Group 7: **Developing an international curriculum for the back end of the Nuclear Fuel Cycle** ***NEW***

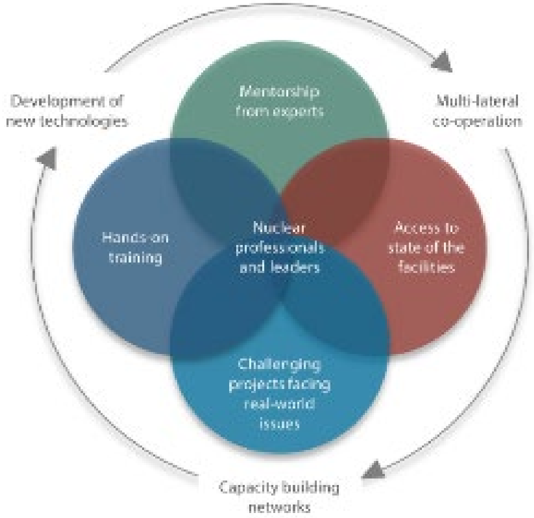
www.oecd-nea.org/globalforum

Nuclear Education, Skills and Technologies (NEST) Framework

57 Organisations

A multinational framework to maintain & build skills and to nurture the next generation of nuclear subject matter experts through transfer of practical experience and knowledge

Participating countries:
Belgium, Canada, France, Germany, Italy, Japan, Korea, Poland, Romania, Russia, Switzerland, USA

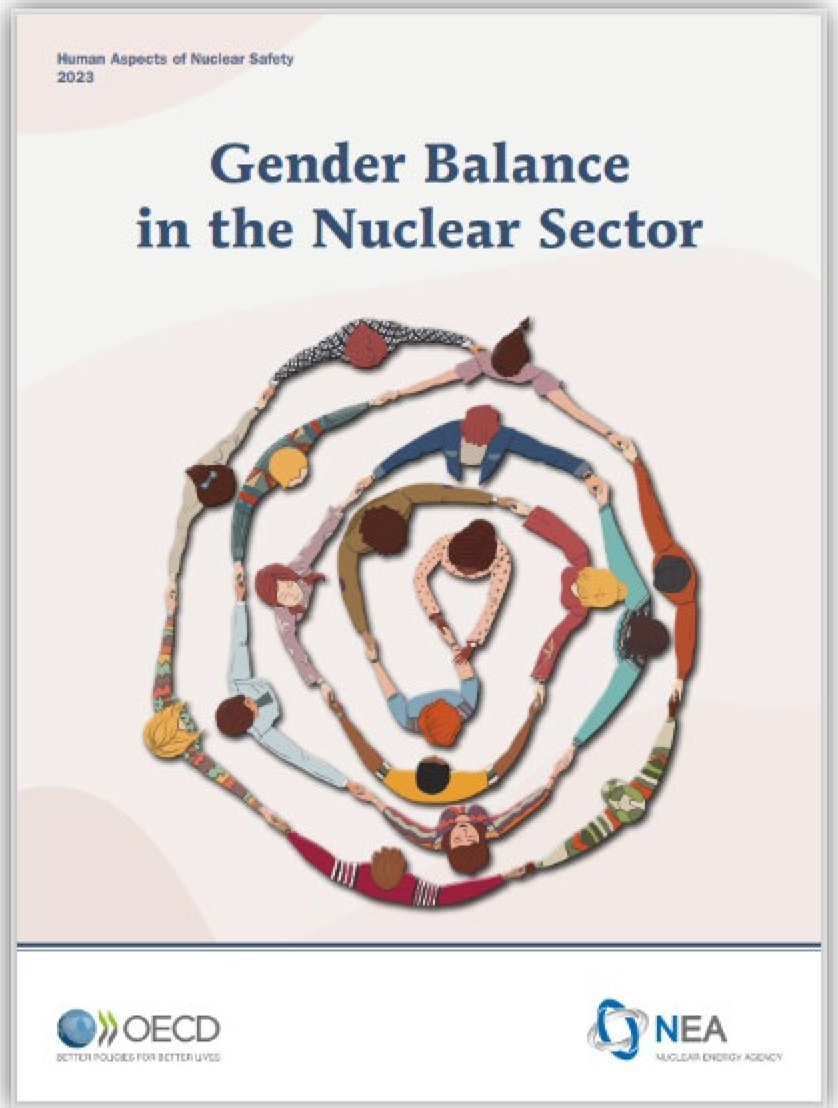


- **Develops skills and competences and transfers knowledge through hands-on training, in the course of challenging nuclear projects**
- **Builds a talent pipeline from universities, to industries, regulators and TSOs**
- **Enables student access to scientific infrastructure, construction projects, and decommissioning activities**

208 Fellows over the life of the current projects

www.oecd-nea.org/nest

NEA Work towards Gender Balance in the Nuclear Sector



Flagship Report Launched on 8 March 2023

- **Takes stock** of current gender balance in nuclear sector in NEA countries
- Provides **first public, international data**
- Objective: To establish policy framework with **recommendations**.

Recommendation on Improving the Gender Balance in the Nuclear Sector adopted by 38 countries on 8 June 2023

'Attract, Retain & Advance + Data' Framework

Attract
women into the nuclear sector

Retain
& support women in the workforce

Advance
& develop women as leaders

→ **Download the report:** *http://www.oecd-nea.org/gender-balance*

The 2035 Project: *Inspire, Mentor and Network*

INSPIRE

Engage and inform secondary school students and educators about nuclear science and technology and related STEM and skills careers

- Create the framework and content for the “AtomExplorer” - a traveling nuclear information and careers exhibit that can be deployed around the world
- Support Global Forum Pipeline Initiatives to engage secondary school students and educators
- Implement Gender Balance Recommendation *Attract* pillar to support national efforts to encourage young women to consider nuclear technology careers

Key partners

- Global Forum on Nuclear Education (Universities)
- National ministries and private sector
- Foundations

MENTOR

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

- “Franchise” NEA’s highly successful international mentoring workshops into a global platform to reach many more students
- Launch the NEA Global Internship Programme
- Expand Global Forum Rising Stars workshops
- Establish online educator workshops and resources
- Expand NEA training programmes and provide young professionals with scholarships

Key partners

- Global Forum on Nuclear Education (Universities)
- Experts from NEA Member Countries
- Professional societies

NETWORK

Provide targeted networking opportunities and build global platforms

- Create a digital platform to support all educational outreach
- Provide a library of video lectures by NEA member experts and other educational materials that can be easily accessed by schools
- Create a global networking platform for Rising Stars alumnae
- Establish global networks of role models, educators and professional society education initiatives

Key partners

- YGN
- WiN Global and Regional WiN chapters
- Universities
- Professional societies

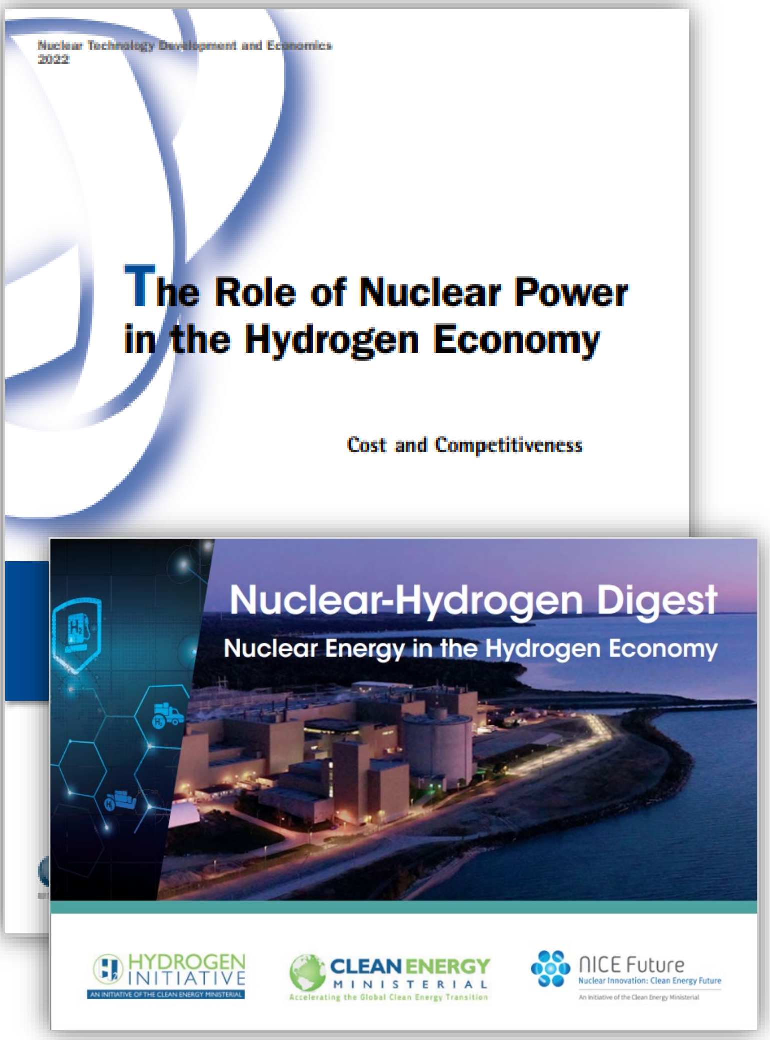
For Climate Action to be Successful, An Enhanced Vision of the Future is Needed

If action on climate is associated with limits to life, economic growth, and freedom, a successful energy transition will be difficult.

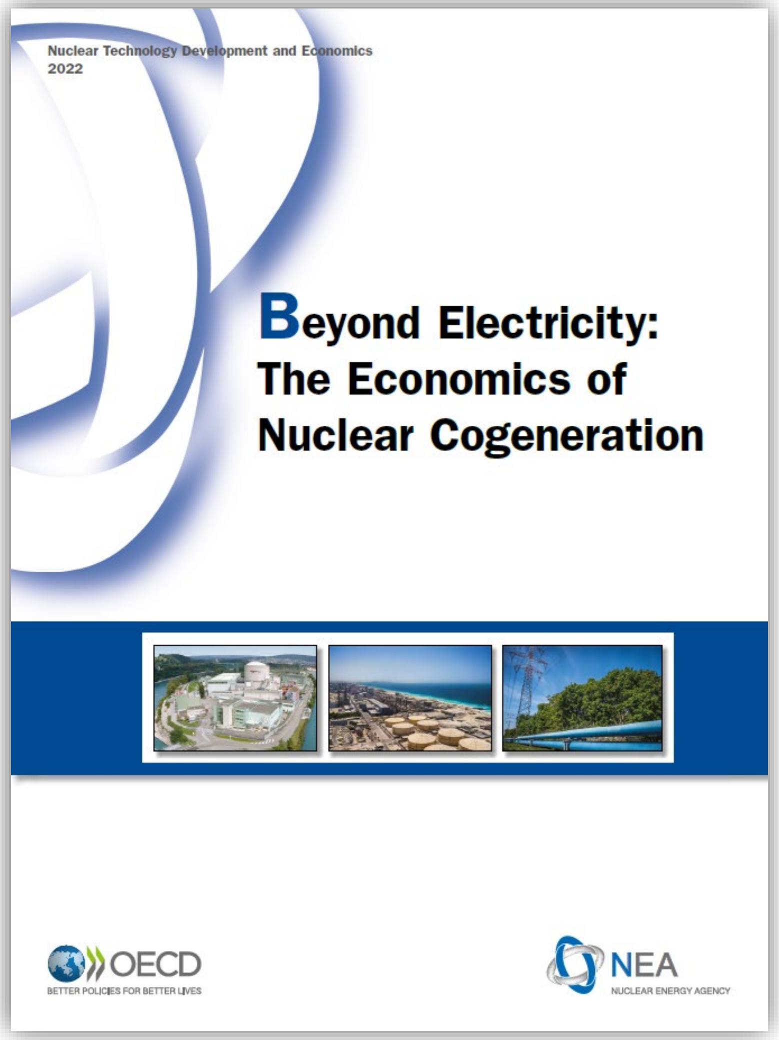
Innovative Nuclear Technologies Help Provide a Solution Set

Thank you for your attention!

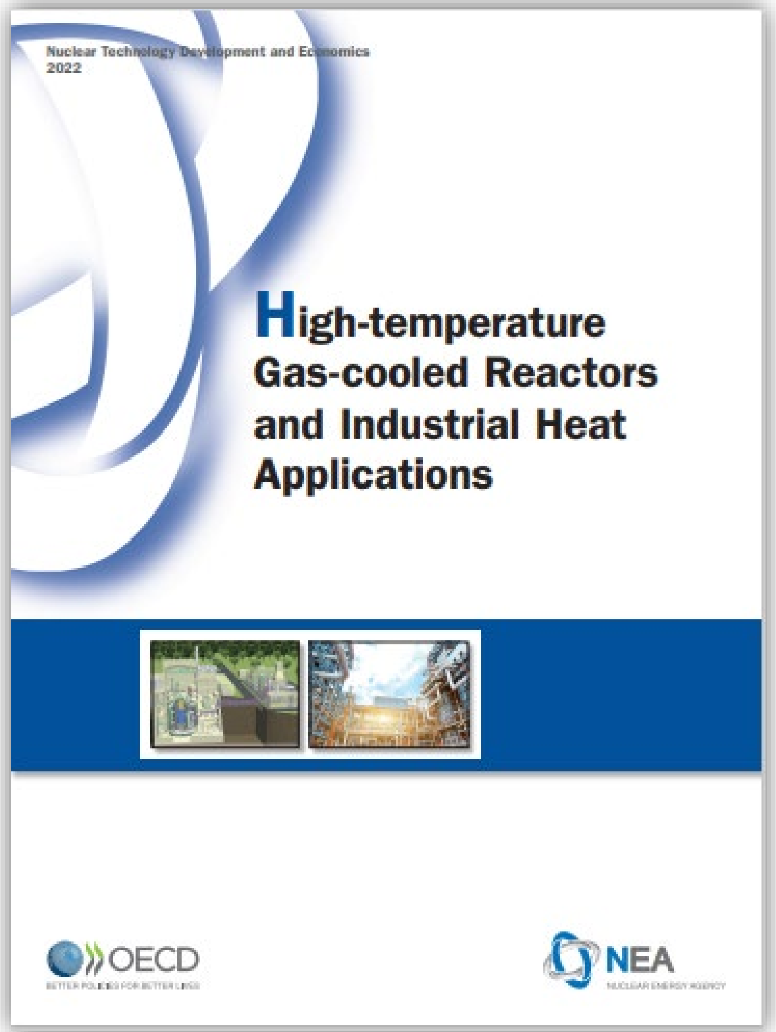
Learn more on: https://oecd-nea.org/



www.oecd-nea.org/nuclear-hydrogen



www.oecd-nea.org/cogen22



www.oecd-nea.org/htgr22