

Global perspectives on the present and the future of nuclear energy

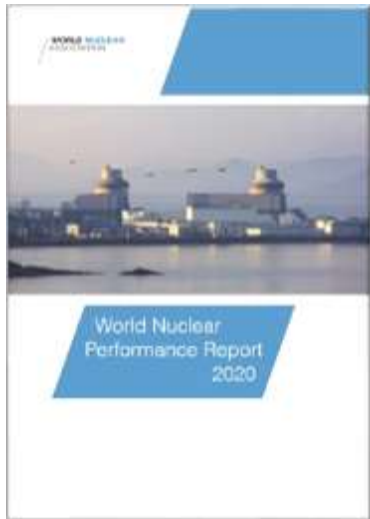


Dr. Sama Bilbao y Leon

Director General

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Mexican Nuclear Society
2021 LAS-ANS Symposium
05 July 2021

Nuclear Performance



<https://www.world-nuclear.org/our-association/publications/global-trends-reports/world-nuclear-performance-report.aspx>

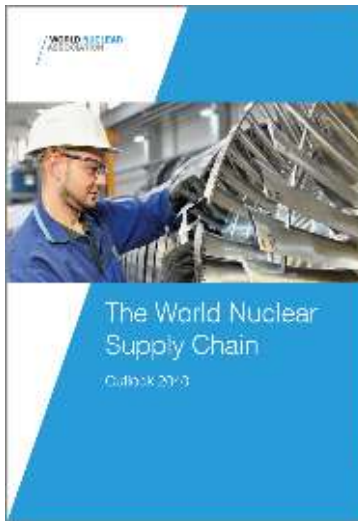
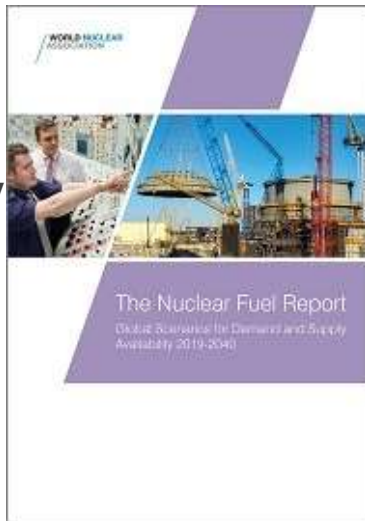


COVID-19 recovery

<https://world-nuclear.org/our-association/publications/policy-papers/building-a-stronger-tomorrow.aspx>

<https://world-nuclear.org/shop/products/the-nuclear-fuel-report-global-scenarios-for-demand.aspx>

Nuclear Fuel



Supply Chain

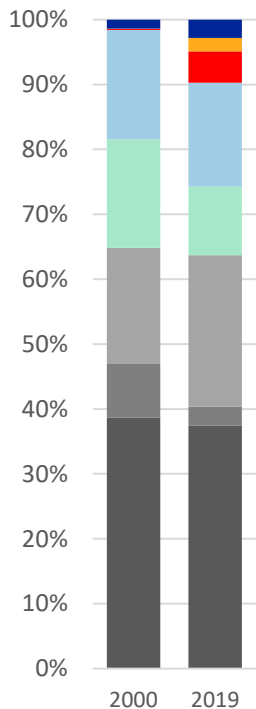
<https://world-nuclear.org/shop/products/the-world-nuclear-supply-chain-outlook-2040.aspx>

Nuclear jobs

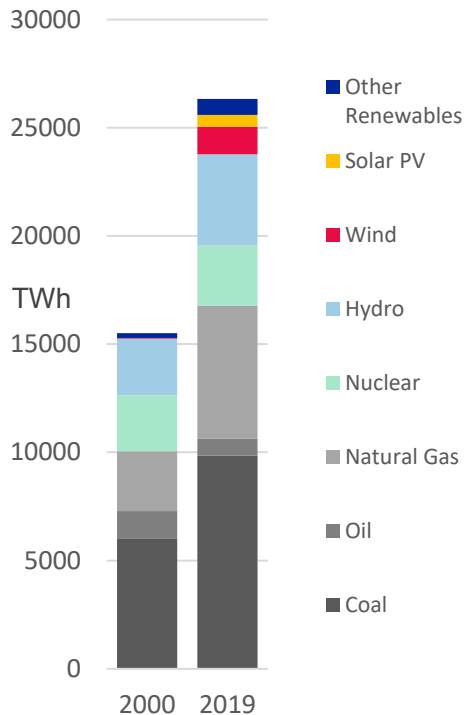


<https://www.world-nuclear.org/our-association/publications/technical-positions/employment-in-the-nuclear-and-wind-electricity-gen.aspx>

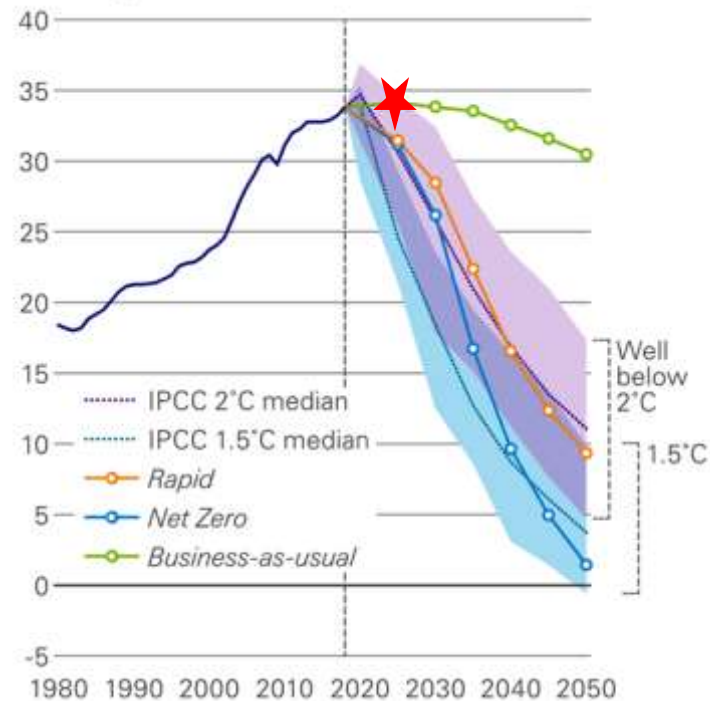
The enormity and the urgency of the climate change challenge are staggering



The share of fossil electricity generation has not significantly reduced since 2000

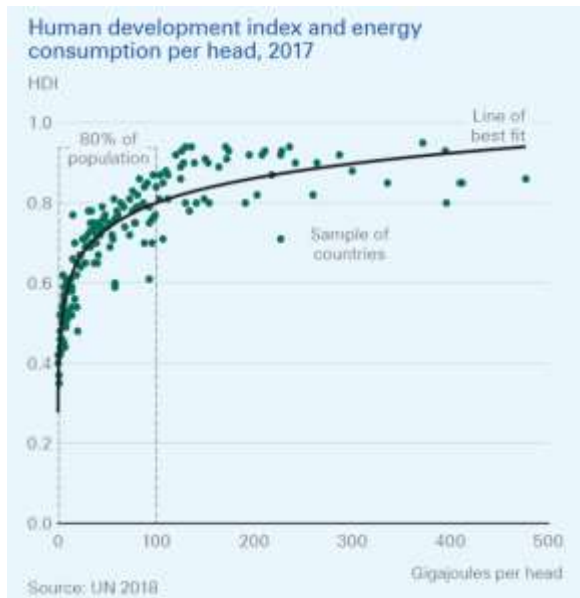


Electricity generation from fossil fuels in 2019 higher than total generation in 2000



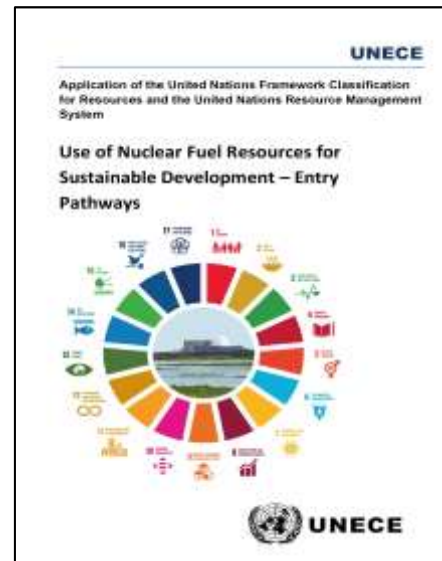
CO₂ emissions must decline over next 30 years.

Less developed nations are focused on both clean energy and socio-economic development



Source: BP Energy Outlook 2019

Around 80% of the world's population today have an average energy consumption of less than 100 GJ per head.

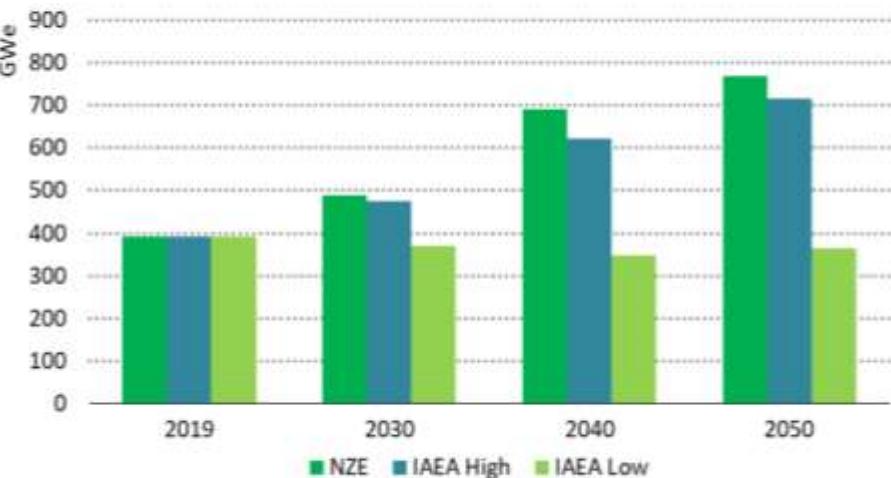


Source: UNECE, 2021 <https://unece.org/sustainable-energy/publications/nuclear-entry-pathways>

Nuclear energy is an indispensable tool for achieving the global sustainable development agenda.

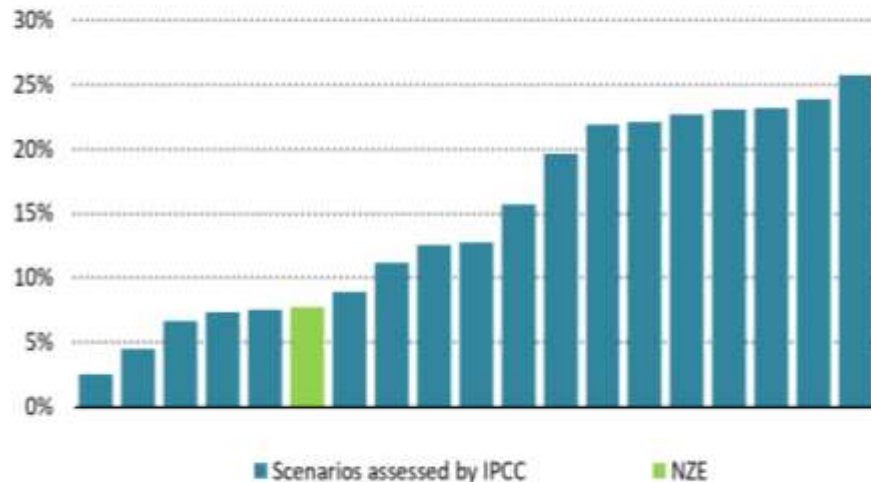
Nuclear energy is essential for deep decarbonization

World nuclear installed capacity (net)



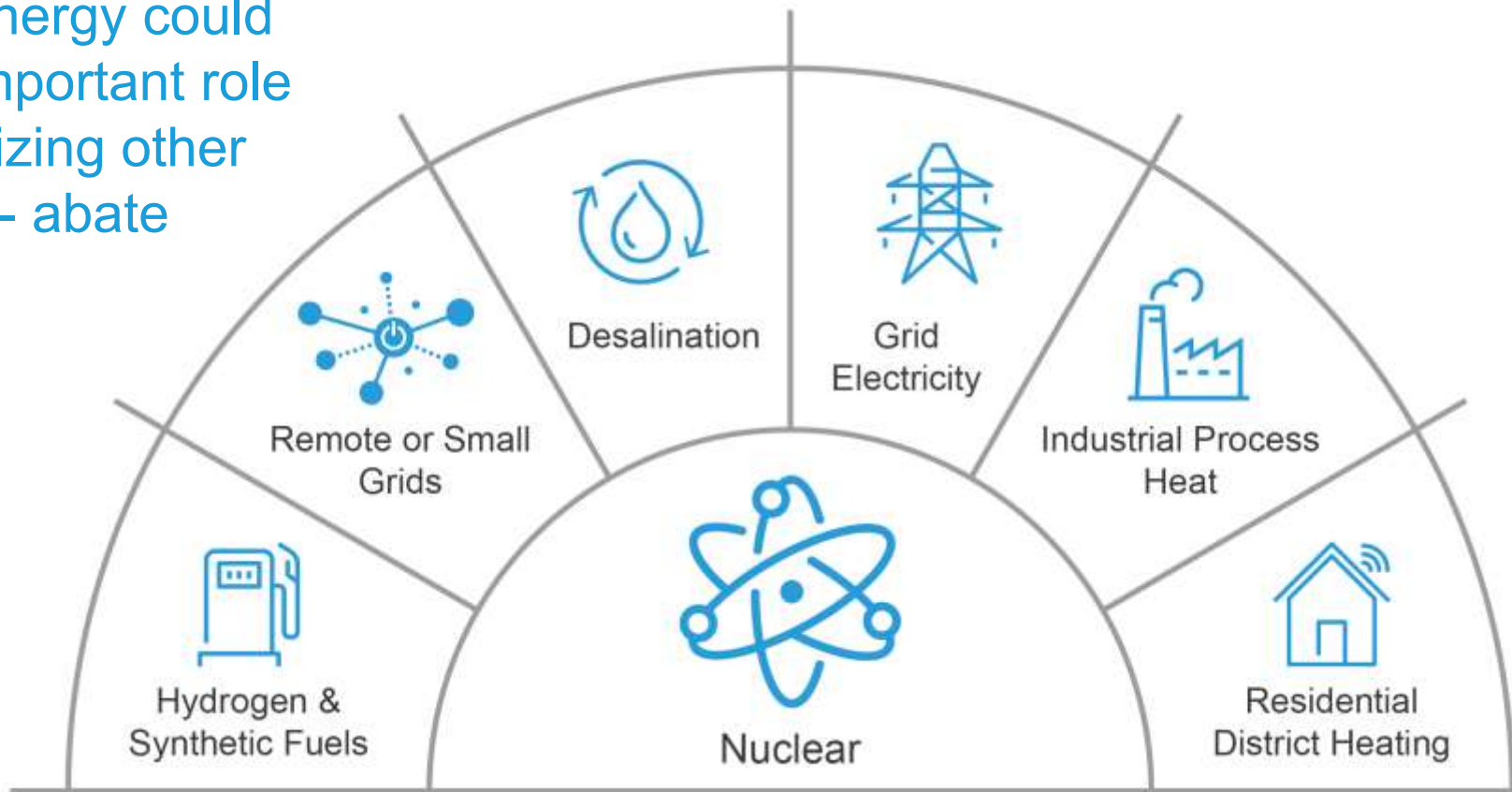
Source: IEA 2021

Share of nuclear in world electricity generation

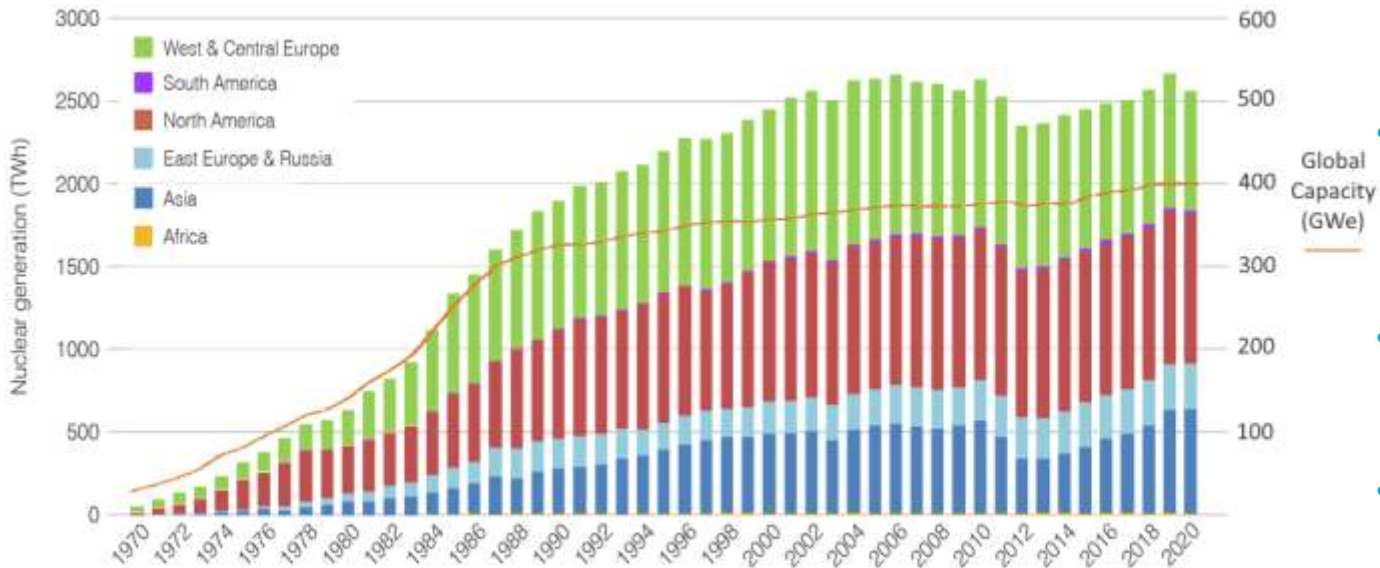


- Nuclear energy needs to grow rapidly if we are to satisfy energy demand, achieve climate targets and help the world meet the sustainable development goals.
- According to IEA Net-Zero Scenario, nuclear power doubles over the next three decades, contributing to the full decarbonisation of electricity, though its share of electricity generation falls to 8% in 2050

As the only low-carbon source that can produce electricity and heat, nuclear energy could play an important role decarbonizing other difficult-to-abate sectors



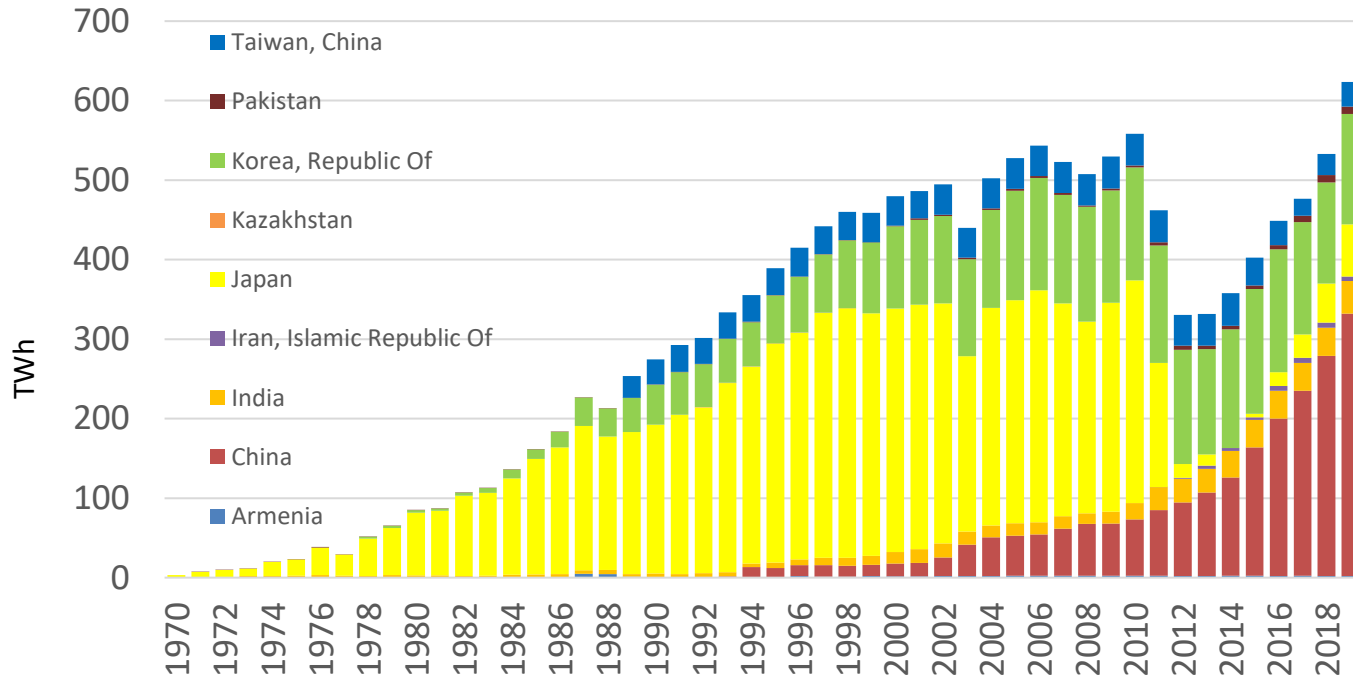
Nuclear electricity generation continues to grow despite decline of capacity



Source: World Nuclear Association and IAEA Power Reactor Information Service (PRIS)

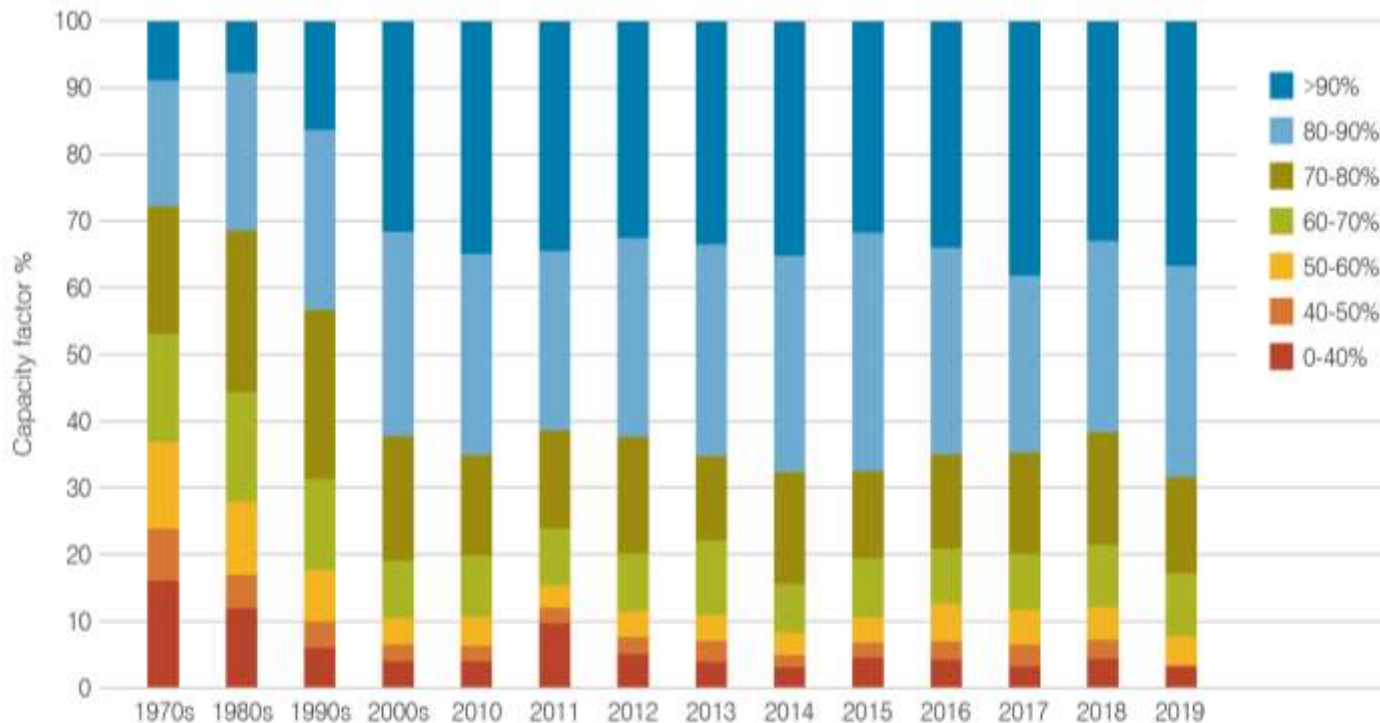
- Rapid expansion of capacity in 1970s and 1980s
- Continued growth in generation in 1990s with improved reactor performance
- Sharp decline in output in 2012 due Fukushima Daichi aftermath
- Fast 2010s growth in Asia leads to near record global output after seven years of growth.

Momentum in nuclear growth has moved to Asia



- Historic growth in Asia nuclear generation first led by Japan, then South Korea and, most recently, China.
- Huge potential for growth in China
- Turkey, UAE, Bangladesh to join Asian nuclear energy nations.
- Others, such as Philippines and Uzbekistan "seriously considering" nuclear.

Improvements in reactor operations



- Improved reactor performance has seen capacity factors rise significantly.
- In 1970s fewer than 3 in ten reactors had capacity factors over 80%.
- In 2019 nearly 7 in ten reactors had capacity factors over 80%.

Mean capacity factor by age of reactor (2015-19)



- Improved performance has been achieved with existing fleet as well as new reactors.
- There is no age-related downward trend in average capacity factors by age of reactor.
- This gives confidence in extended operations beyond 60 years.

Lots of excitement about new nuclear projects, large and small



Barakah 1 - UAE
APR-1400
In operation



Fuqing 5 - China
Hualong One
In operation



Ostrovets 1 - Belarus
VVER V-491
In operation



Akademik Lomonosov
KLT-40S - Russia
In operation



Sodium, US
345 MWe SFR
MS storage
Under Development



NuScale, US
77 MWe PWR
Design Licensed



HTR-PM, China
2x110 MWe HTGR
Under Commissioning



Terrestrial, Canada, US, UK
190 MWe IMSR
Under Development

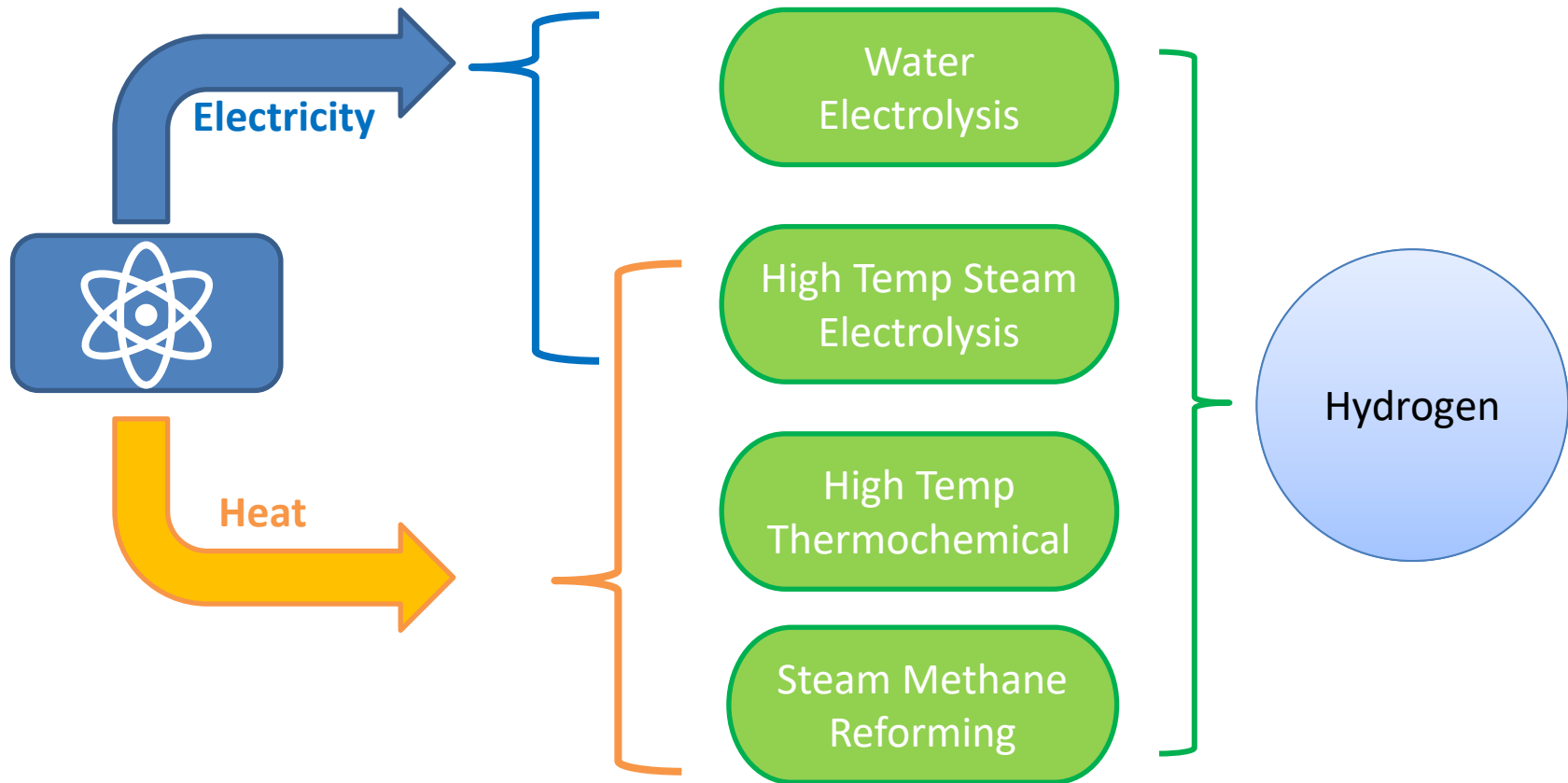


BWRX300, US
300 MWe BWR
Under Review



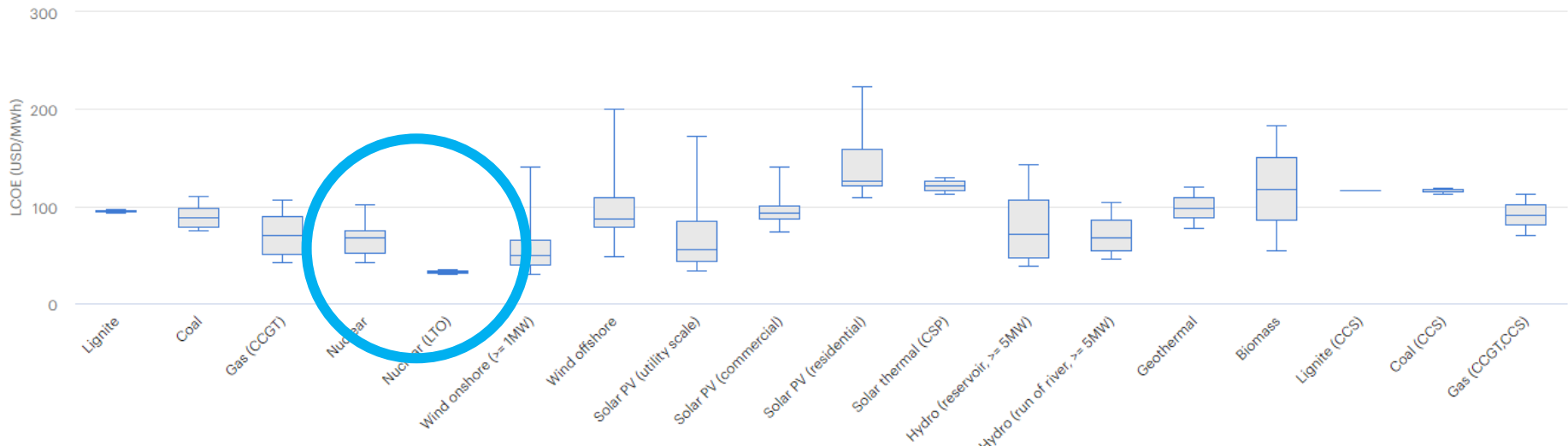
Aurora/Oklo, US
1.5 MWe Heatpipe FNR
Under Review

Nuclear energy can generate zero-carbon hydrogen



Existing nuclear and new nuclear are competitive low-carbon solutions

LCOE by technology, discount rate of 7% ▼



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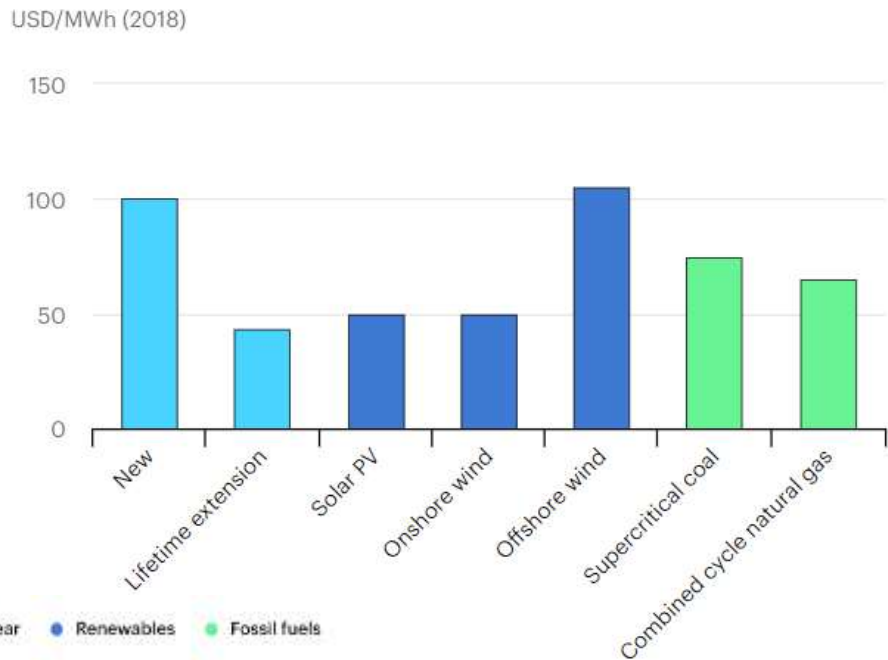
Lifetime extensions of the existing nuclear fleet are crucial in the near term



- Most cost-effective decarbonisation tool
- Preserves know-how and supply chains in nuclear sector
- Shovel-ready jobs able to contribute to post-COVID economic recovery and beyond.
- Technology & socio-economic spill-overs in local and national economies.

Policy and regulatory decision are critical to the fate of the existing fleet

Levelised cost of electricity in the United States, 2040



- Develop policies and markets that value the contributions of nuclear energy
- Establish level playing field for all low-carbon energy sources
- Explore business models that include flexible operation and revenue from products beyond electricity

New nuclear projects needed to maintain long term clean electricity goals and sustained economic development

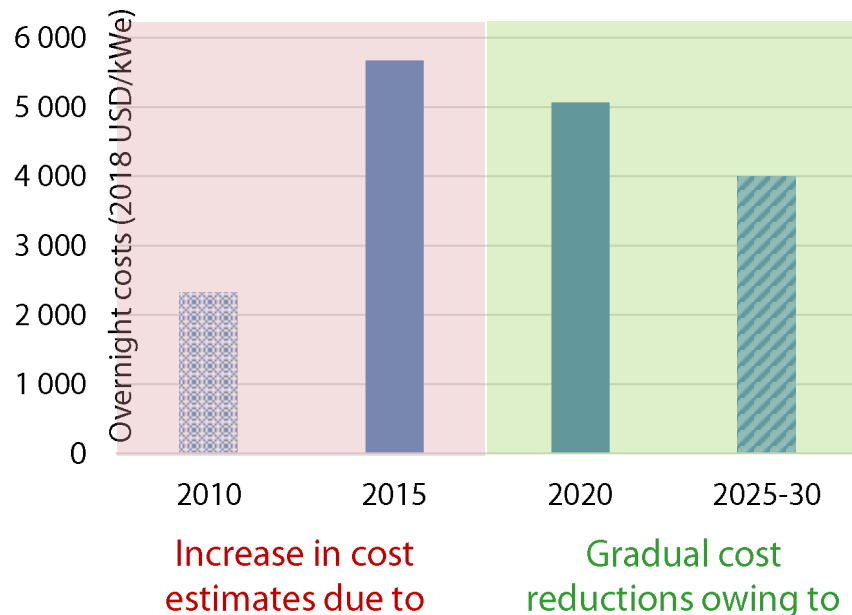
- Nuclear energy needed for clean energy transitions around the world
- New build economic multiplier effect brings enhanced benefits from initial investment.
- The development of nuclear power has historically proven to be a catalyst for industrial and economic growth and prosperity across the world.
- Promotes energy independence and security of supply, and builds resilience against geopolitical shocks.



Recent FOAK Gen-III projects don't tell a good story about new nuclear

- Gen-III initial costs estimates driven by **low level of design maturity** and the **specific political context** of announced budgets
- Recent trend in projected costs reflects **increased design maturity** and **lessons learned** for post-FOAK projects
- Gap between two sets of projections has impacted overall **perceived investment risks** and has potential to impact **public acceptance**

Capital Costs in Western FOAK



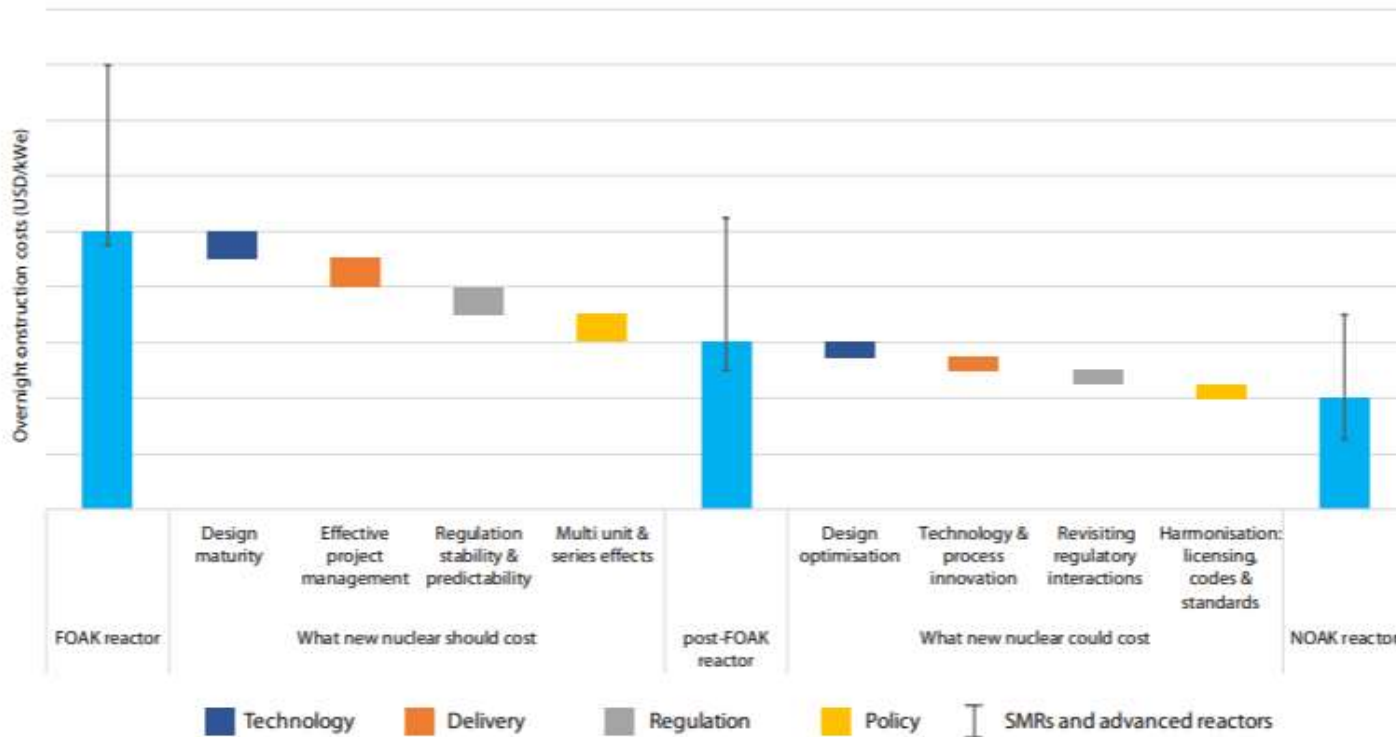
Notes: 2010, 2015 and 2020 OECD average overnight construction cost data based on 2005, 2010, 2015 and 2020 NEA/IEA Projected Cost of Generating Electricity reports, adjusted for USD inflation using OECD statistics.

Source OECD/NEA, 2020 https://www.oecd-nea.org/jcms/61082_Media/unlocking-reductions-in-the-construction-costs-of-nuclear-a-practical-guide-for-stakeholders

https://www.oecd-nea.org/jcms/pl_51110/projected-costs-of-generating-electricity-2020-edition

There is a window of opportunity to reduce nuclear costs

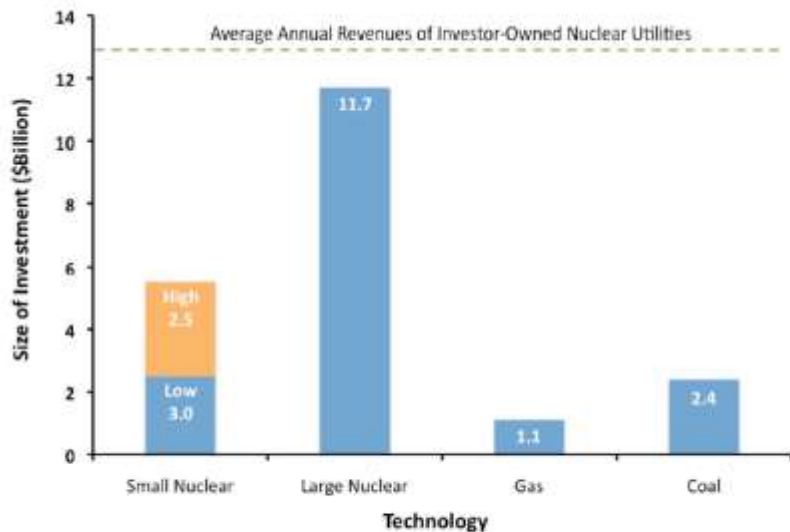
Figure 1: Nuclear cost and risk reduction drivers



Note: kW_e = kilowatt electrical capacity.

SMRs may be a game-changer for nuclear energy...

More Affordable: Business Model



Less Risky: Financing

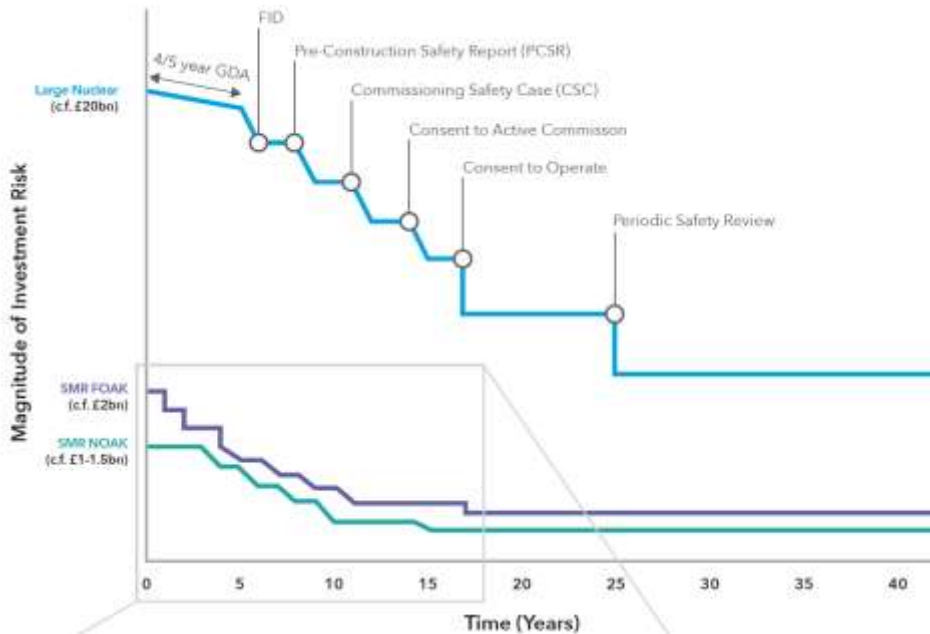
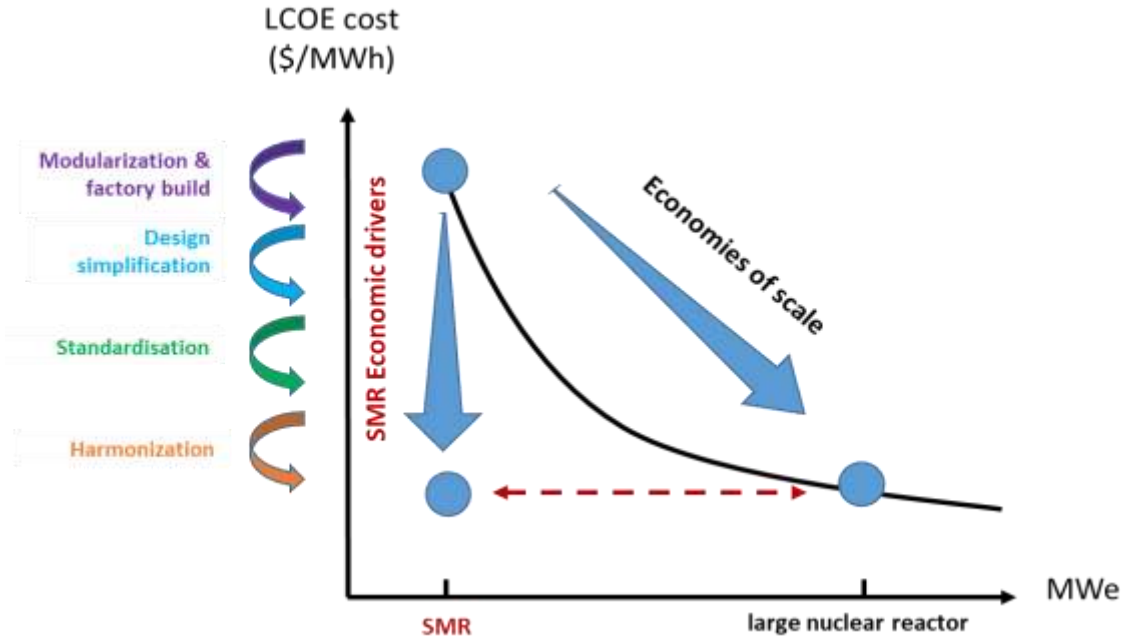


FIGURE 1 Comparison of Size of Investment (i.e., Overnight Cost) with Average Annual Revenues of Investor-Owned Nuclear Utilities¹⁷

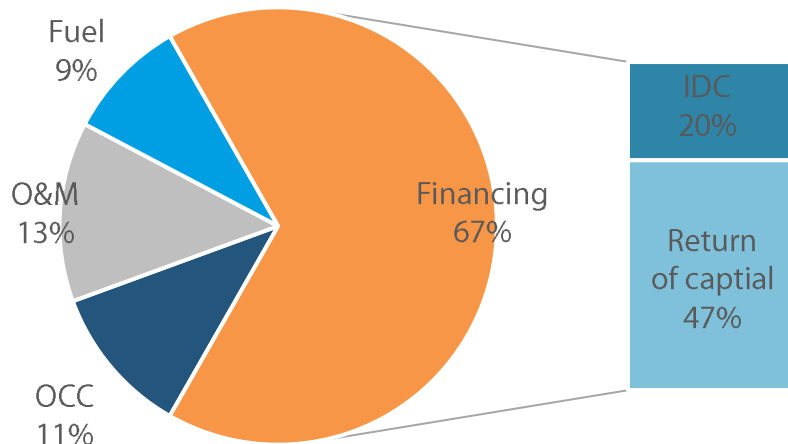
... but many challenges remain to deploy SMRs at large scale

- Technology choice
- Role of demonstration project
- Streamlining of International licensing
- Supply chain consolidation
- Public / private partnerships



Government support needed to instil confidence and incentivise long term planning and investment

Investment costs could represent 78% of nuclear production costs



Source: NEA, 2020 https://www.oecd-nea.org/jcms/pl_30653

Note: Calculations based on OCC of USD 4 500 per kilowatt of electrical capacity (/kW_e), a load factor of 85%, 60-year lifetime and 7-year construction time at a real discount rate of 9%.

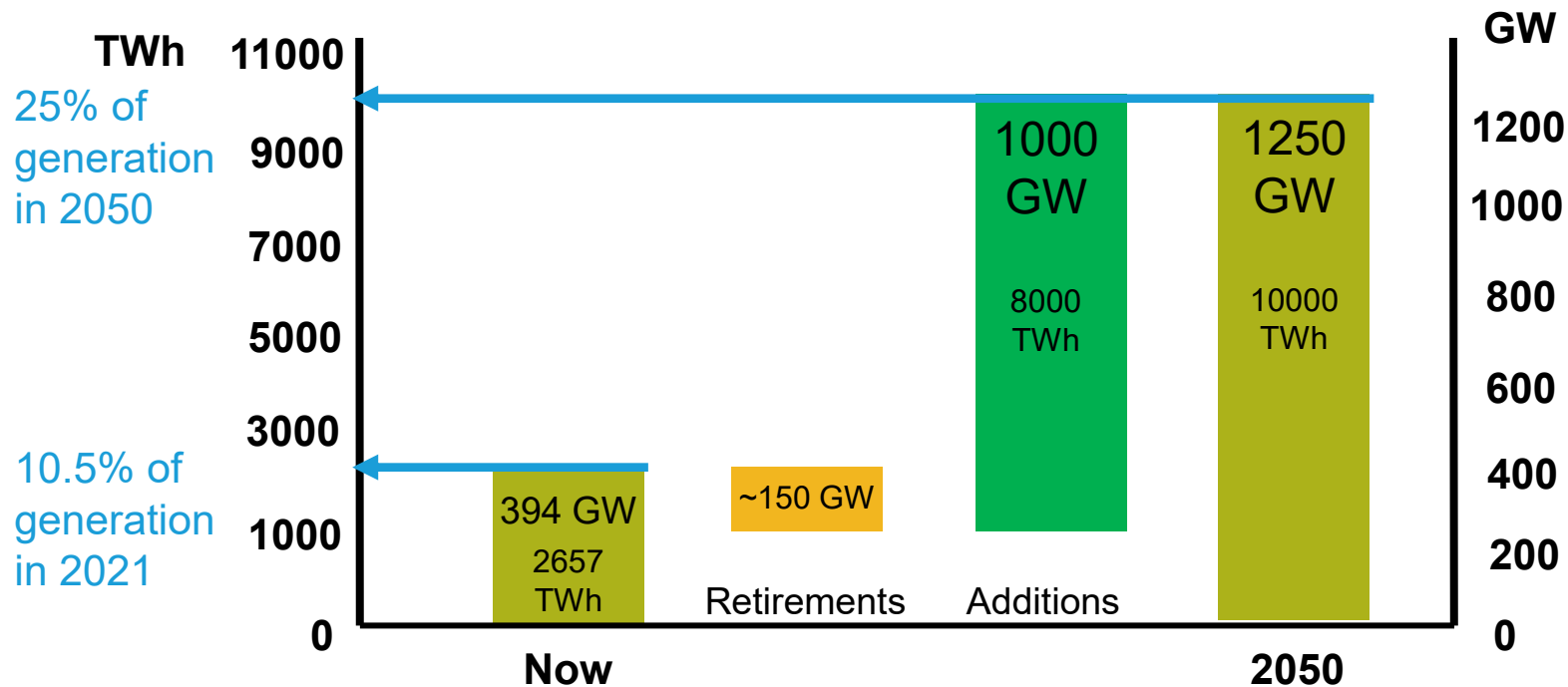
- Streamlining the **nuclear regulatory** sector
- **Level playing field** with other low-carbon technologies
- Unlocking **low-cost finance** for nuclear projects

Innovation is needed to seize the opportunities and face the challenges

- Essential to **sustain** and enhance global nuclear capabilities for nuclear R&D, operation, supply chain and regulation
- Needed to bring **disruptive technologies** to deployment on a **global** basis
- Transformations in the **nuclear regulatory** sector are essential
- **Multilateral cooperation** is critical

The private sector must work together, but cannot do it alone: government support is crucial

A sense of urgency is needed in the global nuclear community to deliver on promises



Source: World Nuclear Association. Growth required for nuclear energy to supply 25% of electricity in 2050 under demand forecast of two-degree scenario (see IEA, 2015, Energy Technology Perspectives 2015.)
Assumption: 91% capacity factor

WORLD NUCLEAR ASSOCIATION

The Harmony programme is a global initiative of the nuclear industry coordinated by World Nuclear Association.



Sama.BilbaoyLeon@world-nuclear.org