NEA
NUCLEAR ENERGY AGENCY

The 21st Century Nuclear Resurgence: Opportunities and Challenges

University of Warsaw
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OECD Nuclear Energy Agency

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

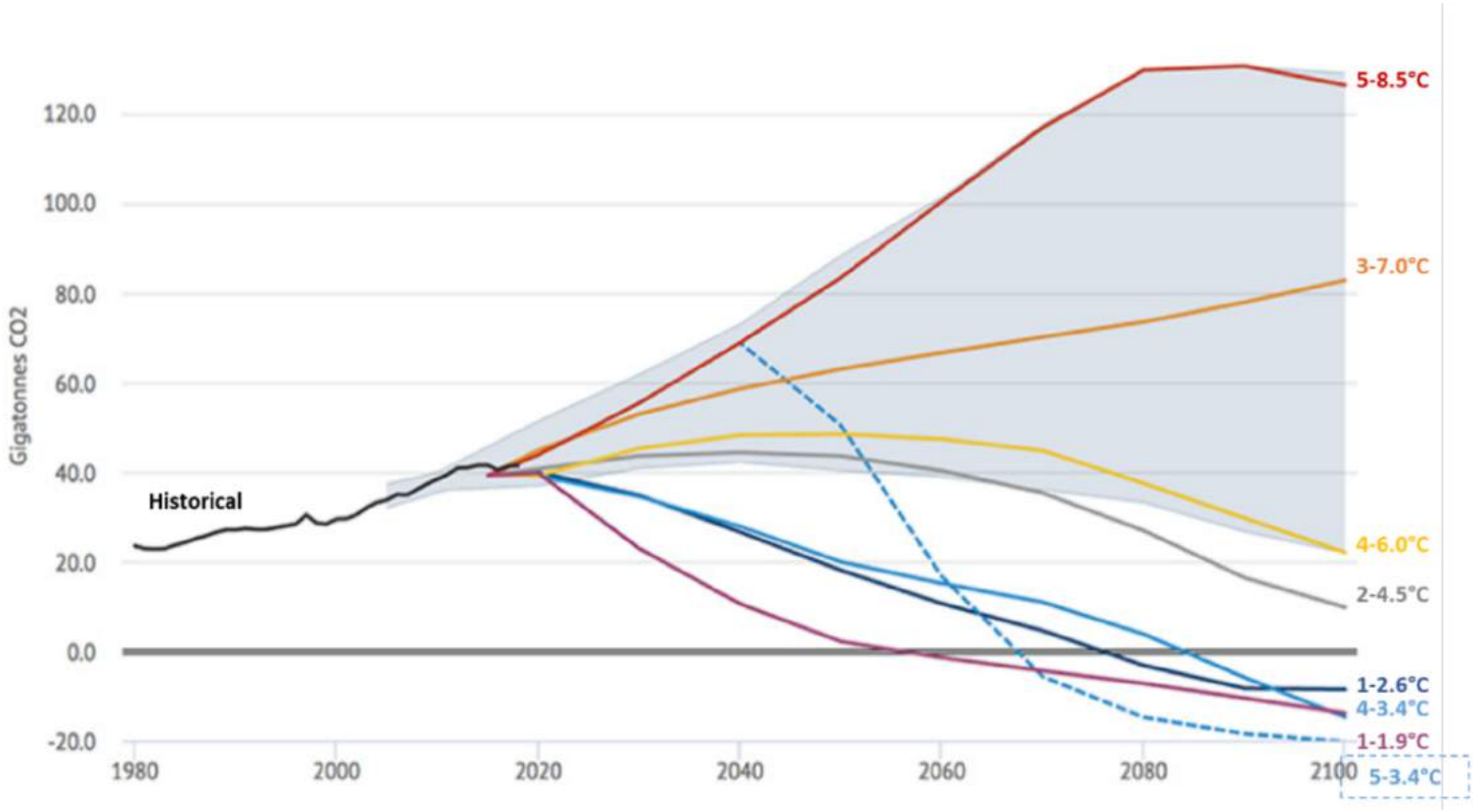
- The premier international platform for cooperation in nuclear technology, policy, regulation, research, and education.
- 34 member countries + strategic partners (e.g., China and India).
- More than 80 working parties and expert groups with over 3000 experts from around the world.
- Global relationships with industry and universities.

NEA countries operate about 81% of the world's installed nuclear capacity

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).

Nuclear in Emissions Reduction Pathways

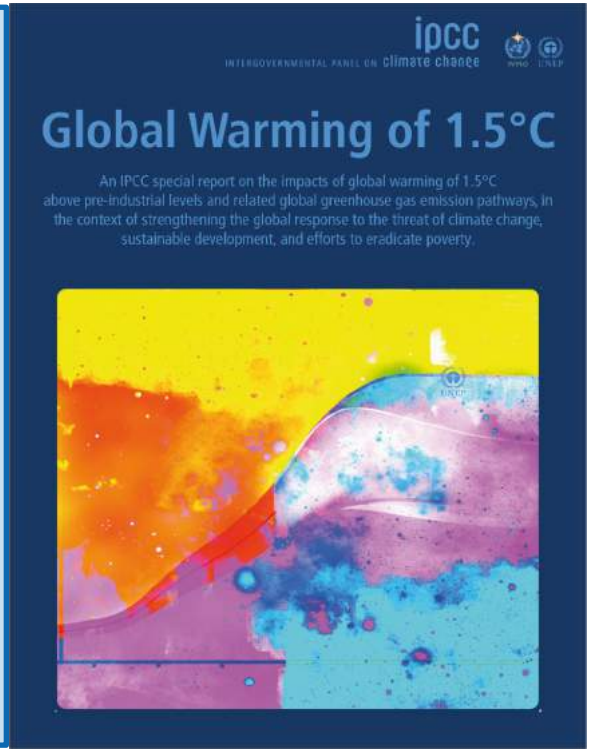
Organisation	Scenario	Climate target	Nuclear innovation	Description	Role of nuclear energy by 2050	
					Capacity (GW)	Nuclear growth (2020-50)
IAEA (2021b)	High Scenario	2°C	Not included	Conservative projections based on current plans and industry announcements.	792	98%
IEA (2021c)	Net Zero Scenario (NZE)	1.5°C	Not included but HTGR and nuclear heat potential are acknowledged.	Conservative nuclear capacity estimates. NZE projects 100 gigawatts more nuclear energy than the IEA sustainable development scenario.	812	103%
Shell (2021)	Sky 1.5 Scenario	1.5°C	Not specified	Ambitious estimates based on massive investments to boost economic recovery and build resilient energy systems.	1 043	160%
IIASA (2021)	Divergent Net Zero Scenario	1.5°C	Not specified	Ambitious projections required to compensate for delayed actions and divergent climate policies.	1 232	208%
Bloomberg NEF (2021)	New Energy Outlook Red Scenario	1.5°C	Explicit focus on SMRs and nuclear hydrogen	Highly ambitious nuclear pathway with large scale deployment of nuclear innovation.	7 080	1670%

Many pathways require global installed nuclear capacity to grow significantly

Nuclear Energy Can—and Must—Play a Larger Role In Support of Global Net-Zero Goals

In its 2018 special report, the IPCC reviewed **90 pathways consistent with a 1.5°C scenario –** i.e., pathways with emissions reductions sufficient to limit average global warming to less than 1.5°C.

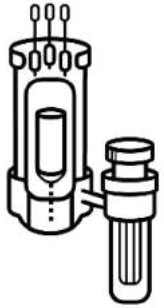
On average, the scenarios reflect the need for global nuclear capacity to **triple by 2050 to 1160 gigawatts**, up from 394 gigawatts in 2020.



The Full Potential of Nuclear Energy to Contribute to Emissions Reductions

Long Term Operation

Large Gen-III Reactors



Small Modular Reactors

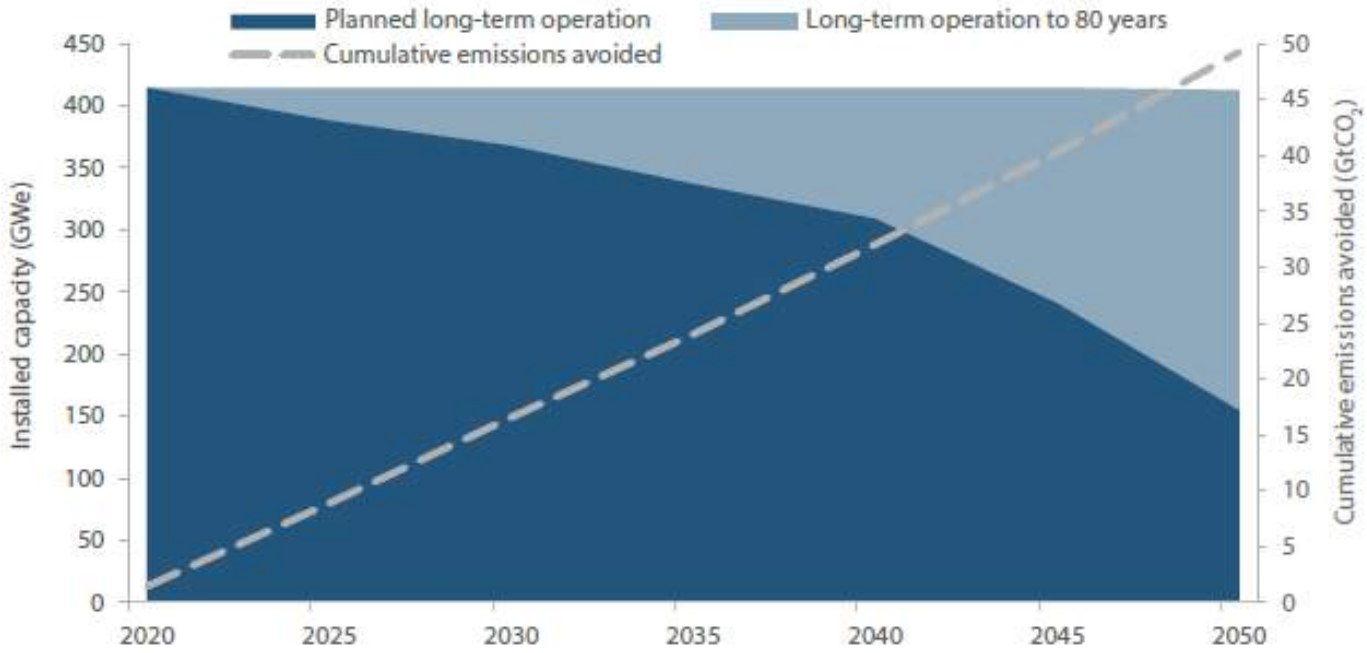
Non-Electrical applications

Complementary nuclear technologies and applications

Long-term Operation of Current Nuclear Plants

- Presently, the average age of nuclear power plants in OECD countries is 36 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)

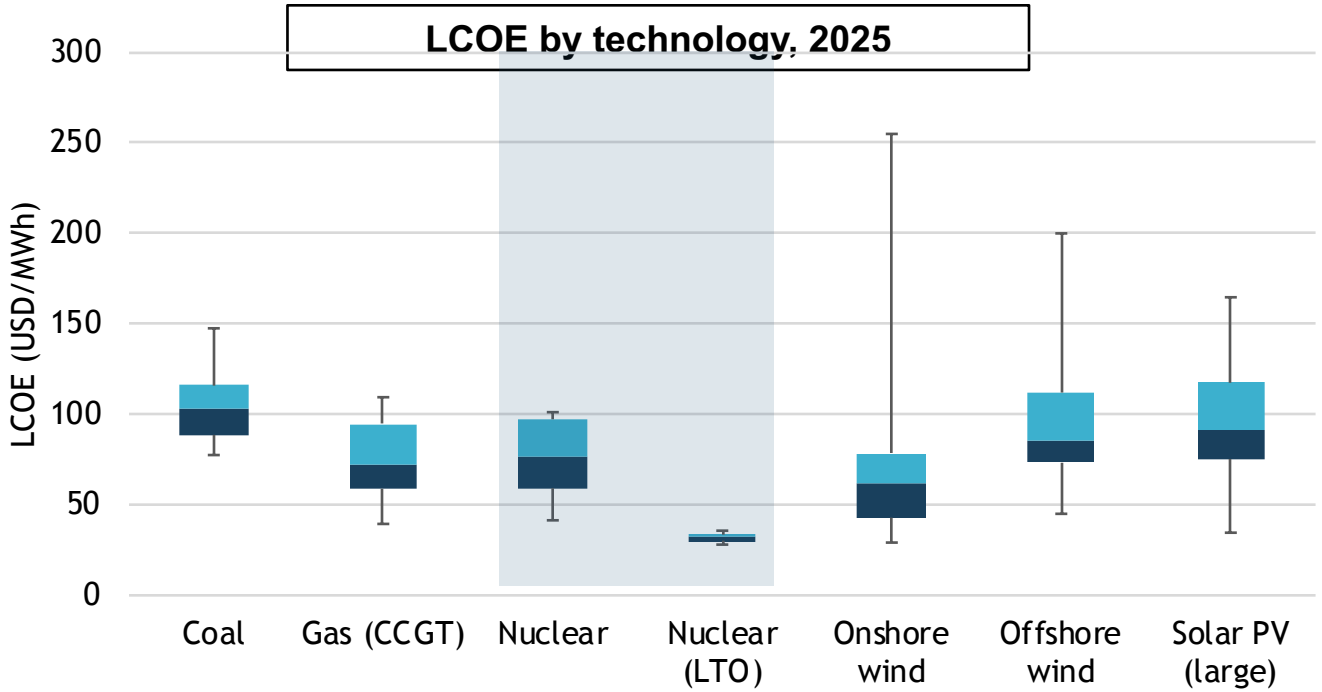


Note: Note: It is assumed that nuclear power (12 gCO_2eq/kWh) is displaced by gas with a carbon footprint of 490 gCO_2eq/kWh (Bruckner, 2014). By 2050, 25% of nuclear reactors are used for nuclear heat applications, also displacing gas. By 2050, nuclear reactors operate with a 90% availability factors 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

Challenges to 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 recognise the value of existing nuclear plants to system reliability and carbon reduction.
- Some government policies are leading to the premature shut down of nuclear plants, **placing Net Zero further out of reach.**



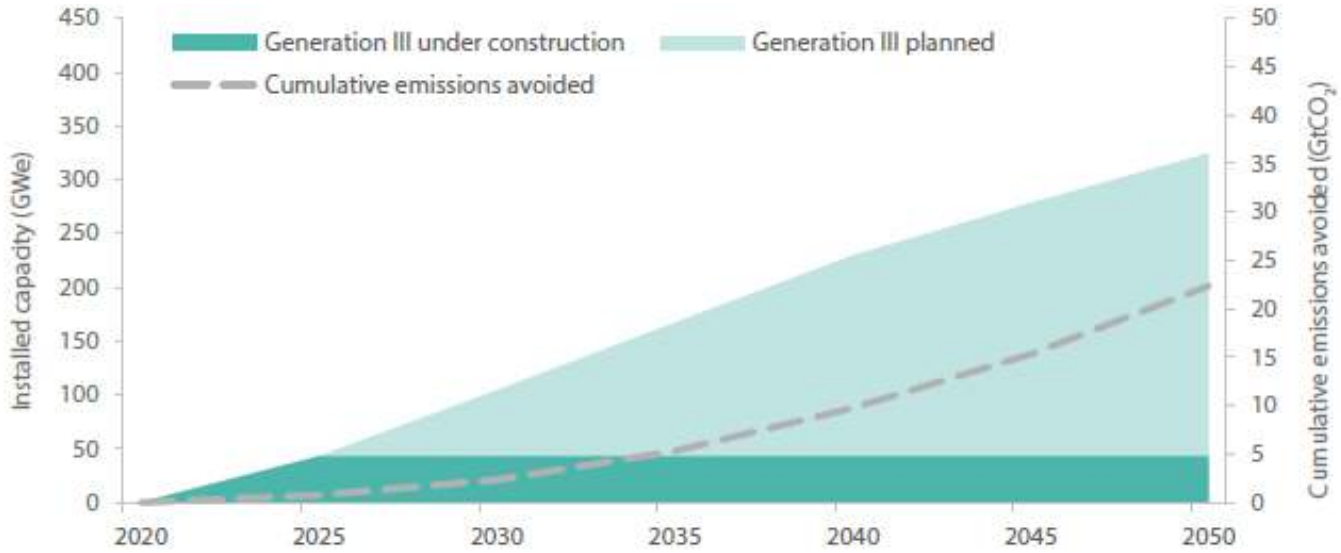
Note: Coal includes lignite plants. Discount rate of 7% and carbon price of USD30/tCO2
Source: IEA/NEA (2020)

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)



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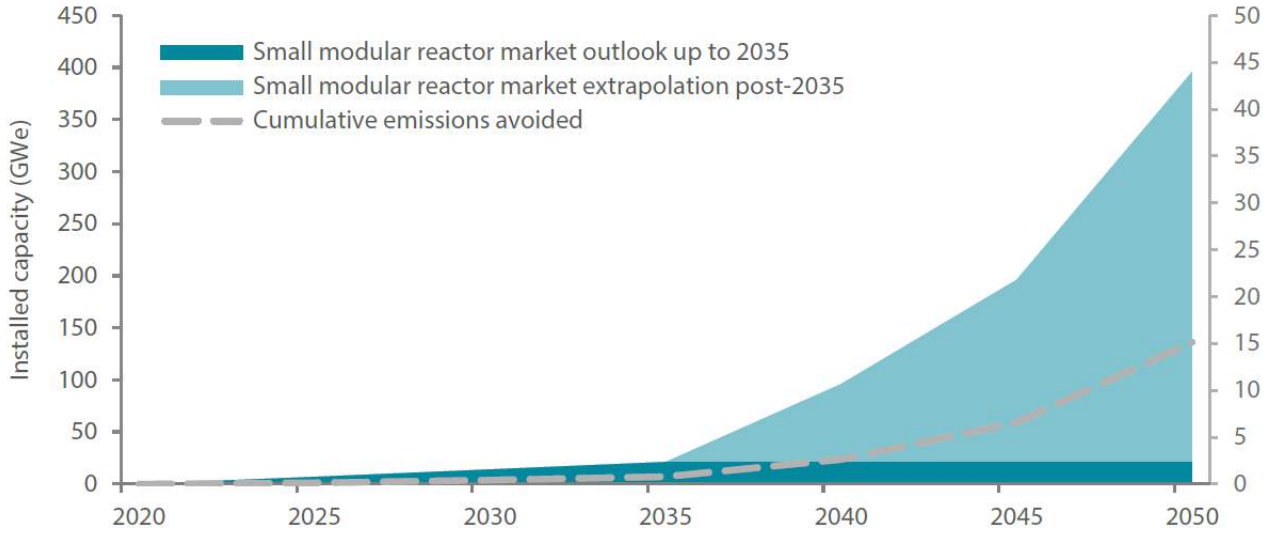
Small Modular Reactors and Generation IV Reactors

- 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



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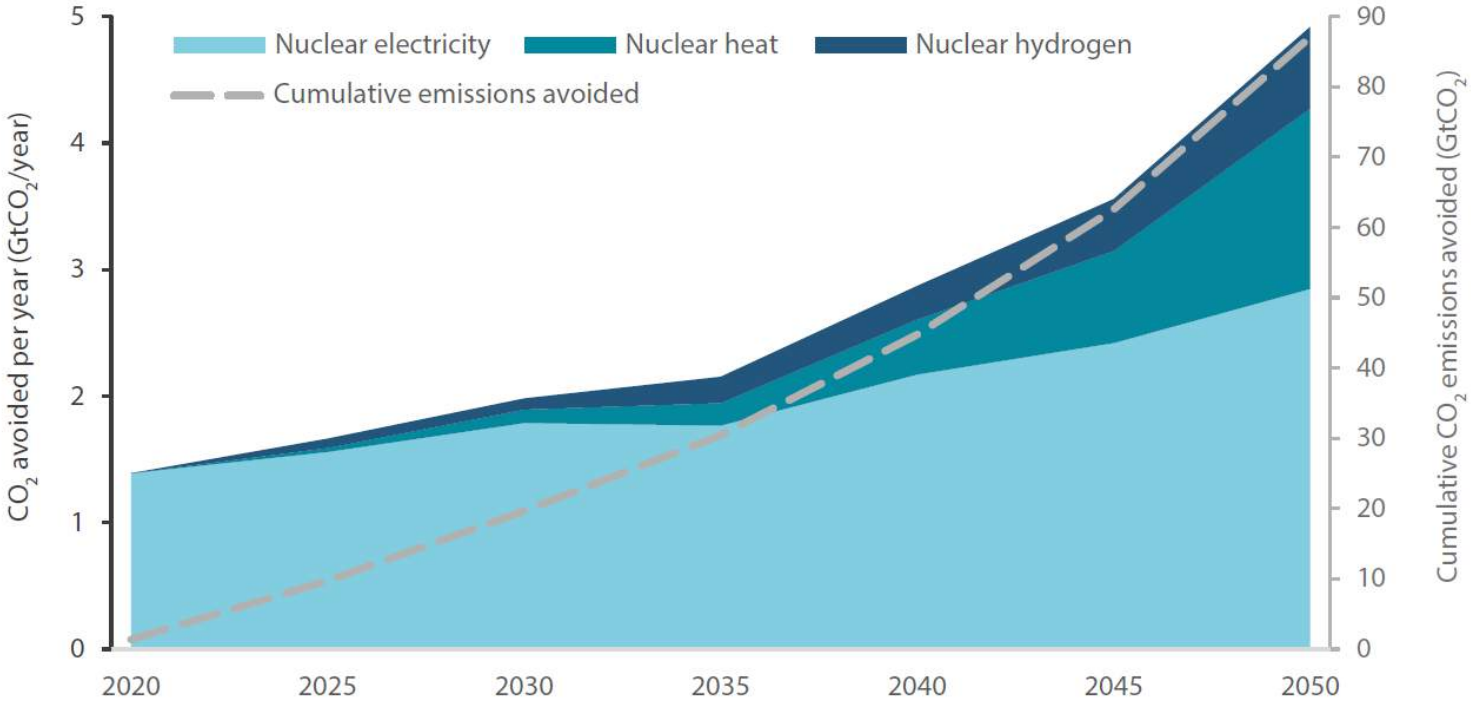
Power and Non-power Applications of Nuclear Energy

- 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

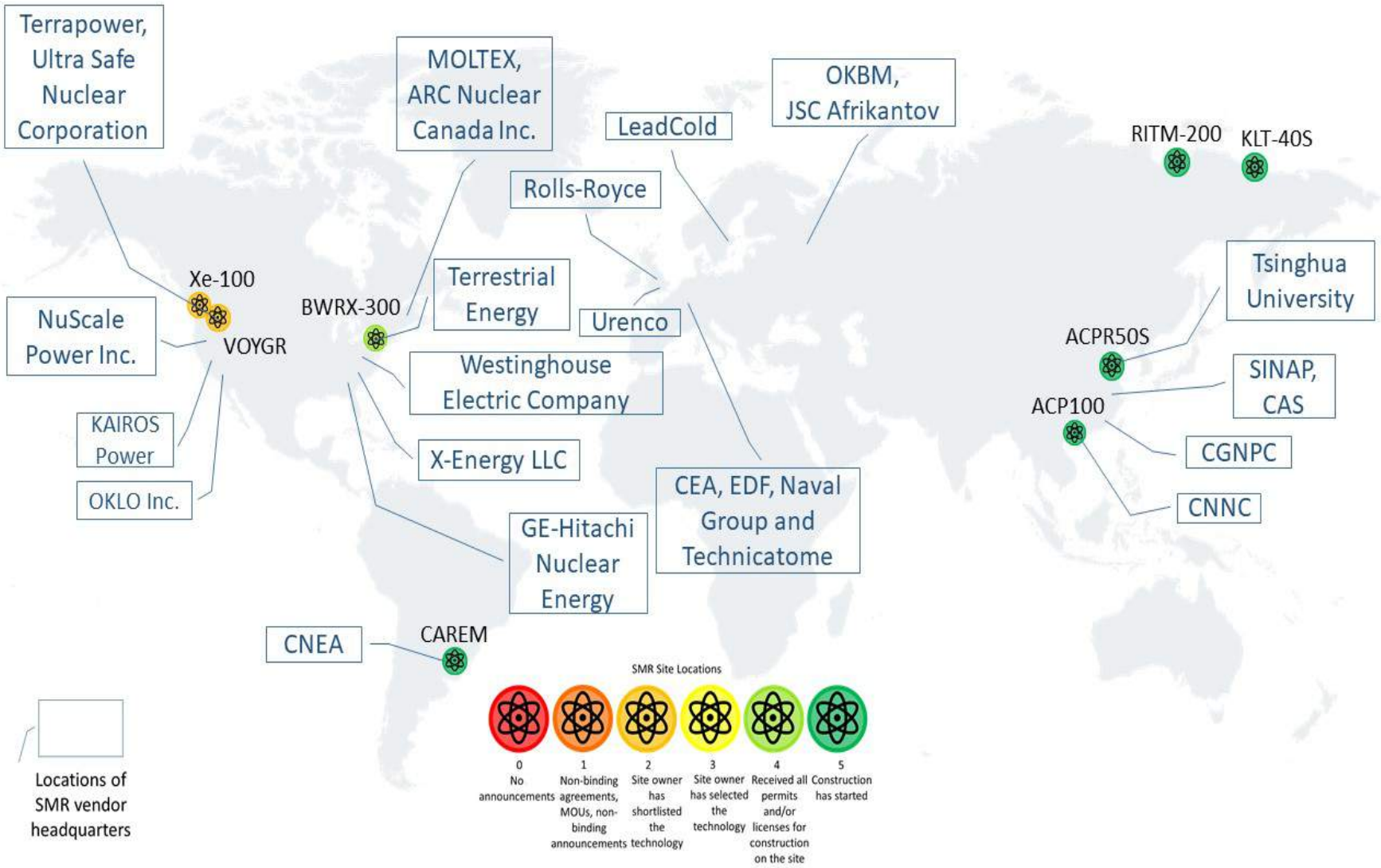
ON-GRID
- 200-300 MWe
- Replace coal

OFF-GRID
- Remote sites
- Replace diesel

MERCHANT SHIPPING
- Marine Production
- Off bunker fuel

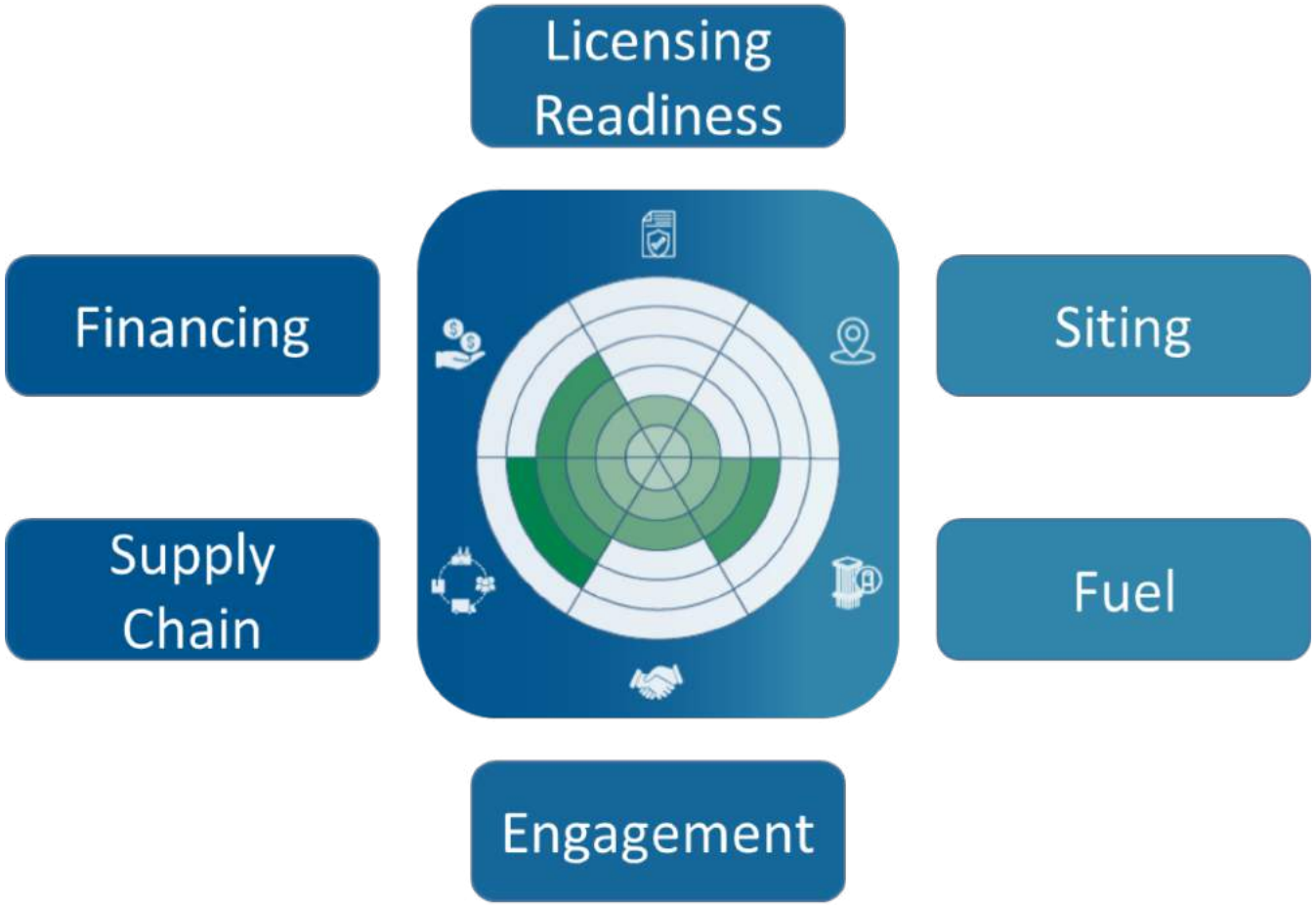
HEAT
- 285 - 850 °C
- Industrial cogeneration

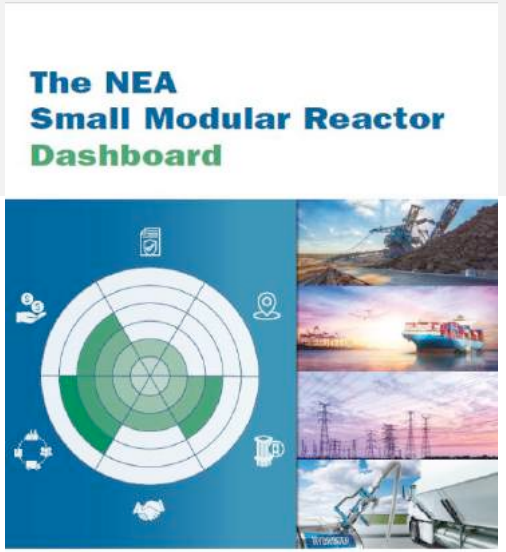
Locations of SMR Vendor Headquarters and Potential Sites for a Selection of SMRs



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



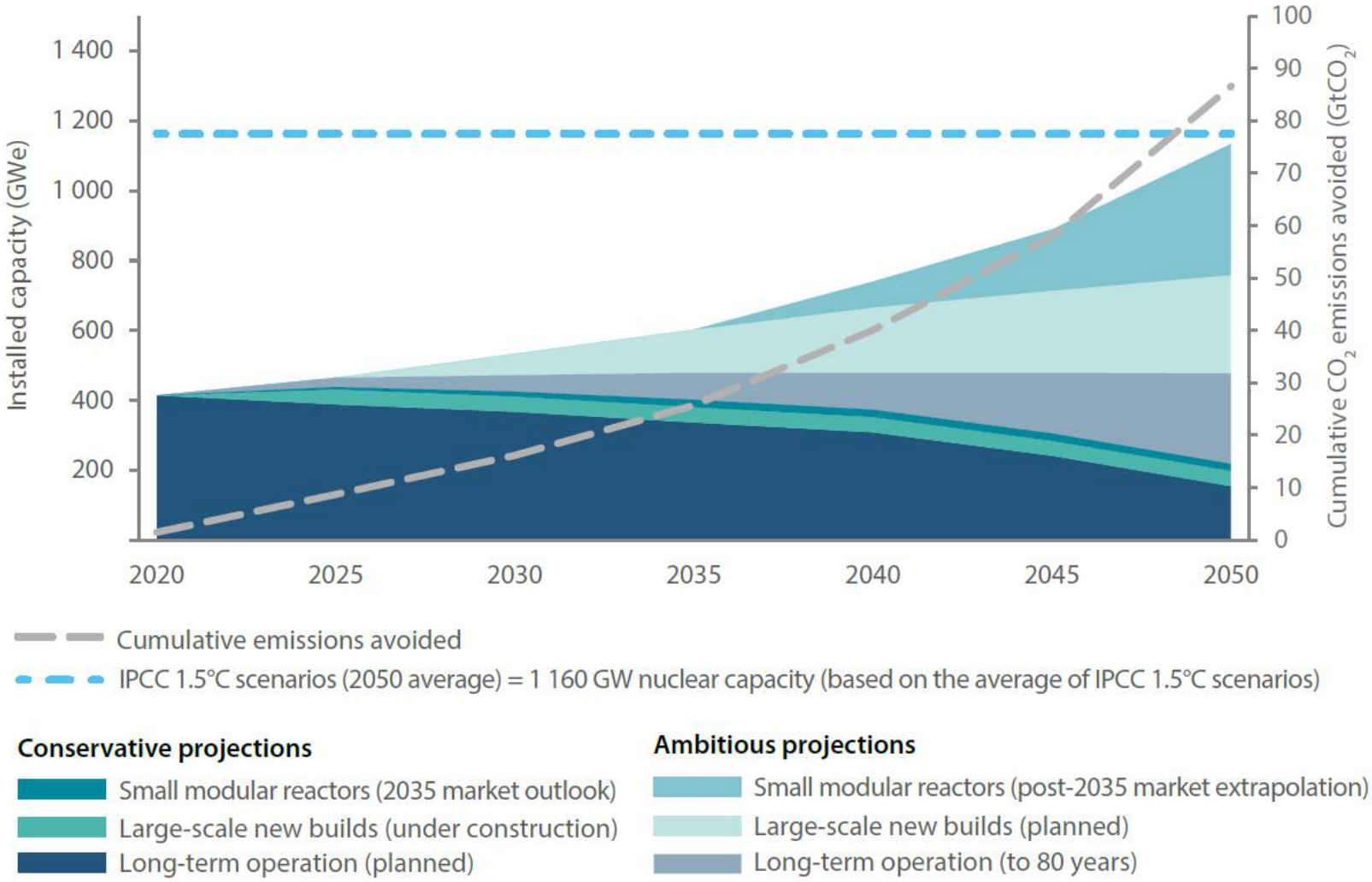


1st edition launched on March 13, 2023

SMRs Have an Important Role to Play *Alongside Long-term Operation and New Builds of Large Nuclear Power Plants*

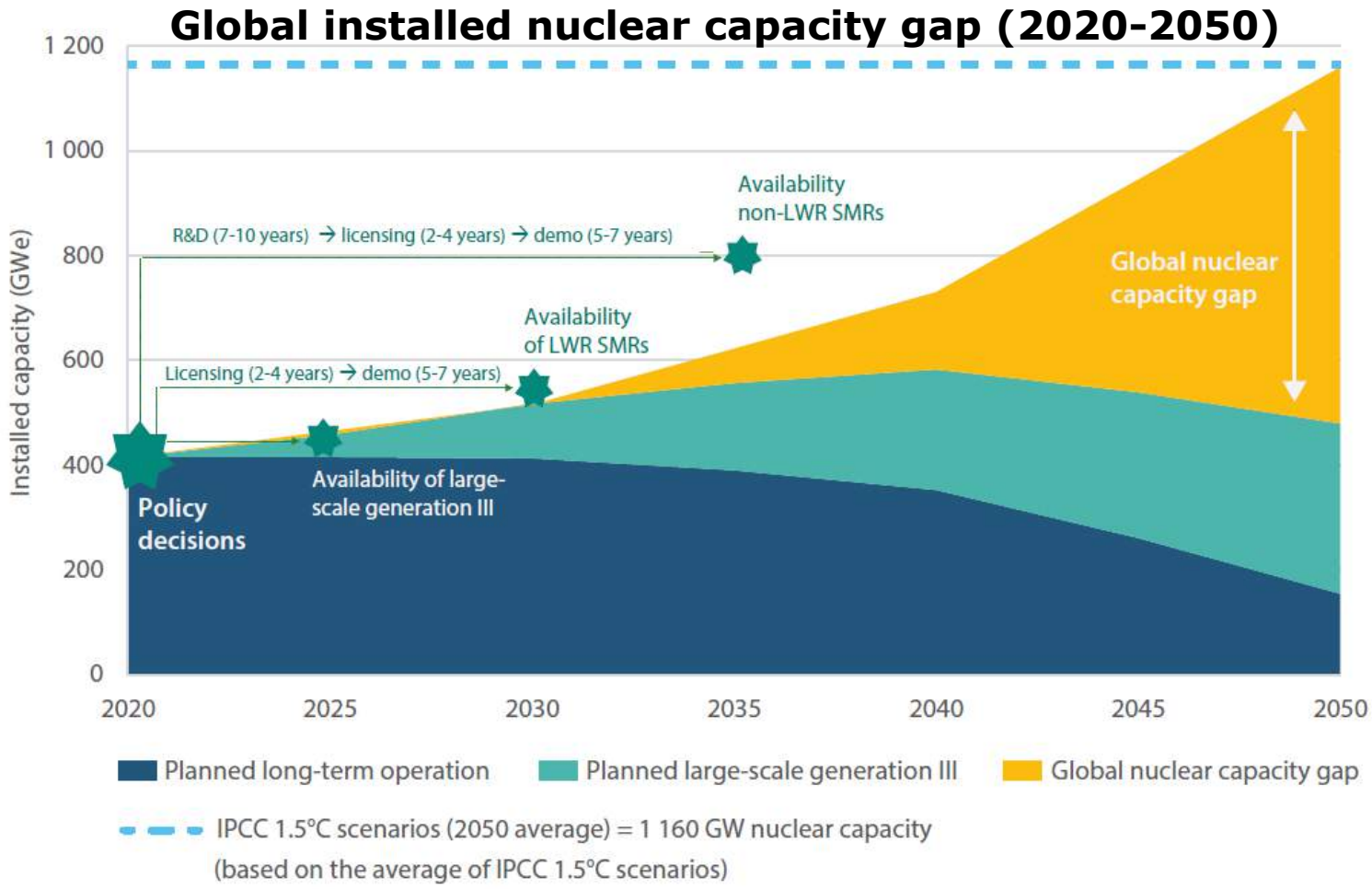
Reaching the target of 1160 gigawatts of global installed nuclear capacity by 2050 will require a **combination of long-term operation, large-scale Generation III, small modular reactors, and non-electric applications** such as nuclear-produced heat and hydrogen.

Full potential of nuclear contributions to Net Zero

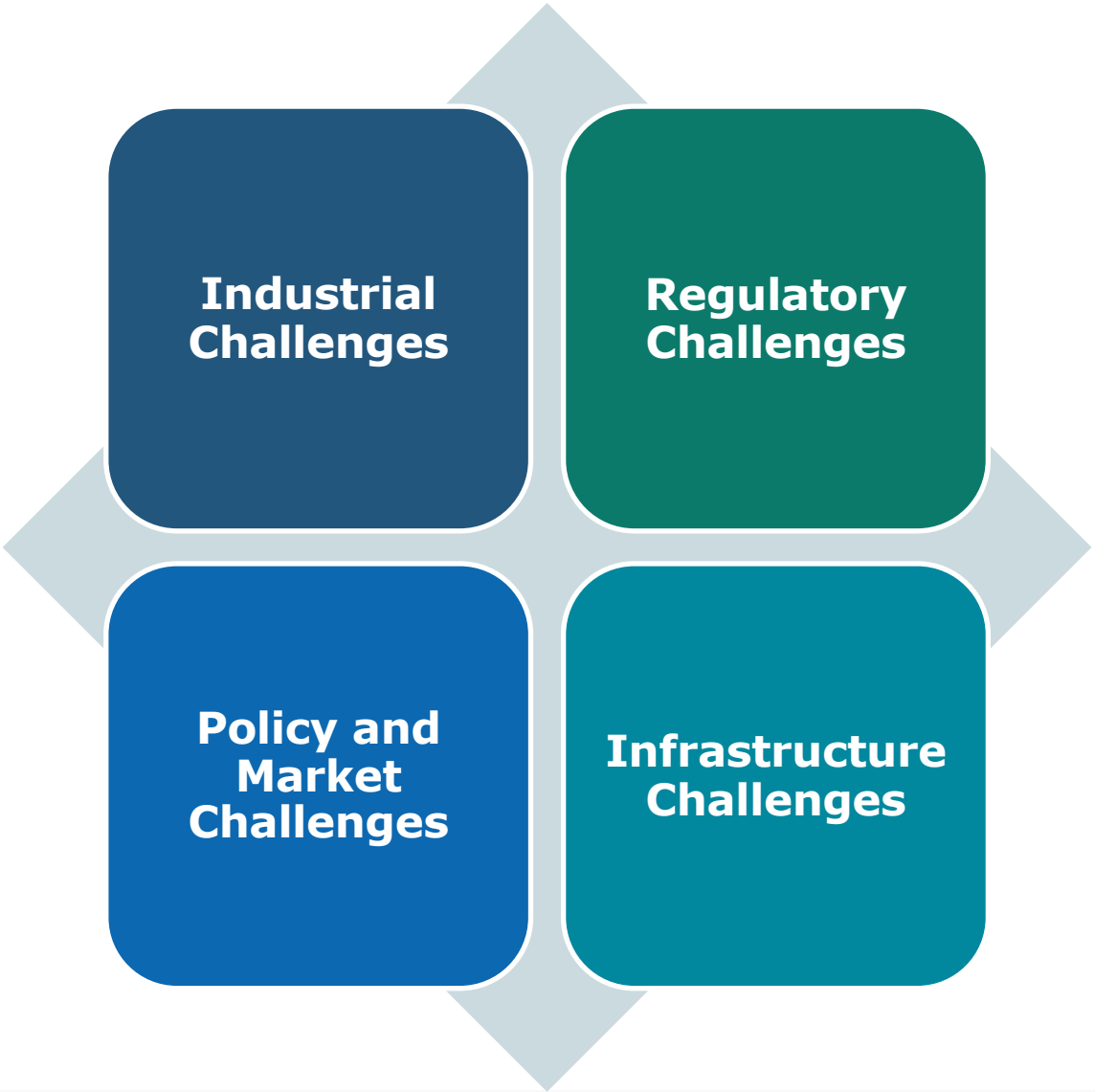


Global Installed Nuclear Capacity Gap

- 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**



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



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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

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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
- **Global Thinking**—regulators must act nationally but think globally; otherwise there cannot be a true global market for new technologies
- **Accept New Paradigms**—new technologies may be game-changers in areas such as EP and security, but regulators must be truly risk-informed

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Policy and Market Challenges

- **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; industry cannot/will not absorb all the risks
- **Financing**—government policies are needed to support financing of new nuclear construction and other high-capital investments needed to reach Net-Zero

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

Infrastructure Challenges

- **HALEU**—the lack of a clear path to provide high assay LEU is already a barrier to new technologies
- **Codes and Standards**—industry, governments, regulators and other stakeholders must commit to strive toward simplified and harmonised nuclear standards
- **Human Resources**—more must be done to promote a new generation of nuclear experts while promoting greater diversity and gender balance

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Global Forum on Nuclear Education, Science, Technology and Policy

Provides academic institutions around the world with a framework for **interaction, co-operation, and collective action**

Areas of work

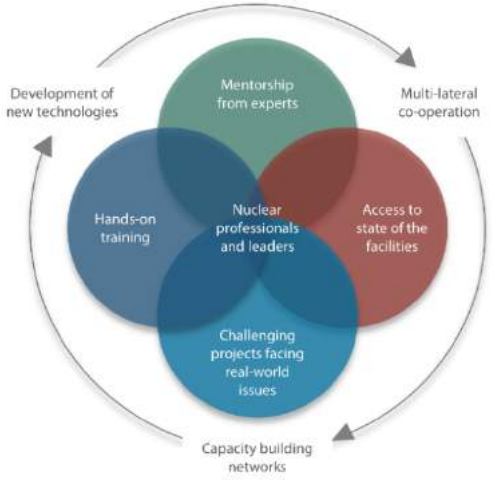
- **Achieving Gender Balance in Nuclear Technology and Academic Workforces**
- **Defining the Future of Nuclear Engineering Education**
- **Rethinking the Relationship Between Nuclear Energy and Society**
- **Revitalising Innovation in the Nuclear Sector to Improve the Future Competitiveness of Nuclear Energy**
- **Rebuilding Expertise in Nuclear Law**

The Council of Advisors (CoA):
35 members from 21 academic and research organisations from Australia, Belgium, Canada, Germany, France, Italy, Japan, Korea, the United Kingdom, and the United States

Upcoming Event: ***Global Forum Rising Stars Workshop, Sept. 2023, hosted by MIT***

- 20-21 Sept 2023 workshop at MIT for female graduate students & post-doctoral researchers
- Career development and mentoring, student presentations and discussions
- Email RisingStars@oecd-nea.org to be notified when nomination process opens

Nuclear Education, Skills and Technologies (NEST) Framework



57 Organisations

208 Fellows over the life of the current projects

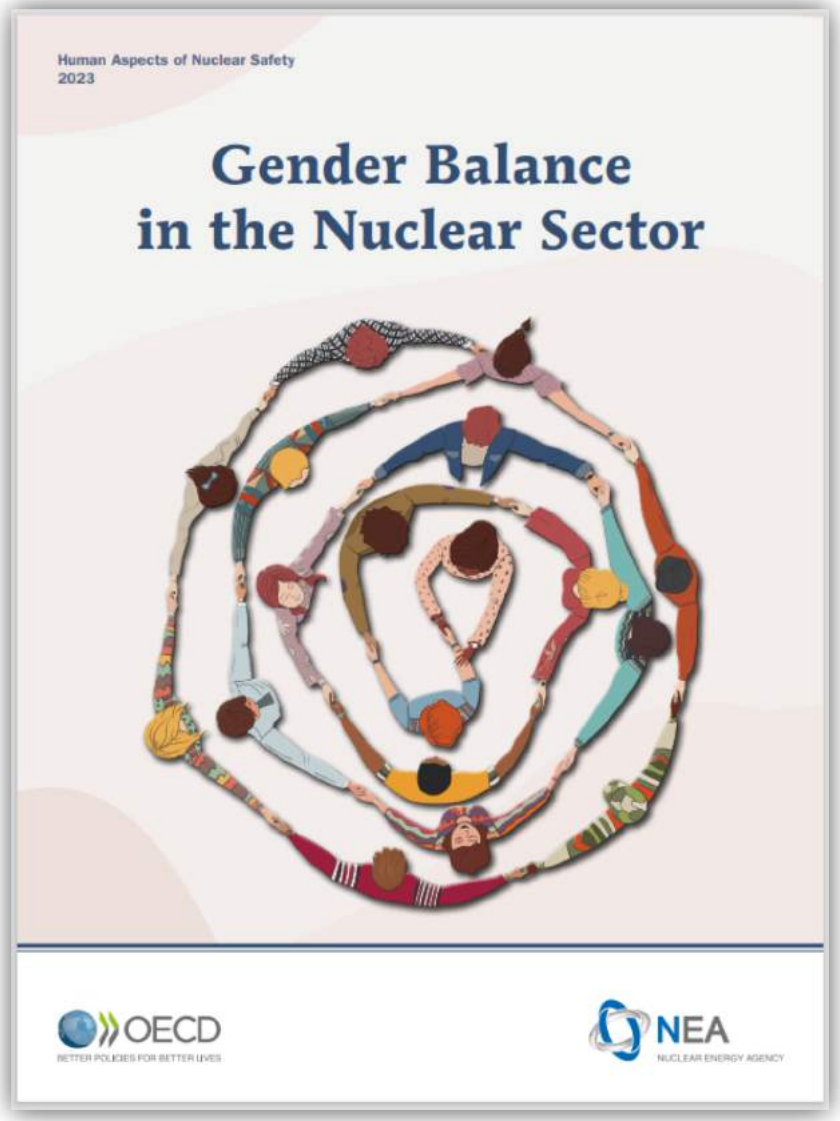
A multinational framework to maintain & build skills and to nurture the next generation of nuclear subject matter experts through transfer of practical experience and knowledge

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

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

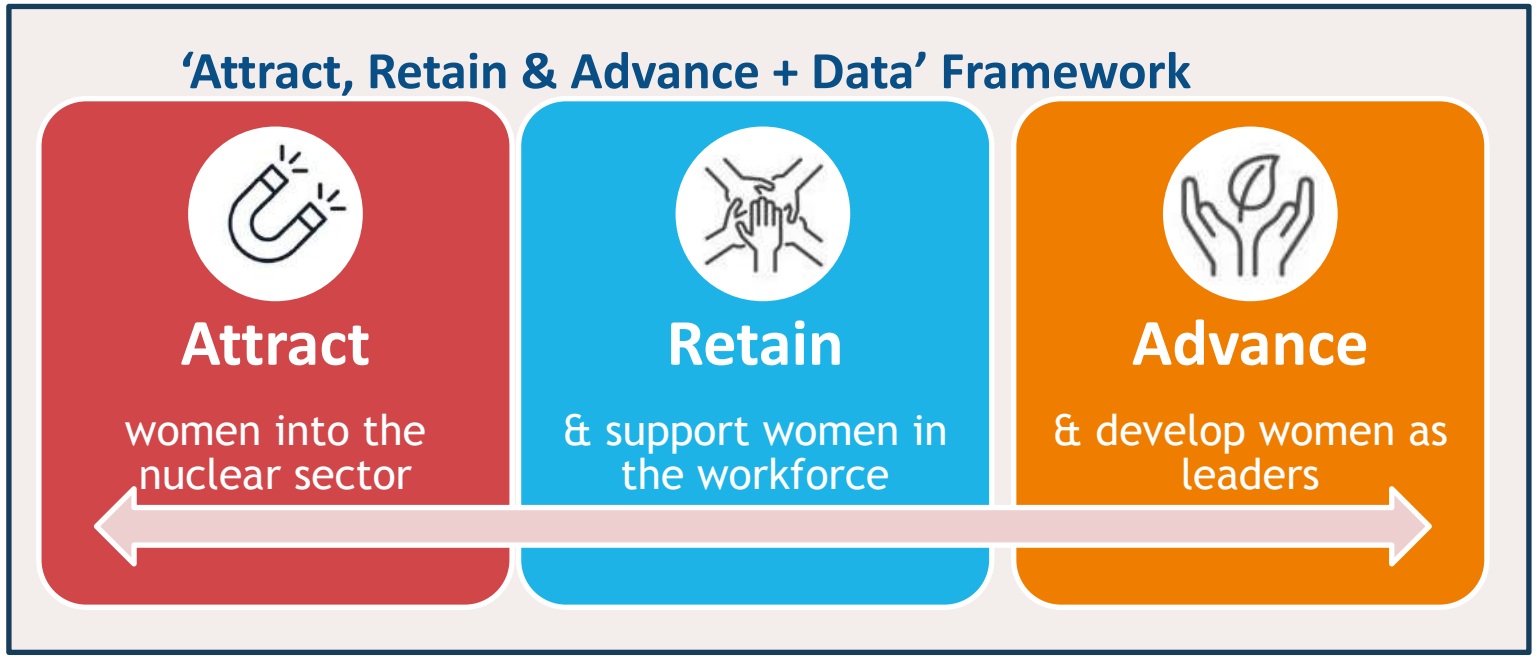
www.oecd-nea.org/nest

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.**



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

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