Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

Safety Implications of Lifetime Extensions

Some countries plan to keep the oldest nuclear power plants running decades beyond their original lifetimes. That raises safety and security questions.

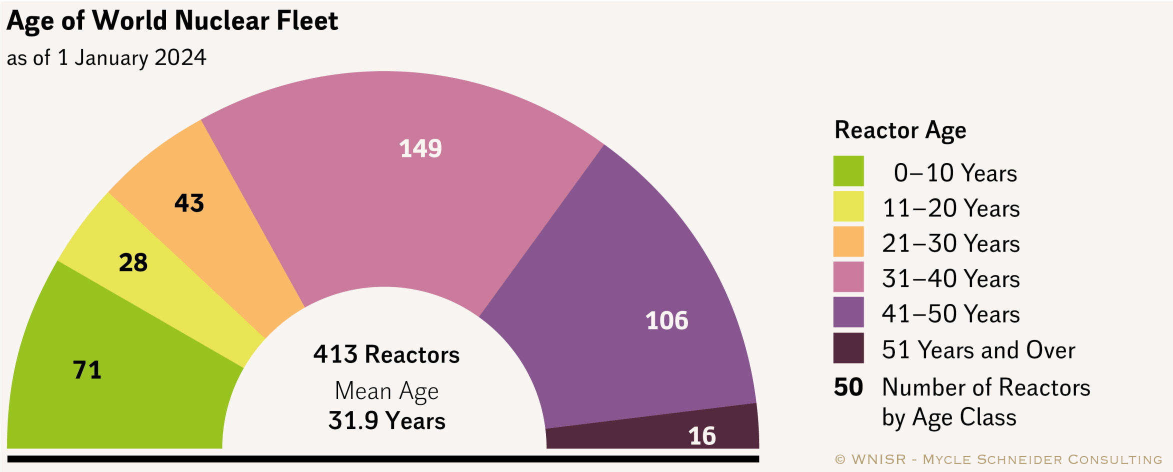
The Volkswagen Beetle 1200 was manufactured from 1974 to 1985. Later it was considered technically outdated and replaced by a new model. Today, the 1200 Beetle is on display in a museum (see photograph). Occasionally, an aficionado with a special permit and an "H number plate" (H for "historical") can be seen driving the streets in this vintage model.

Nuclear power plants are treated differently: 168 reactors around the globe, commissioned in the same time period, continue to operate to this day. Some are advocating the idea of keeping them splitting atoms for another ten or twenty years.

Close to two thirds of the 413 nuclear power plants operating around the world at the beginning of 2024 are 31 years or older (Figure 1)[1]. They are becoming increasingly prone to incidents.

[1] Mycle Schneider et al., "World Nuclear Industry Status Report 2023", December 2023.

Figure 1: Age Distribution of Operating Reactors in the World. Sources: WNISR, with IAEA-PRIS, 2024



Nuclear power plants from the beginnings of the commercial use of nuclear power were usually designed to operate for up to 30 to 40 years. Equipment experts make a distinction between ageing and obsolescence. What is true for both is that the frequency of incidents increases.

- Ageing[2] is the time-dependent change of function-related characteristics of technology components, materials and operating systems relevant to safety, documentation – and personnel.
- Obsolescence affects facility concepts, technological processes or administrative regulations because the state of the art of science and technology advances with time.

In all technical systems, including nuclear power plants, ageing causes the quality and reliability of components to gradually deteriorate with operating time[3]. The consequences of this ageing process are what is known as fatigue and embrittlement of materials, which can ultimately lead to the formation and propagation of cracks.

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[2] RSK, “Recommendation - Management of ageing processes at nuclear power plants”, 374th Meeting, 22 July 2004.

[3] German Nuclear Safety Standards Commission (KTA), “KTA 1403 – Ageing Management in Nuclear Power Plants”, Version of November 2017.

The negative consequences of ageing materialize in two different ways:

- On the one hand, ageing causes progressive weakening of highly irradiated reactor materials, which, in the case of safety-relevant components, can lead to failure with disastrous results.
- On the other hand, there is an increase in the number of minor disruptions, incidents and outages due to minor leaks, cracks or short circuits.[4]

Obsolescence of facility concepts is a category that includes risks that are unknown or incorrectly assessed at the time of power plant development and construction – underestimated hazards resulting from site-specific risks (earthquakes, tsunamis, flooding, wildfires) or terrorist attacks, for example. Nobody would have considered the possibility of passenger airplanes being misused as guided missiles or remote-controlled armed drones prior to the attacks on the World Trade Center in New York City in 2001 (See also Factsheet “Nuclear Terrorism”).

Lessons from Historical Nuclear Disasters Provide Basis for Safety Standards

Three major reactor accidents have occurred in the past forty years – Three Mile Island (1979), Chernobyl (1986), and Fukushima (2011) – as well as a large number of neardisasters. Today, the accumulation of insights gained from historical nuclear disasters forms the basis of the safety standards for nuclear power plants that are currently under construction and also for those scheduled to continue to operate beyond their originally envisaged operational lifetimes.

Extensive and costly replacements of equipment are necessary to ensure that vintage plants retrospectively comply with current safety standards. Furthermore, in practice, it is impossible to replace several key components including the reactor pressure vessel and the containment. However, through ageing, their condition systematically deteriorates

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[4] Federal Office for the Safety of Nuclear Waste Management, “Jahresberichte zu meldepflichtigen Ereignissen”, 6 October 2019, see base.bund.de/DE/themen/kt/stoerfallmeldestelle/berichte/jahresberichte/jahresberichte.html;jsessionid=704DE0CC803ED73D34CB44F4527D1F50.internet9625.

over time. This leads, despite elaborate testing programmes, to an increased risk of failure of safety-relevant components, especially in the case of lifetime extensions.[5]

However, nuclear power plants must be designed so that they can—as claimed—withstand extreme events from first to last day of operation. In other words: To ensure compliance with the standards of the International Atomic Energy Agency (IAEA), they must seek to comply with the state-of-the-art until the end of their operational lifetime.[6]

In the real world, the safety level of vintage facilities usually falls short of today's requirements by a large margin. Increasingly expensive retrofitting measures may help, but this approach has its limits. In particular, design-based safety deficiencies cannot be fully remedied through subsequent measures.

Major Differences in Safety Requirements Between Major Nuclear Countries

In the U.S., the Nuclear Regulatory Commission (NRC) does not require upgrading to state-of-the-art of power reactors. Utilities are required to demonstrate "that the effects of aging will be adequately managed for each structure, system, and component identified, so that their intended function(s) will be maintained **consistent with the current licensing basis** for the period of extended operation" [emphasis added].[7] This means that in the U.S. system the licensing basis for new nuclear power plants are not applicable for operating nuclear power plants, which have to fulfil the original requirement in place at the time of start-up. In the U.S. lifetime extension is based on 10-year Periodic Safety Review (PSR).

In France, the basic requirement is very different. The Nuclear Safety Authority (ASN)[8] in 2013 stated that as in the future the current reactors will co-exist with Generation-III

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[5] Yves Marignac, "Zusammenfassung der Studie 'Reduktion der Sicherheitsmargen von Alt-KKW. Der Fall Beznau'", WISE-Paris, 2016.
[6] According to IAEA Safety Principle 5: "Protection must be optimized to provide the highest level of safety that can reasonably be achieved."; see "Principle 5: Optimization of Protection", in IAEA, "Fundamental Safety Principles", IAEA Safety Standards Series No. SF-1, Vienna, 2006.
[7] US-NRC, „Guidance for License Renewal and Subsequent License Renewal", NUREG-1800, Rev.2, 2010, see nrc.gov/reactors/operating/licensing/renewal/slr/guidance.html.
[8] Autorité de Sûreté Nucléaire (ASN)

reactors[9] whose designs “respond to significantly enhanced safety requirements. Current nuclear reactors **must therefore be upgraded to meet these new safety requirements**, the state of the art in nuclear technologies” [emphasis added][10].

Consequently, in February 2021, ASN published a Decision[11] defining the modifications to be carried out in view of the operation of EDF’s 900-MW reactors beyond 40 years. The reactor-by-reactor requests stipulate multiple upgrades including to power supply and cooling water availabilities, protections against fire, climate, and earthquake risks, as well as post-accidental conditions. But while some work has been implemented over the past three years, most of the improvements will be stretched out over very long time spans and – obviously – some differences with the benchmark of the most recent designs will always remain after backfitting. EDF can take its time with Gravelines-6 for example, 15 of 35 mandatory improvements are to be carried out by 2035 when the reactor will already be in its 50th operational year. How can it be deemed satisfactory to operate a nuclear reactor for a decade with identified safety deficiencies?

Operators of vintage plants regularly claim that upgrading has brought their machines to state-of-the-art safety standards up to the end of their technical lifetime. That assumption is highly questionable and one wonders whether many of them belong where the VW Beetle 1200 has long been: in a technology museum.

Last update: 2024

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[9] E.g. Framatome’s European Pressurized Water Reactor (EPR) or Westinghouse’s AP1000.

[10] ASN, “CODEP-DCN-2013-013464”, Letter to the President of EDF, dated 28 June 2013, see asn.fr/content/download/131141/asn_position/CODEP-DRC-%202014-013126.pdf.

[11] ASN, “Décision n° 2021-DC-0706 de l’Autorité de sûreté nucléaire”, 23 February 2021, see asn.fr/l-asn-reglemente/bulletin-officiel-de-l-asn/installations-nucleaires/decisions-individuelles/decision-n-2021-dc-0706-de-l-asn-du-23-fevrier-2021.