Note: Beznau nuclear power plant. PWR Unit 1 is 52 years old, being the oldest operating reactor in Europe.
Source: Courtesy of SwissNuclear.

Long-term Operation of Nuclear Power Plants and Decarbonisation Strategies

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Outline

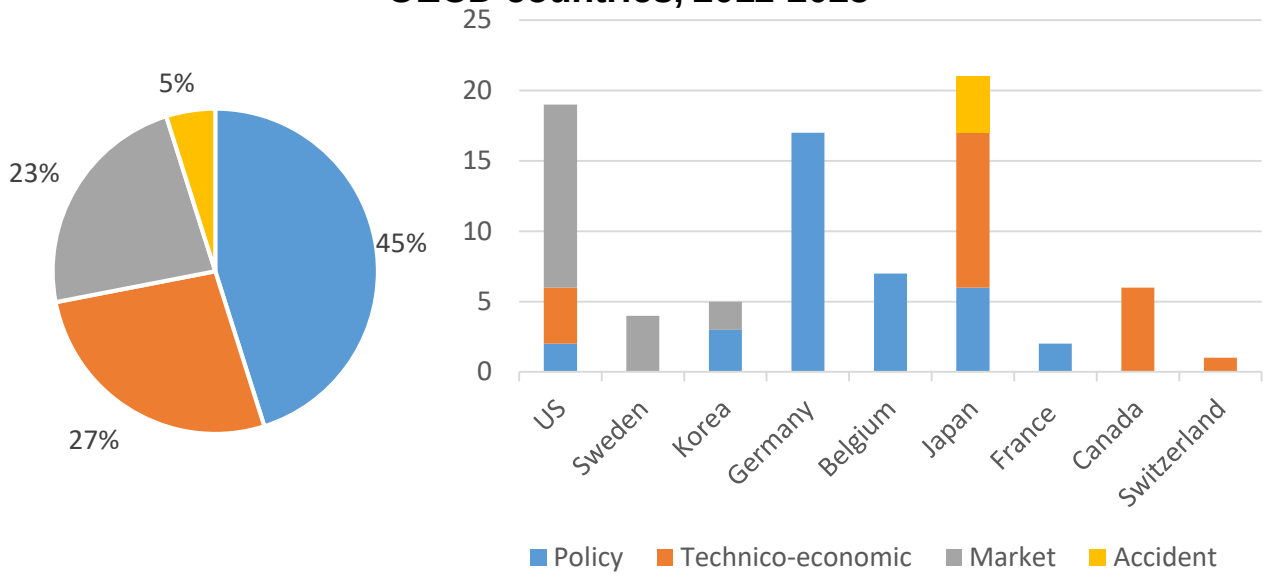
- Motivation: *The Challenge of Decarbonising without Long-term Operation (LTO)*
- Scope and Objectives: *The Holistic Nature of LTO Investment Decisions*
- Key Findings
- Conclusions and Policy Recommendations
- Publication of the Report

Motivation:

The Challenge of Decarbonising without Long-term Operation (LTO)

- Nuclear power is **the second largest source of low-carbon** electricity in the world (1st in OECD)
- LTO benefits also include **affordability** and **security of supply** considerations
- More than 60% of recent closures motivated by **policy decisions and challenges with existing markets**

Plant closures by country and reason according to stated policies in OECD countries, 2011-2025

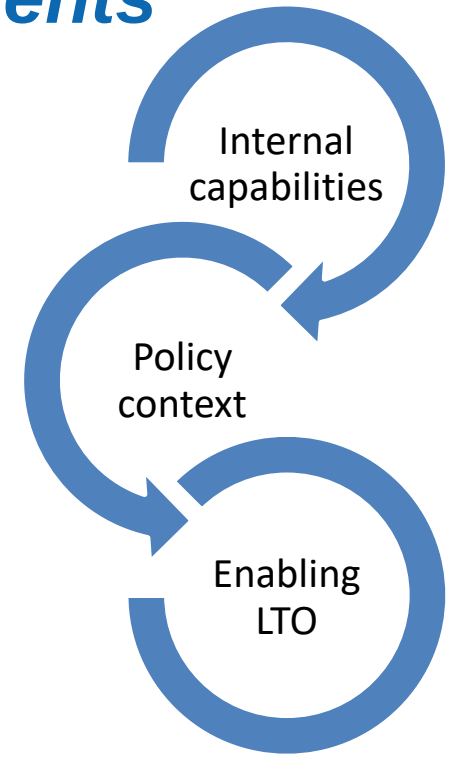


Note: The technologies covered are LWRs and PHWRs. The plant closures in Japan due to policy reasons were decided by the utilities considering the request from national and/or local government.

With an **average age of 35 years** in most OECD countries**, LTO investments will play a growing role** to support ambitious decarbonisation strategies in the **current decade**, and governments have a key enabling role to play

Scope and Objectives:
The Holistic Nature of LTO investments

- In practice, LTO decisions are complex and require the analysis of multiple factors **beyond technical aspects**.
- Enabling LTO requires a holistic approach encompassing the **internal capabilities** of the existing fleet and the specificities of their **policy context**.
- Opportunity to **update the 2012 LTO costs figures** and to include new values in the 2020 edition of the IEA/NEA Projected cost of Generating Electricity publication



Objective: perform a comprehensive analysis of LTO in all its dimensions in order to identify key factors/conditions that would enable longer operating timeframes for existing reactors to meet climate targets.

Key Findings

Preconditions for LTO

1. LTO is enshrined in most regulations as part of a continuous improvement logic

   I. Case Study – Assessing the impact of legal operational limits in Japan

2. No major technical showstopper for longer operating periods and adaptations

   II. Case Study – Operation beyond 60 years in the United States

LTO in decarbonisation strategies

3. LTO supports ambitious decarbonisation strategies and *other policy priorities*
4. The importance of a low-carbon mix based on mature solutions
5. Managing emissions in a predictable manner
6. The competitiveness of LTO in today's electricity markets

   III. Case Study – LTO costs in Japan: Lessons from the NEA EGLTO

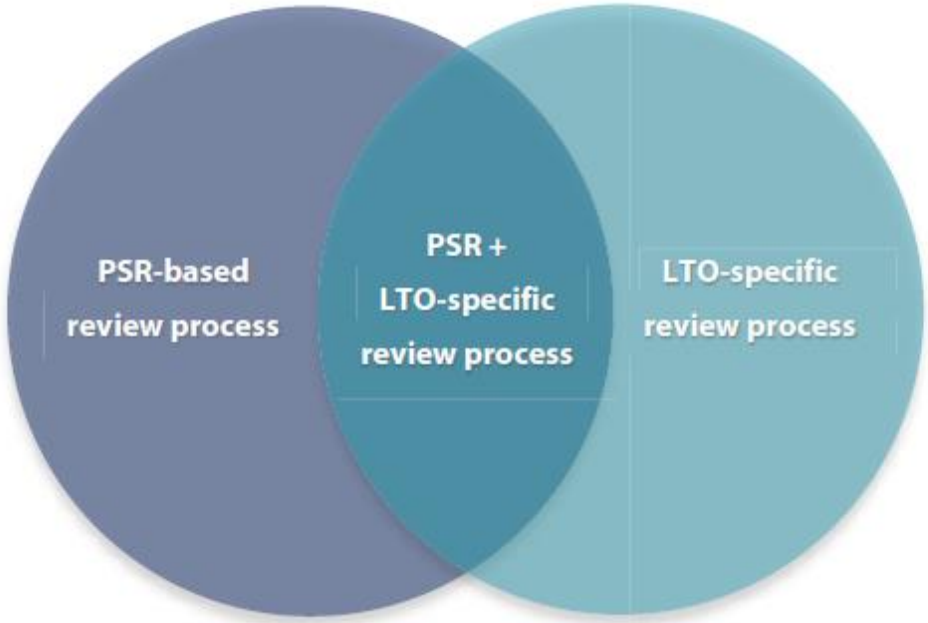
Industrial implications of LTO

7. Operations continue to improve despite ageing
8. Supply chain risks are a rising concern

1. LTO is enshrined in most regulations as part of a continuous improvement logic

- Most laws or regulations provide for indefinite terms or allow for **unlimited extensions**
- In terms of safety, **ageing issues** and **new safety** and **security requirements** are the main areas of the LTO-review process
- Environmental impact assessments, including **transboundary consultations**, can be part of the LTO-review process

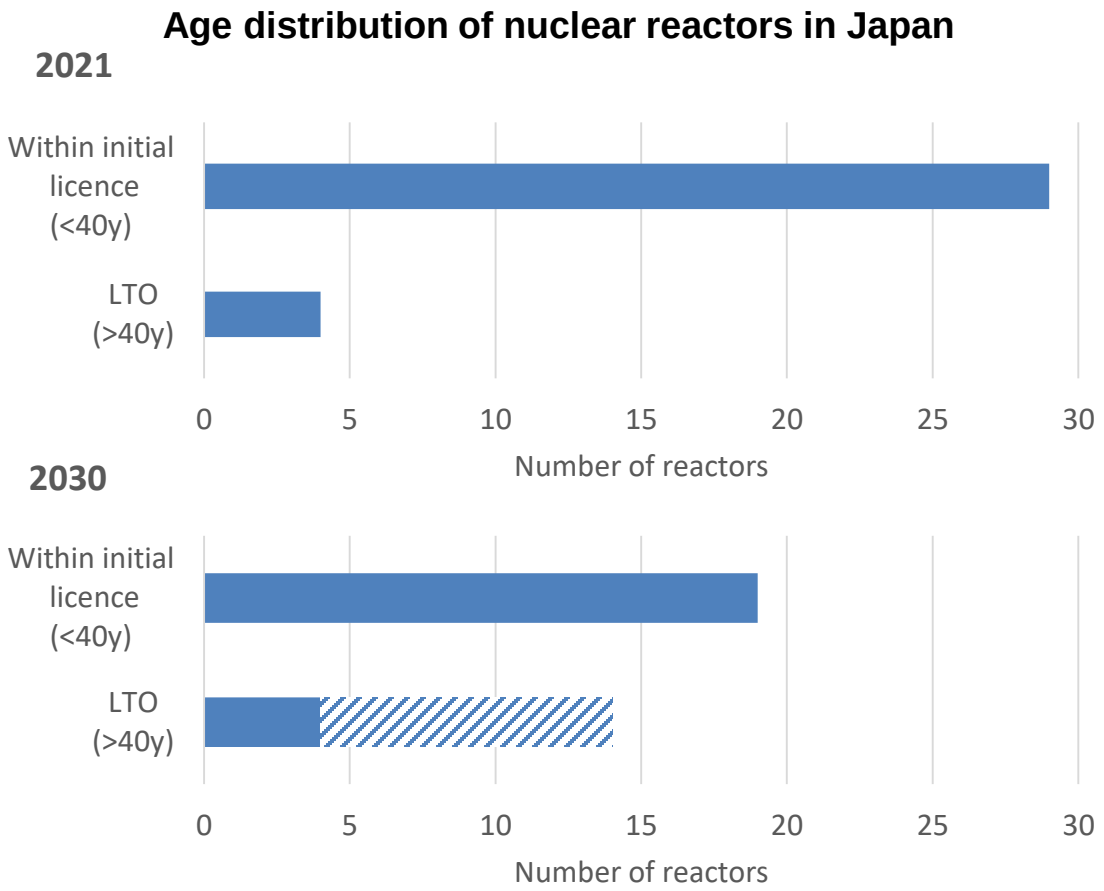
LTO approval approaches



Source: OECD/NEA (2019)

I. Case Study – Assessing the impact of legal operational limits in Japan

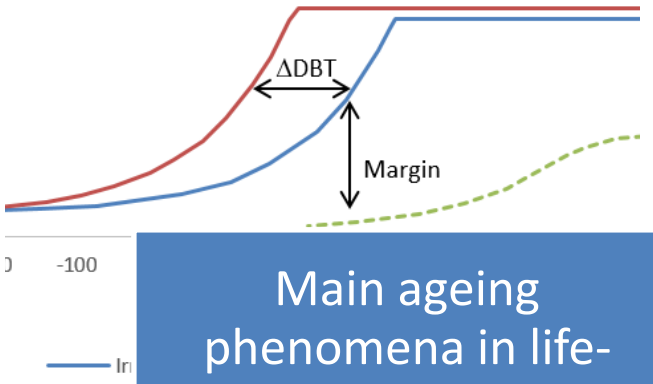
- Japan is one the **few countries** limiting the overall operational lifetime by law up to 60 years
- Limiting the operational lifetime **reduces the economic attractiveness of LTO**, especially if investment cost are high
- The 6th Strategic Energy Plan targets for nuclear power **will be difficult to achieve without LTO**



Source: IAEA PRIS, JAIF (2021)

2. No major technical showstopper for longer operating periods and adaptations

Almost all components can be replaced



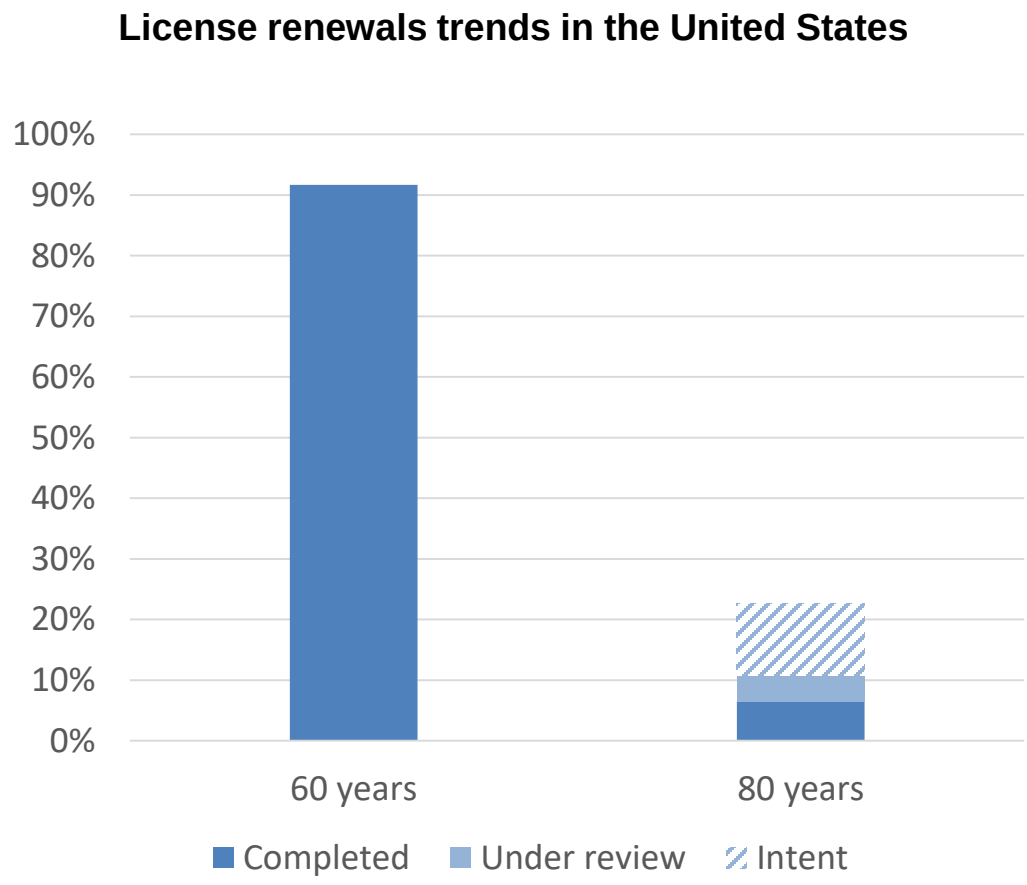
Main ageing phenomena in life-limiting components well-understood

Safety upgrades are typically combined with plant enhancements (e.g. power uprates)

LTO should not face major generic technical barriers if utilities implement **enhanced ageing management programs** using the technical evidence already available while **performing the necessary repairs and replacements.**

II. Case Study – Operation beyond 60 years in the United States

- Technical uncertainties for operations beyond 60 years are **decreasing**:
  - *6 reactors approved and intent covers 20% of the US fleet*
- **Technical evidence exists** but more efforts needed to track:
  - *Increased susceptibility to existing ageing phenomena*
  - *New degradation modes*
- Final decision mainly driven by market conditions rather than technical challenges



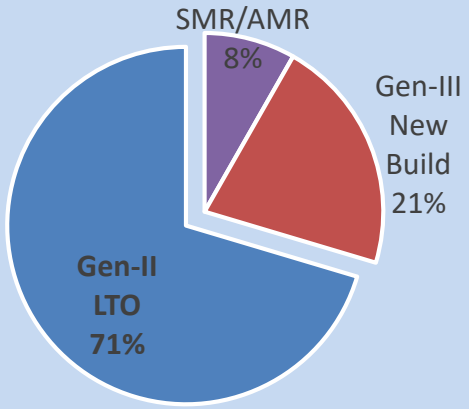
Source: OECD/NEA based on NRC (2021) and NEI (2020)

3. LTO supports ambitious decarbonisation strategies *and other policy Priorities*

Source: OECD/NEA and IEA/NEA (2020)

Avoiding carbon emissions

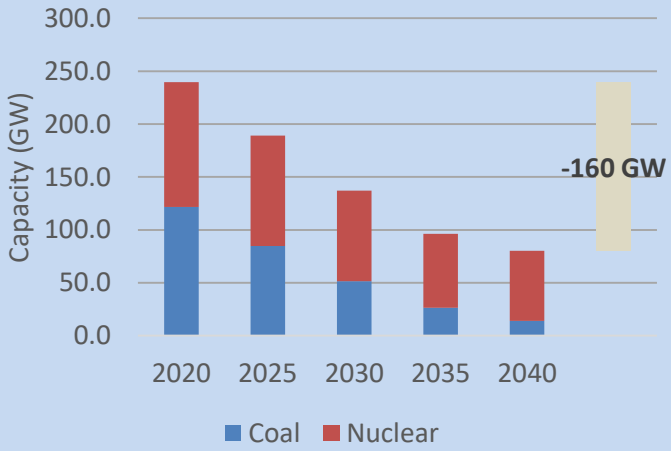
Projected global cumulative emissions avoided by nuclear power, 2020-2050



LTO could help bridge the gap towards carbon neutrality and absorb shortfalls in emissions reductions and new capacity additions

Enhancing security of supply

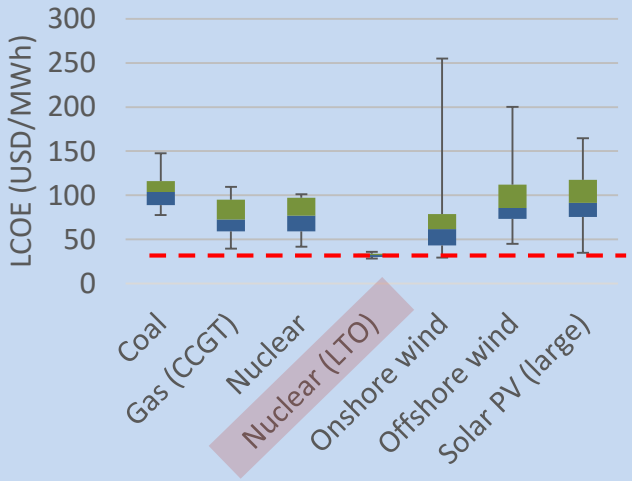
Evolution of nuclear and coal capacity in Europe according to stated policies, 2040



Maintaining adequate capacity levels through LTO can reduce system stress and support the integration of higher shares of variable renewables

Fostering system affordability and investment efficiency

LCOE by technology, 2025

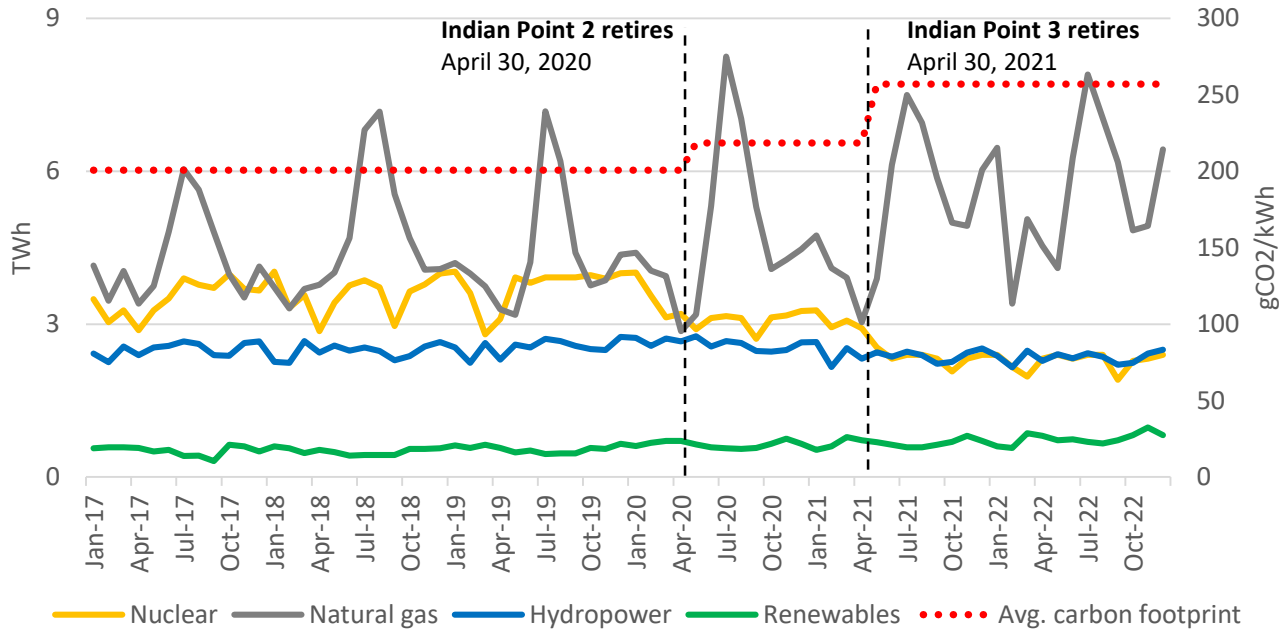


LTO is the most competitive low-carbon option providing also sizeable benefits at the system level, and more time to sequence investment plans

4. The importance of a low-carbon mix based on mature solutions

- Nuclear power provides **system strength and flexibility** as well as low and predictable operational costs
- In the short term, nuclear power is likely to be **replaced by a combination of variable renewables backed up by fossil-fired plants:**
  - *Increased CO2 emissions*
  - *Increased price volatility*

Electric power generation by fuel, New York ISO, Jan-2017-Dec 2022

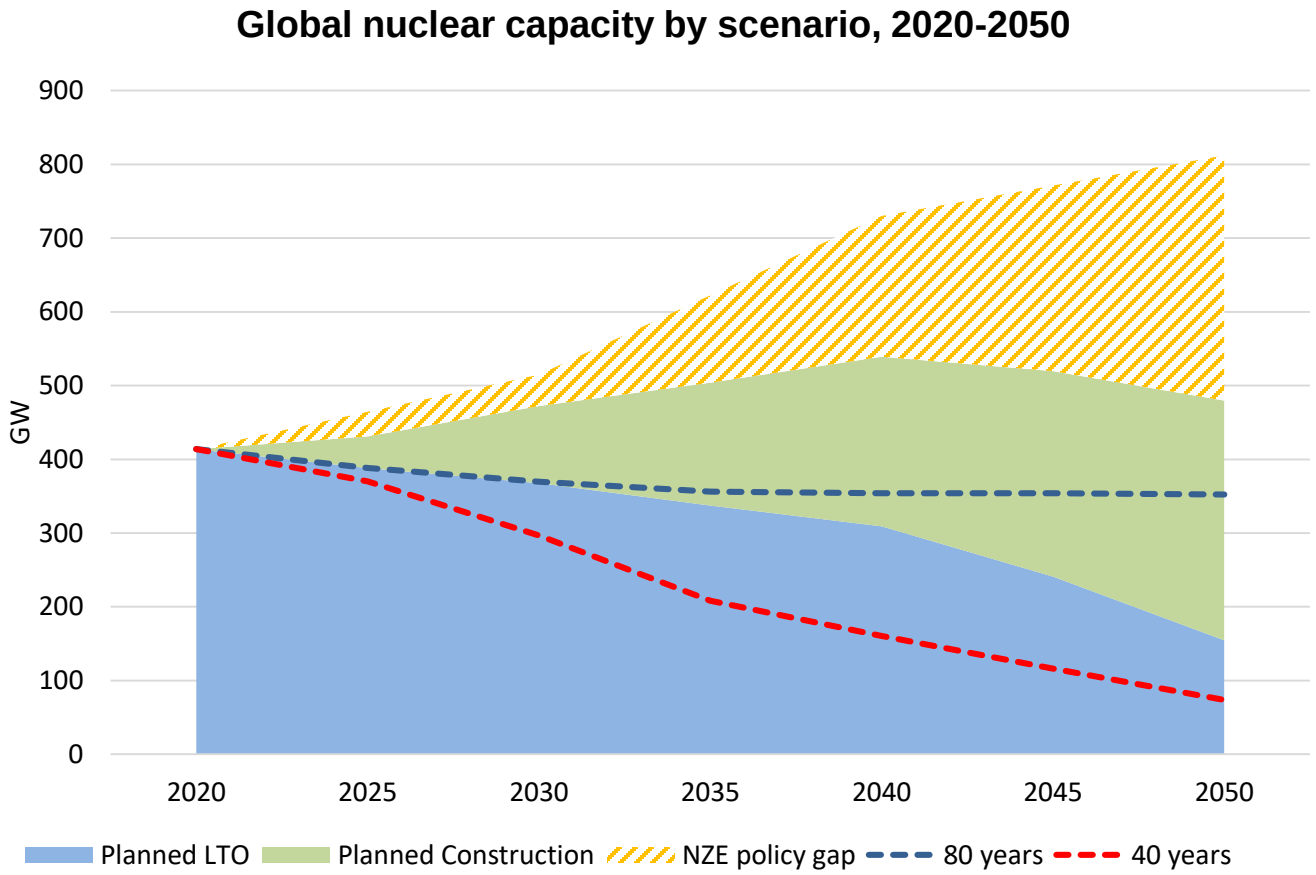


Note: Carbon intensity has been computed using the mean values for each technology from Bruckner (2014). Source: OECD/NEA using data from EIA (2021)

Effective decarbonisation strategies i) **avoid the closure** of existing low-carbon assets and ii) **combine** different low-carbon options to displaced fossil fuels and minimize risks

5. Managing carbon emissions in a predictable manner

- **LTO together with new build** key to keep up with climate targets by 2030.
- **Longer operating periods** could help bridge the gap towards **carbon neutrality** with LTO representing 40% of the emissions avoided by 2050.
- Effective way to **absorb shortfalls** in emissions reductions and new capacity additions.



Note: Planned LTO projections take into account announced closures and extended lifetimes, in line with stated policies, market conditions and regulatory approvals principally in Europe and the United States

5. Managing carbon emissions in a predictable manner

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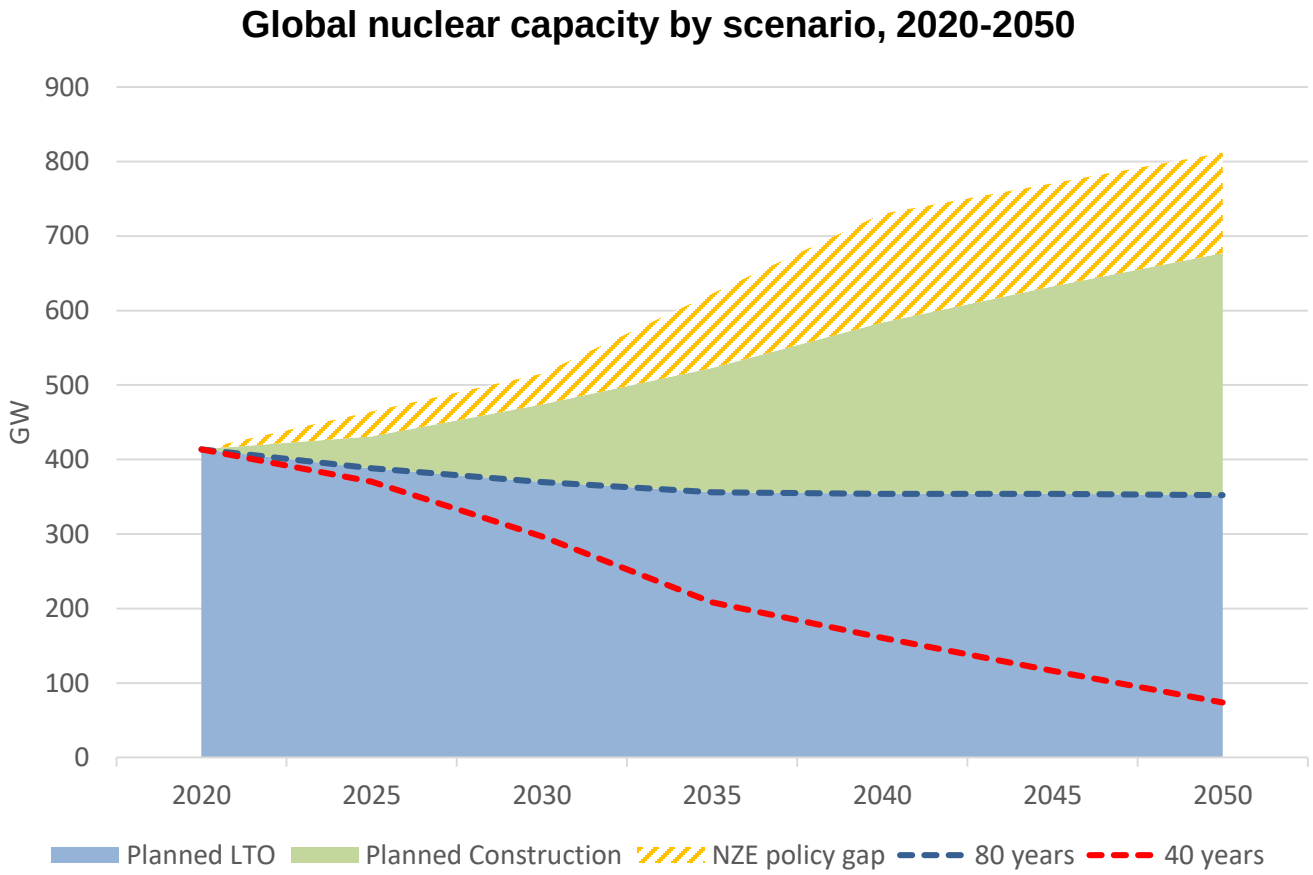

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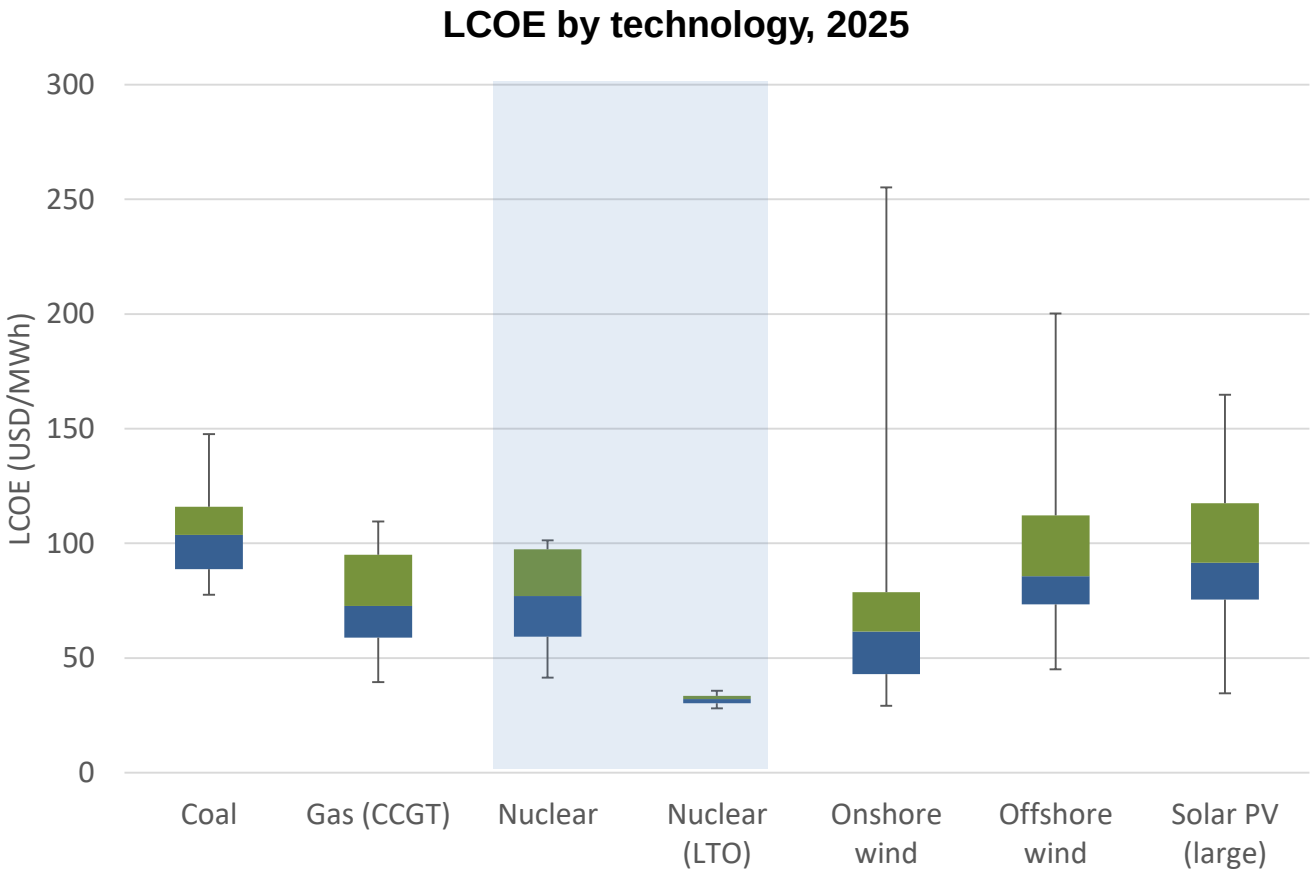
6. The competitiveness of LTO in today's electricity markets (1/3)

- LTO is the **most competitive low-carbon option** in many regions.
- **VRE integration and external cost reductions** associated with dispatchability, air pollution and climate change benefits.
- **Additional time** to sequence investment decisions and optimise industrial plans and policies.

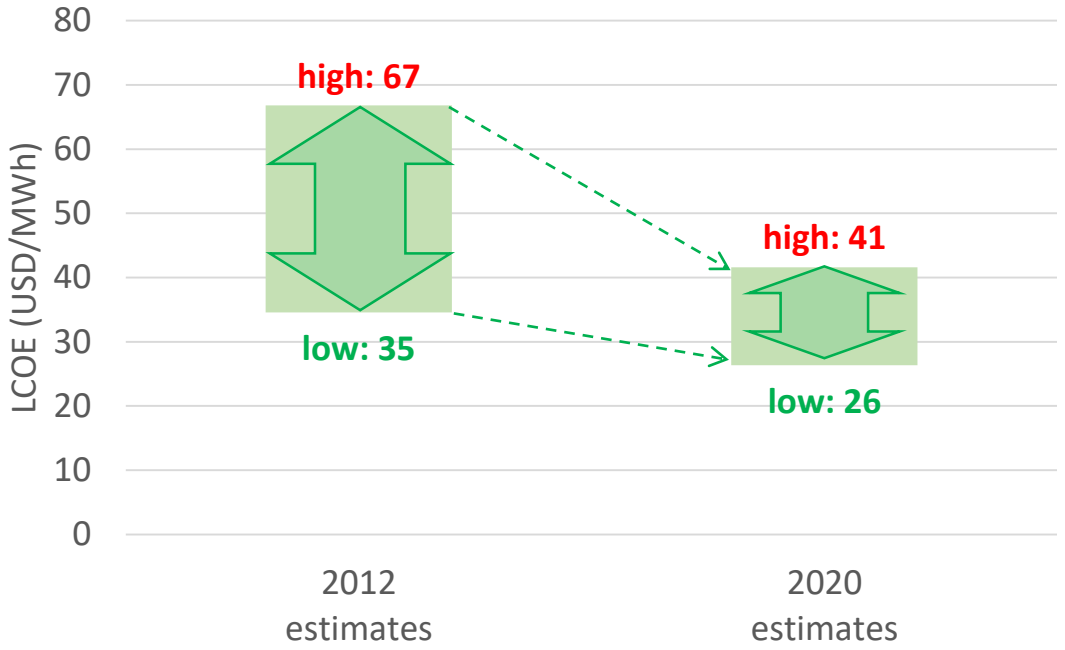


Note: Coal includes lignite plants. Discount rate of 7% and carbon price of USD30/tCO2
Source: IEA/NEA (2020)

6. The competitiveness of LTO in Today's Electricity Markets (2/3)

- LTO investments for LWRs can be estimated at **USD450-950 per kWe** and fall into three main categories:
  - *LTO program*
  - *Replacement & other works*
  - *Post-Fukushima safety upgrades*
- Financing **risks are low**:
  - *Predictable investments owing to a well-developed learning curve*
  - *Reduced technical scope and complexity*
  - *Relatively small-sized investments*

Based on new data and analysis, NEA has updated the estimated ranges for levelised cost of electricity for 20 years of LTO

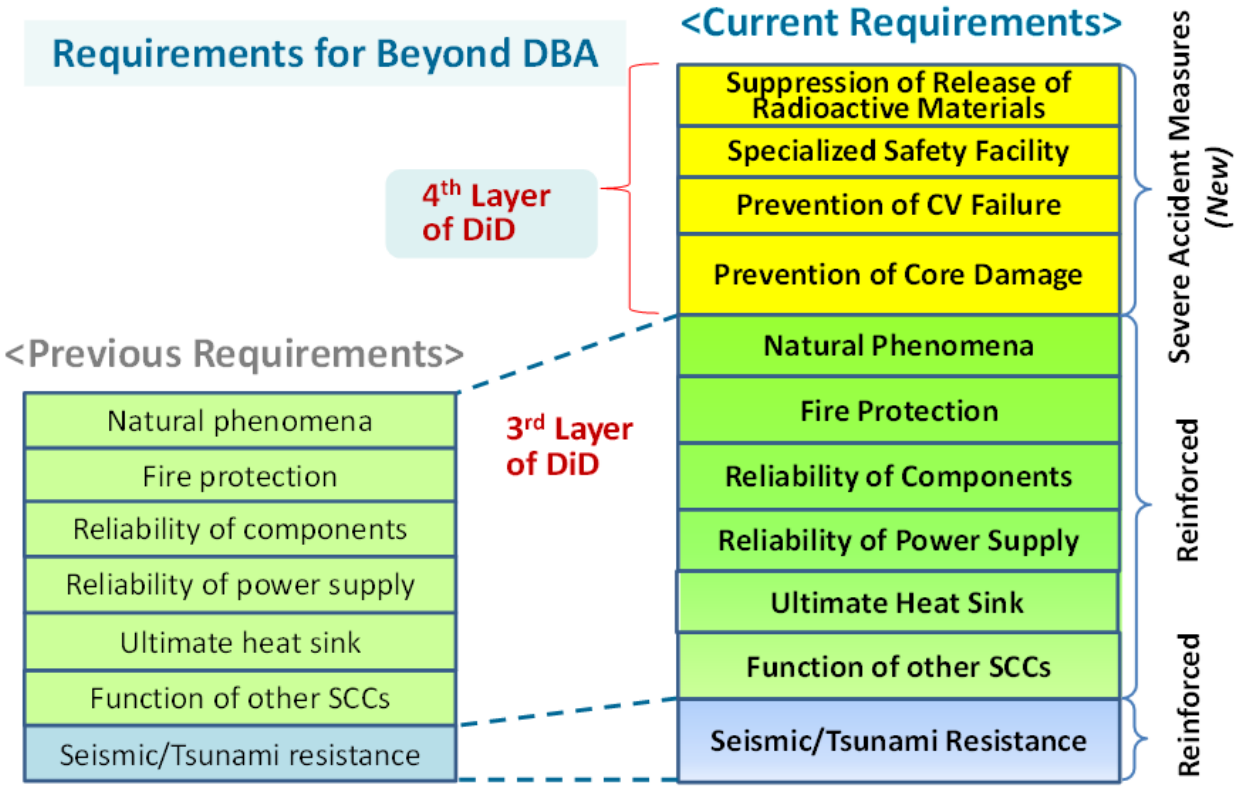


Note: 2012 values computed for overnight costs of USD_{2010}500-1090 per kWe, discount rates of 3% and 8%. 2020 values computed for overnight costs of USD_{2018}450-950 per kWe, discount rates of 3%, 7% and 10%. Capacity factor of 85% in both cases.
Source: NEA(2012) and IEA/NEA (2020).

III. Case Study – LTO costs in Japan: Lessons from NEA EGLTO

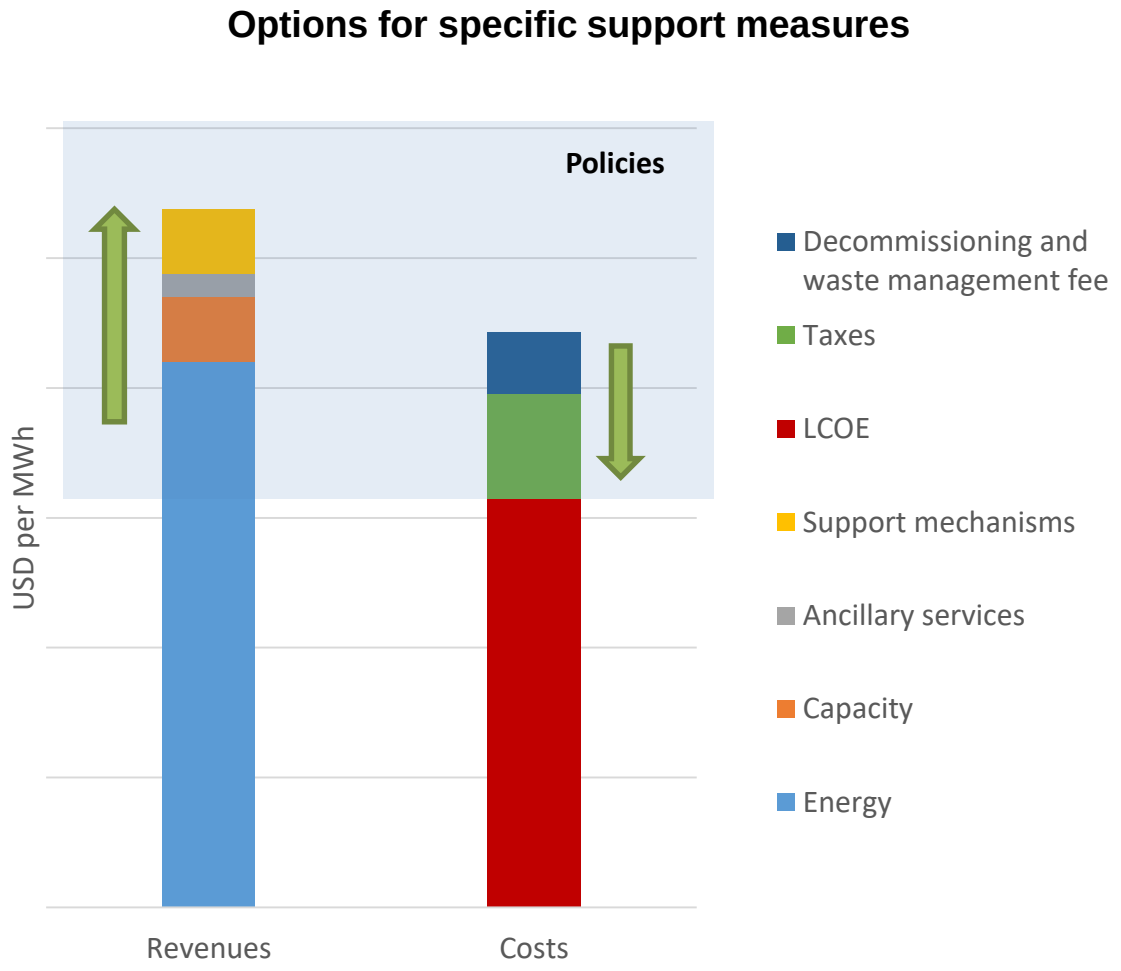
- Adapting to **new regulatory requirements** and building **local public acceptance** dominate investments over the last years
- As a result, LTO costs in Japan **can be greater** than in other jurisdictions (e.g. EU, US)
- LTO still remains **a competitive option** in Japan compared with variable renewables and fossil fuels (>USD90/MWh)

Evolution of regulatory requirements in Japan



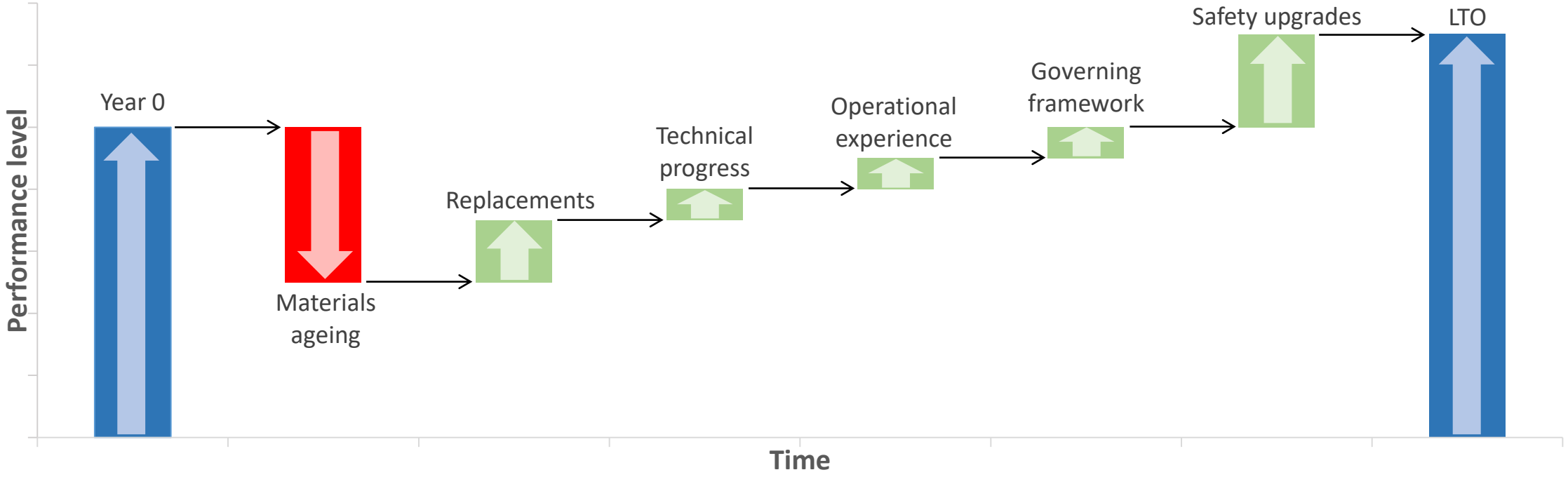
6. The Competitiveness of LTO in Today's Electricity Markets (3/3)

- It is important for electricity markets to **place value on desired performance** and outcomes: low-carbon, dispatchability, reliability and security
- Many low-carbon investments in deregulated markets are incentivized by **specific support measures:**
  - *These measures should be applicable to **LTO, which supports strategic priorities***
- Measures can create incentives on **both the revenues and costs sides**



7. Operations continue to improve despite ageing

Qualitative evolution of the performance level of an NPP over time

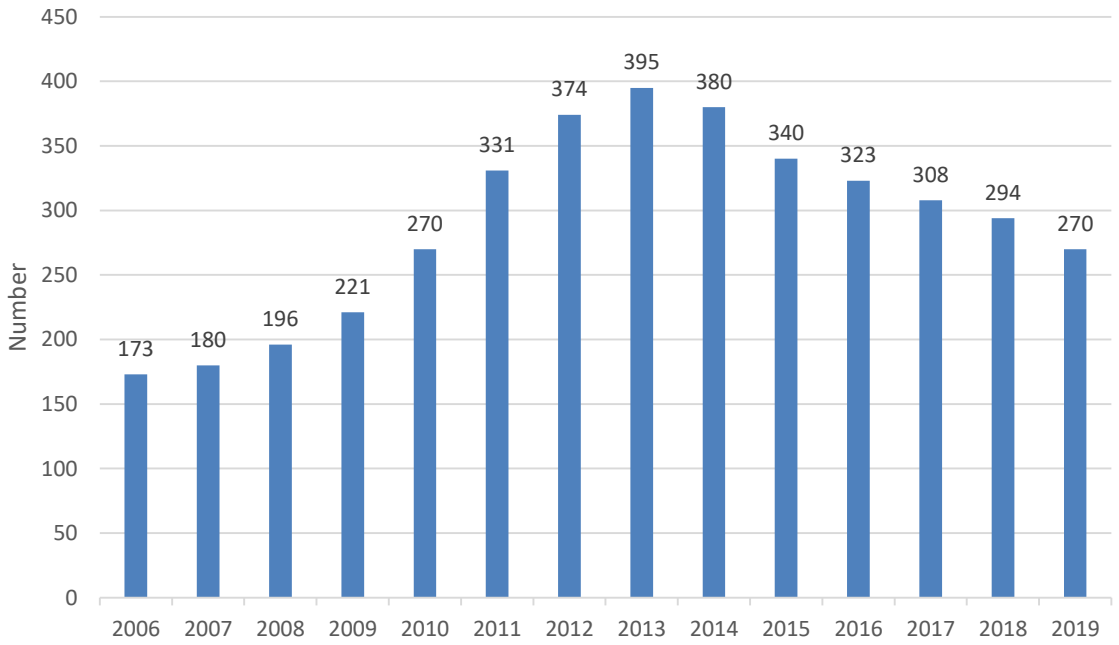


NPP performance results from the combination of several factors, including **organisational aspects,** that enable continuous safety and operational improvements.

8. Supply chain risks are a rising concern

- Components obsolescence resulting from **market and policy uncertainties** and **high qualification needs**
- Difficulties to **attract and retain** talent
- A range of industrial solutions to address this challenge:
  - Commercial-grade dedication
  - High collaboration and harmonization
  - Reverse engineering
  - Human resource and **knowledge management**

Companies holding N-type ASME qualification, 2006-2019



Source: OECD/NEA based on data WNA (2020)

The supply chain is critical in **sustaining** operational and economic performance and **nuclear industrial policies** provide a functional framework to build up industrial capabilities

Conclusions and Policy Recommendations

Enabling LTO

LTO is a safe and mature solution to foster ambitious decarbonisation strategies

- **Maintain existing low-carbon capacity**
- **Enlarge the technical basis on ageing mechanisms and their management**

Existing nuclear power plants can be enhanced to cope with a changing environment

- **Support new technologies and plant enhancements**
- **Foster cooperation to capitalise on extensive industrial experience**

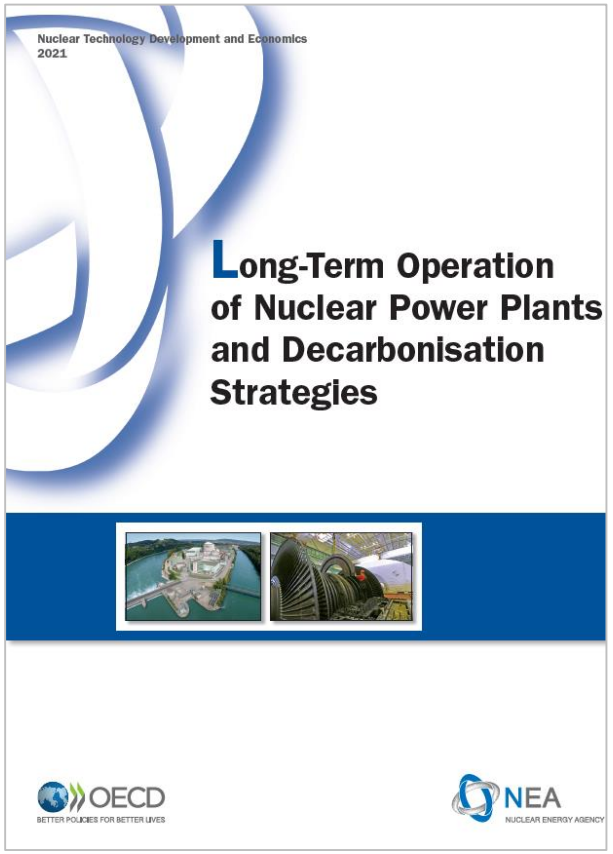
The supply chain is critical in sustaining operational and economic performance

- **Sustain supply chain capabilities and nuclear expertise at all levels**
- **Build long-term and predictable industrial plans**

Recognising the full value of the LTO option in decarbonisation strategies

- **Reform market regulations to ensure that the system value of extending operations is adequately remunerated**

New Report: *Long-Term Operation of Nuclear Power Plants and Decarbonisation Strategies*



Launched in July 2021 with an event that gathered legal and industry experts

Report: https://www.oecd-nea.org/jcms/pl_60310/long-term-operation-of-nuclear-power-plants-and-decarbonisation-strategies

Launch event: https://www.oecd-nea.org/jcms/pl_60360/the-most-cost-effective-decarbonisation-investment-long-term-operation-of-nuclear-power-plants

Thank you!

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