Axpo energy reports

Nuclear energy

Introduction

A secure, affordable and sustainable supply of electricity is fundamental to the functioning of Swiss society and the economy. Hydropower, nuclear power, new renewable energies and the central location of Switzerland in the European power grid mean Switzerland now benefits from very good conditions for a reliable supply.

In the coming decades, this comfortable situation will come under pressure if no suitable countermeasures are put in place. The electrification of mobility and heating, and population growth are likely to increase electricity demand significantly. In addition, data centres, cloud services and generative AI require increasing energy. At the same time, the planned phase-out of nuclear power means that a substantial part of domestic electricity production will be lost in the long term.

The winter half-year in particular are becoming more and more important. Switzerland already consumes more electricity in the winter half-year than it produces. In the darker months of the year, there is more demand for heat and people generally spend longer indoors, which increases the power consumption of electronic devices and lighting. In addition, hydropower produces more electricity in the summer half-year due to the seasonal runoff profile with a high proportion of run-of-river water. The current buildout of renewable energies in Switzerland and neighbouring countries is also based to a large extent on solar energy, which generates the majority of its electricity in the summer half-year. The seasonal difference between the summer surplus and the winter deficit is increasing, making it increasingly difficult to achieve a secure supply of electricity in the winter half-year.

In addition to close cooperation with neighbouring countries and the EU, securing the supply of electricity in the future also requires secure, affordable and sustainable domestic electricity production to be developed. As part of the Axpo Energy Reports, we take a look at four technologies that can substantially increase domestic electricity generation in the winter half-year. These are wind energy, new nuclear power plants, solar energy and gas-fired power plants.

The report specifically highlights the regulatory and social framework conditions that are required for the construction of new nuclear power plants. The report is therefore not an interpretative document for nuclear power in general. The report is not intended to be a position paper and does not assess whether development is necessary to secure winter electricity supplies by 2050. It only describes the prerequisites that have to be met for the construction of new nuclear power plants.

This report deals with the development of new nuclear power plants in Switzerland by 2050.

Disclaimer: This report was originally drafted in German and has been carefully reviewed by experts, particularly with regard to terminology and content accuracy. The translations are intended to make the report more accessible to a nationwide and international audience and have been produced with the utmost care. In the event of any questions regarding interpretation, the original German version is considered authoritative.

Table of contents

ARE	Swiss Federal Office for Spatial Development
AP1000	Advanced Passive 1000 (Westinghouse reactor type)
FOEN	Swiss Federal Office for the Environment
SFOE	Swiss Federal Office of Energy
FSC	Swiss Federal Supreme Court
FAC	Swiss Federal Administrative Court
CFD	Contract for Difference
ENSI	Swiss Federal Nuclear Safety Inspectorate
EPR	European Pressurised Reactor
ERR	Economic Regulatory Regime
FOAK	First of a Kind
IAEA	International Atomic Energy Agency
NEA	Swiss Nuclear Energy Act SR 732.1
NEO	Swiss Nuclear Energy Ordinance SR 732.11
NPP	Nuclear Power Plant
KNS	Commission for Nuclear Safety
LCOE	Levelised Cost of Electricity
NAGRA	National Cooperative for the Disposal of Radioactive Waste
OCC	Overnight Capital Cost
OECD	Organization for Economic Cooperation and Development
PGA	Peak Ground Acceleration
RAB	Regulated Asset Base
SMR	Small Modular Reactor
TRL	Technology Readiness Level
DETEC	Swiss Federal Department of the Environment, Transport, Energy and Communications
ZWIBEZ	Beznau interim storage facility
ZWILAG	Würenlingen interim storage facility

01

Summary

There are currently four nuclear power plants in operation in Switzerland, which cover just under 40 percent of the electricity supply during the winter half-year. While current legislation prohibits the construction of new plants, the existing nuclear power plants may be operated for as long as they are deemed safe by ENSI. There is no statutory term limitation.

Globally, more than 400 reactors are in operation and more than 60 are under construction. Over 30 countries are aiming to triple their nuclear energy capacity by 2050. New construction decisions are based almost entirely on Generation III/III+ reactors, such as the AP1000 from Westinghouse (USA) or the EPR series from EDF (France). Both of these reactors would also be an option for Switzerland. Potential locations include, in particular, the existing locations: Gösgen and Leibstadt have the best structural and logistical conditions, while Beznau and Mühleberg are much more limited in terms of space. Seismic requirements, cooling and flooding risks can be managed at all four locations. Radioactive waste is stored in interim storage facilities until the deep geological repository is put into operation; two legally established, independent funds ensure the long-term financing of disposal and decommissioning activities.

Social attitudes towards nuclear power are polarised, with around half of the population in favour of nuclear power, while the other half rejects it. With the submission of the "Blackout stoppen" ("Stop blackouts") popular initiative, the ban on the construction of new power plants is being renegotiated at a political level. The Swiss Federal Council rejects the initiative, but is proposing an indirect counterproposal, which provides for the lifting of the ban on the construction of new power plants in the Swiss Nuclear Energy Act. The consultation process is showing that there is mixed support for this. Due to the legal deadlines, the parliamentary consultation is expected to be completed by 2026 followed by a referendum.

For the construction of a new nuclear power plant by 2050, the lifting of the ban on new construction projects would be a mandatory prerequisite. In addition, a suitable framework would be needed to enable investments in new nuclear power plants. The legal basis for this would first have to be created. This framework would have to include the appropriate sharing of risk between the public authorities and private investors, changes in the approval process, and funding instruments:

- The appropriate sharing of risk between the public authorities and private investors is particularly necessary for the early project phases exposed to risk. For example, project development can hardly be financed by the private sector, as both the optional referendum on the legal foundation for funding and the optional referendum on the granting of the general licence represent uncontrollable risks.

- The duration of the authorisation procedure in Switzerland is now considerably longer than in most comparable countries. In addition, the process is subject to regulatory uncertainty, which increases the risk of unplanned delays. Such delays can have significant financial consequences: If a completed power plant cannot be commissioned due to a pending appeal against the operating licence, annual losses amounting to several hundred million Swiss francs will be incurred. Targeted measures to speed up procedures and reduce the risk of delays are therefore necessary.

- Like all other power generation technologies, nuclear power plants also cannot be operated cost-effectively without government subsidies. The subsidy requirements for new nuclear power plants in Switzerland is – depending on cost and revenue assumptions – between 16 and 91 Swiss francs per MWh (see Figure 1). The high investment costs and long construction times call for innovative financing models.The most promising approaches are the British Regulated Asset Base (RAB) model or a combination of investment contributions and a sliding market premium. The RAB model offers the advantage of lower capital costs, as more risks are borne by the government/electricity customers during the construction phase. The combination model, on the other hand, would require additional government participation or guarantees, which would have to mitigate the risk of stricter safety regulations, for example due to accidents outside of Switzerland.

Based on our assumptions and modelling, construction costs of between 7100 and 10 830 Swiss francs per kW must be expected for new nuclear power plants in Switzerland. Accordingly, the levelised costs range from 80 to 155 Swiss francs per MWh depending on the assumptions, and 108 Swiss francs per MWh under reference assumptions[1]. In contrast, the modelled market revenue only amount to around 64 Swiss francs per MWh and thus cover 41 to 80 percent of the total costs. The remaining portion would have to be covered by appropriate funding instruments. As approximately 55 percent of electricity production is generated in the winter half-year, the specific subsidy requirements for winter electricity stand at 80 Swiss francs per MWh under reference assumptions. All in all, it is clear that a new nuclear power plant is not economically viable without government subsidies.

The construction of a nuclear power plant will lead to a high level of domestic economic added value and will create thousands of jobs during the construction phase as well as long-term employment in the operation of the plant. At peak times, up to 10 000 people can work on the construction site at the same time – thus making for an extraordinary decades-long project for Switzerland that is fundamentally feasible, as the experience gained from projects such as the NRLA (New Rail Link through the Alps) and the Linth-Limmern pumped-storage power plant has shown.

In addition to the debate on the lifting of the ban on the construction of new nuclear power plants, two other political processes are underway: The requested Swiss Federal Council report on Burkart's postulate (long-term operation and risk sharing) is due by Q1 2026 and is intended to outline the requisite regulatory and financial framework conditions for safe long-term operation. Furthermore, the general licence application for the deep geological repository has been submitted; a decision by the Swiss Federal Council and the subsequent approval of the Swiss Federal Assembly are expected for the period around 2030 and are ultimately subject to the optional referendum.

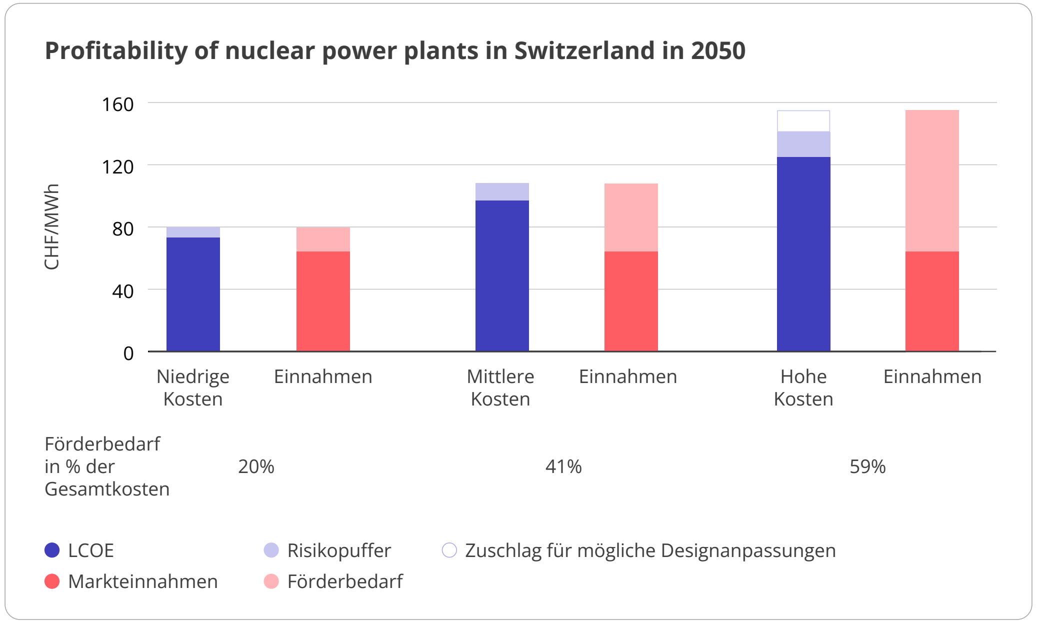

Figure 1: Profitability of nuclear power plants in 2050 in Switzerland; comparison of the levelised cost of electricity (LCOE), risk buffer with surcharge for possible design adjustments and market revenue in CHF, real in 2024. The difference results in the subsidy requirements.

On the whole, the report shows that the construction of a new nuclear power plant in Switzerland is technically feasible and possible at suitable locations. However, achieving this by 2050 requires political decisions to be made at an early stage, approval procedures to be speeded up, suitable funding mechanisms created and social acceptance ensured.

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[1] A "reference assumption" is being defined for the analysis – a scenario with average location conditions, average costs and a regulatory framework that is considered the minimum requirement for implementing nuclear power plant projects.

02

Technology

Nuclear power plants account for almost 40 percent of the Switzerland's winter power supply – new reactors of Generation III+ could be built at existing sites

In brief

- There are three nuclear power plants in operation in Switzerland: Beznau I & II (two reactors), Gösgen and Leibstadt. Together, they cover almost 40 percent of the electricity supply in the winter half-year.

- More than 400 reactors are in operation worldwide and approximately 60 more are under construction. More than 30 countries support the objective of tripling the capacity of nuclear power plants by 2050.

- Presently, Generation III/III+ reactors form the basis for almost all new building decisions. Two Generation III+ plants are being built in Europe, with nine more under development. Key technologies include the Westinghouse AP1000 and EDF's EPR series. This report focuses on Gen III+ plants. As commercial SMR solutions may be available from the early 2030s, SMR development should continue to be pursued.

- The locations under consideration for new nuclear power plants in Switzerland are mainly existing or decommissioned plant sites in Gösgen, Leibstadt, Beznau and Mühleberg. The greatest challenge is the limited space available. Seismic risks, cooling, flood protection and grid connection are considered to be easily manageable.

- Nuclear power plants are generally used in base load operation in order to amortize high fixed costs through many full-load hours. Technically, however, they can also achieve load-dependent operation and frequency control.

- Radioactive waste must be disposed of in a deep geological repository. Until this is possible, it will be stored in the Würenlingen central interim storage facility and in the Beznau interim storage facility. Two legally established funds ensure the financing of waste disposal and decommissioning, with contributions made regularly by the operators based on cost estimates updated every five years.

- Rising temperatures as a result of climate change are not a major problem for the cooling of new nuclear power plants. The cooling technologies used only heat the flow minimally and extract only small volumes of water.

2.1
Nuclear power in Switzerland

There are currently three nuclear power plants in operation in Switzerland: Beznau I & II (two reactors), Gösgen and Leibstadt. The Mühleberg nuclear power plant was decommissioned in 2019, with the plant being dismantled ever since. The definitive cessation of operation of the two reactors in Beznau was announced for 2032/33. In general, nuclear power plants in Switzerland are allowed to operate for as long as they are deemed safe. While it is currently generally assumed that a plant can be operated for 60 years, operations lasting 70 to 80 years are quite conceivable, but require an in-depth examination of the technical and economic viability. Table 1 provides an overview of the nuclear power plants in Switzerland.

Over the past five years, these nuclear power plants accounted for an average of 32 percent of domestic electricity generation and as much as 38 percent in the winter half-year. The nuclear power plants make a stable contribution to base load and are an important

Nuclear power plants in Switzerland

	Commissioning	Power	Status
Beznau I + II	1969, 1971	2 x 365 MWe	In operation, decommissioning 2032/33
Leibstadt	1984	1220 MWe	Operational
Gösgen	1979	1010 MWe	Operational
Mühleberg	1971	373 MWe	Decommissioning 2019

Table 1: Overview of nuclear power plants in Switzerland

Focus: **Cancelled new construction projects in Switzerland after Fukushima**

Resun AG and nuclear power plant Niederamt AG planned the construction of three new nuclear power plants in Switzerland. Both were cancelled in 2017 after the accident at Fukushima and the imposed ban on new construction. Resun AG was a joint venture between Axpo and BKW with the aim of constructing two replacement plants – one at the Beznau site and one in Mühleberg. The nuclear power plant Niederamt AG was Alpiq's project to develop a new plant at the Gösgen site. Both companies submitted their applications for general licence in 2008. The approval process was in progress until it was no longer pursued by the authorities due to the Fukushima accident and the applications were in the end withdrawn by the initiators.

factor in the energy supply security, especially in the winter half-year.

The long-term reliability of Swiss nuclear power plants is reflected in their average availability over the previous operating period[2], which is in excess of 80 percent in all of the plants: Gösgen leads the way with 89.4 percent, followed by Beznau II (88 percent), the decommissioned Mühleberg plant (87.8 percent) and Leibstadt (82.7 percent). Due to a one-time, prolonged shutdown from 2015 to 2018, Beznau I has the lowest availability of 80.4 percent.

In addition to domestic production, Switzerland also sources electricity from nuclear power plants outside of its borders. Through long-term contracts[3], EDF supplies around 10 to 12 TWh of electricity from French nuclear power plants to Switzerland every year, which corresponds to 13 to 16 percent of its annual demand. In the winter half-year in particular, these imports cover 15 to 20 percent of the electricity supply and underline the key role of nuclear power for energy supply security in Switzerland. Domestic nuclear power plants and imports from French nuclear power plants thus cover more than half of the Swiss electricity demand in the winter half-year.

Following the Fukushima accident in 2011, Switzerland decided to phase out nuclear power and imposed a ban on the construction of new nuclear power plants. As a result, new construction projects at the time were also discontinued (see Focus). However, a lifting of this ban is currently under discussion in the Swiss Parliament. Detailed information on current political developments can be found in Section 8 Politics.

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[2] IAEA, 2026, Switzerland
[3] Internal Axpo presentation

2.2

Technological development

Demand and current global expansion

At around 2500 TWh, nuclear power currently supplies just under 10 percent of global electricity (see Figure 2) and is the second most important source of low-emission energy after hydropower. Global nuclear power production is expected to reach a new high in 2025, with 416 reactors.

In recent years, the interest shown in building new nuclear power plants and extending the operating life of existing nuclear power plants has increased significantly. Some 62 reactors totalling more than 65 GW are currently under construction, half of which are in China. More than 30 countries support the goal of tripling nuclear energy capacity by 2050.[4] Over the past five years, more than 60 reactors have had their operating lives extended to over 40 years. Annual investments in the construction of new plants and lifetime extensions have increased by around 50 percent since 2020 and amount to more than 60 billion US dollars[5].

Development of nuclear reactor technologies

Nuclear reactor technologies can essentially be classified in terms of two dimensions: technology generation and plant size (see Figure 2). Over the course of around seven decades, four generations of technology have emerged. Developed between the 1950s and 1970s, Generation I reactors laid the foundation for commercial nuclear power, but have since been decommissioned.

Generation II reactors form the backbone of today's infrastructure and represent almost all of the 416 reactors in operation. Built mainly between the 1960s and 1990s, these units have robust safety systems and proven operational safety.

Generation III/III+ reactors are an evolution of the previous generation with a simplified design and improved safety features, including passive safety systems that operate without an external electricity supply or human intervention. Many reactor designs were developed after the Fukushima accident to incorporate additional safety modifications.

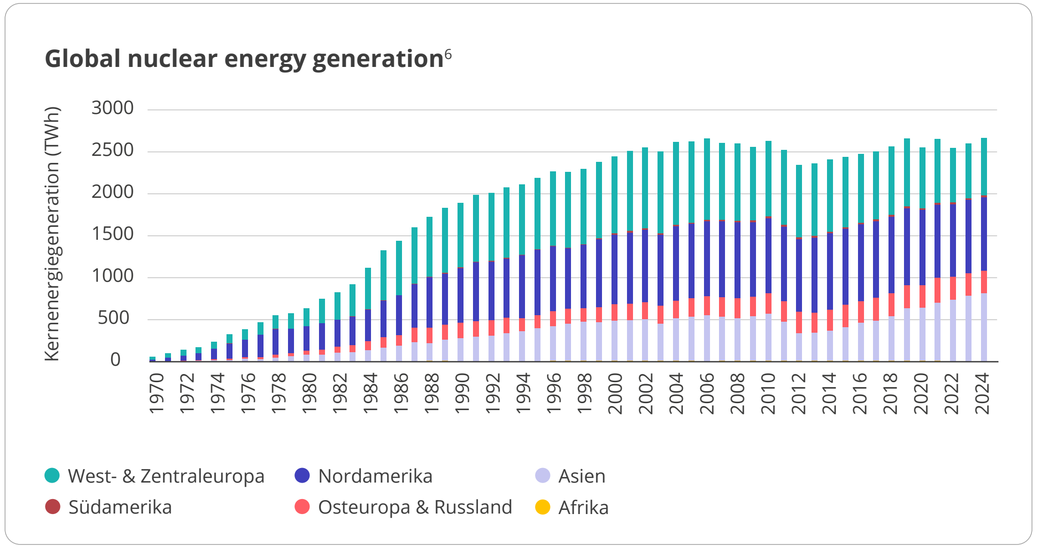

Figure 2: Nuclear energy generation in TWh from 1970 to 2024, split up into continents

Generation IV reactors are completely new designs based primarily on a different type of cooling technology or using different fuels. These new designs promise better safety, less waste and improved fuel efficiency.

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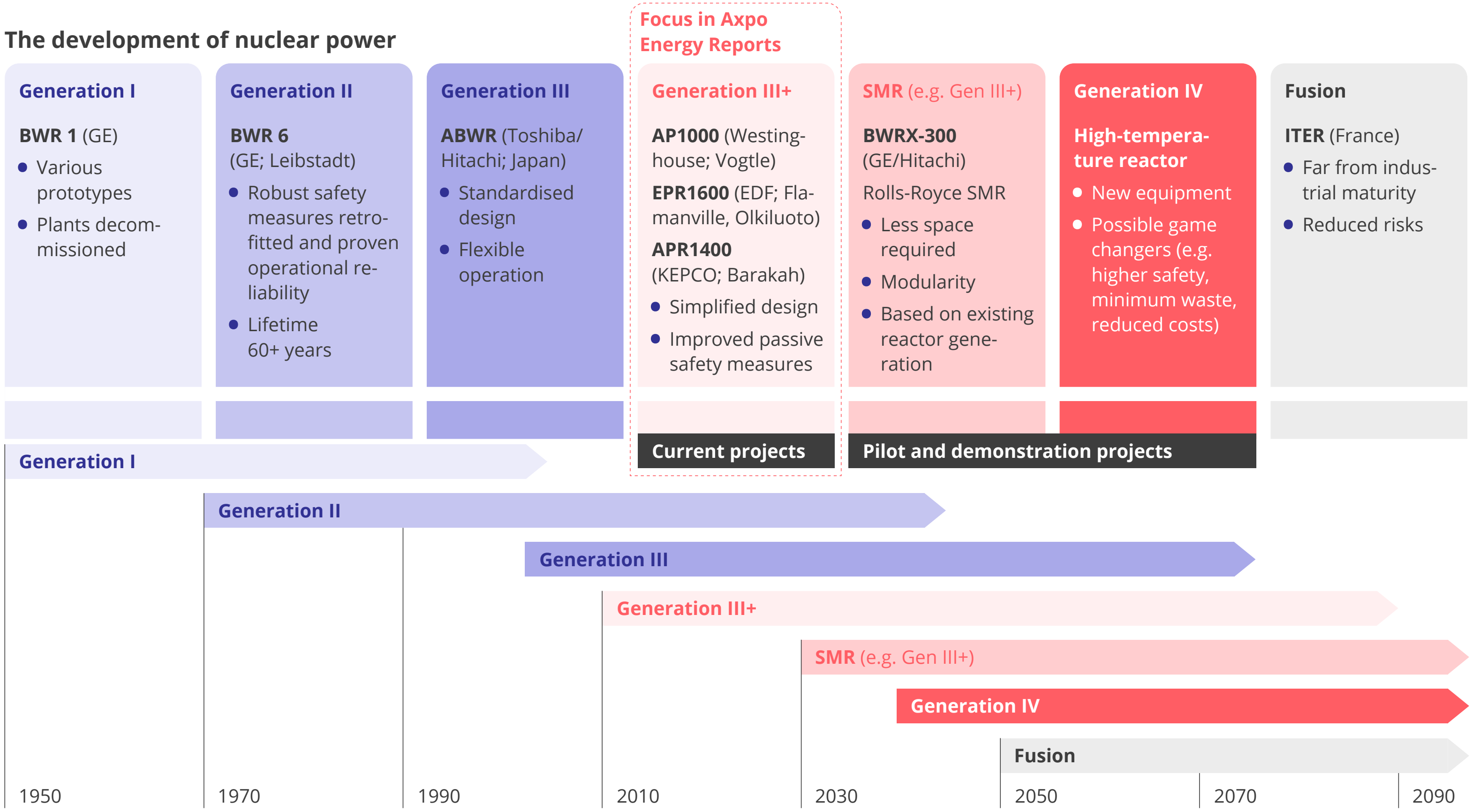
[4] World Nuclear Association, 2024, Six More Countries Endorse the Declaration to Triple Nuclear Energy by 2050 at COP29

[5] IEA, 2025, The Path to a New Era for Nuclear Energy

[6] World Nuclear Association, 2025, World Nuclear Performance Report 2025

Reactors with smaller plant sizes are currently also being designed on the technological basis of Gen III+ and Gen IV. These “Small Modular Reactors” (SMR) have a lower output, a smaller footprint and, thanks to their modularity, promise cost reductions, as some of them can be industrially manufactured (series production) in factories at the manufacturer’s premises. The expected shorter construction period should have a positive impact on financing (faster commencement of production and thus earlier return of invested funds).

The development of nuclear power



Focus in Axpo Energy Reports

Generation I

BWR 1 (GE)

- Various prototypes
- Plants decommissioned

Generation II

BWR 6 (GE; Leibstadt)

- Robust safety measures retrofitted and proven operational reliability
- Lifetime 60+ years

Generation III

ABWR (Toshiba/Hitachi; Japan)

- Standardised design
- Flexible operation

Generation III+

AP1000 (Westinghouse; Vogtle)

EPR1600 (EDF; Flamanville, Olkiluoto)

APR1400 (KEPCO; Barakah)

- Simplified design
- Improved passive safety measures

SMR (e.g. Gen III+)

BWRX-300 (GE/Hitachi)

Rolls-Royce SMR

- Less space required
- Modularity
- Based on existing reactor generation

Generation IV

High-temperature reactor

- New equipment
- Possible game changers (e.g. higher safety, minimum waste, reduced costs)

Fusion

ITER (France)

- Far from industrial maturity
- Reduced risks

Current projects

Pilot and demonstration projects

Figure 3: Overview of development of nuclear power across generations

Focus on Gen III+ in this report

The Axpo Energy Reports focus on technologies that can make a substantial contribution to domestic electricity production in the winter half-year by 2050. Under the current set of rules (see section 4.2), in order to construct a new nuclear power plant by 2050, the approval process would have to be started in the early 2030s. To facilitate this, the technology would have to be sufficiently known and tested.

Gen III+ reactors are available and there is sufficient experience to carry out a thorough evaluation. Today, Gen III+ is the basis for almost every decision to build commercial nuclear power plants worldwide.

Two reactor types are fundamentally feasible for Switzerland: AP1000 from Westinghouse (USA) and the EPR series[7] from Framatome / EDF (France).

Small Modular Reactors (SMRs) could be commercially available from the early 2030s. However, an assessment would currently be based primarily on statements made by the reactor developers, which are often far too optimistic. Gen IV reactors are still at a very early stage of development, with a focus on pilot and demonstration projects (see Innovation section). In addition, Swiss regulation has so far been drafted on the basis of Gen II and III+ reactors, but not Gen IV (source: OECD NEA SMR Dashboard 2025).

Current expansion of Gen III+ reactors
As of February 2025, there are 44 large-scale Gen III+ power plants operating around the world. Reactors currently under construction belong almost exclusively to the category of large Gen III+ reactors (nominal power greater than 1 000 MW each). The following projects are ongoing in Europe (as of October 2025):

- 2 under construction: AP1000 (0), EPR (2 x UK, Hinkley Point)

- 9 in development: AP1000 (3 x Poland, 2 x Bulgaria, 2 x Ukraine), EPR (2 x United Kingdom, Sizewell)

In addition, other power plants are at an advanced stage (e.g. in Sweden, the Netherlands, Slovenia, the Czech Republic, France).

As a result, there is extensive planning and operating experience with existing, planned and under-construction plants, as well as an experienced industry in several countries. This information serves as the basis for a technical and economic evaluation of the reactors, including costs, construction time and operational safety.

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[7] The EPR series has two versions: 1) The EPR1600 is in service at Olkiluoto-3 (Finland) and Taishan-1 / 2 (China); France's Flamanville-3 entered service in 2024. 2) EPR2 is the simplified, standardised successor to EDF, planned as a fleet of six blocks, first in Penly, then in Gravelines and Bugey. It is also under discussion for new construction projects in other European countries.

2.3

Innovation

There are three innovation paths in nuclear power: Small Modular Reactors (SMR, Gen III+), Gen IV reactors (also possible as SMR) and nuclear fusion. They address different objectives – from modular implementation and system flexibility (SMR) to fundamentally new efficiency and resource approaches (Gen IV) and as yet unrealised physical principles (fusion). Table 2 provides an overview of these innovation paths.

What all of these approaches have in common is the aspiration to provide safe, low-emission and reliable energy. However, they differ significantly in terms of technological maturity, market prospects, cost and regulatory risks, and their potential contribution to winter supply, particularly in the Swiss context. See box for more details on Gen III+ SMR.

Innovation paths of nuclear energy

	Gen III+ SMR	Gen IV	Nuclear fusion
Technology	Small Modular Reactors: small, modular and standardised reactors based on Gen III technology (some vendors are planning SMR with GenIV designs).	Next-generation nuclear reactor designs[8] aim to improve safety, sustainability, efficiency and cost, primarily through new cooling media or higher operating temperatures.	Fusion of light atomic nuclei at 100+ million °C
Output	50–300+ MWe per module	Variable: <10 to >500 MWe depending on design	Objective: 200–1 000+ MWe
Safety	Proven safety technology	Bigger corrosion challenges as well as operational, safety and regulatory challenges[9] as alternative coolants are used (salt, lead, gas)	Inherently safe (no core meltdown possible), minimal radioactive waste
Technology readiness level*	7–8 Historical development for military applications (submarines), no commercial demonstrator in the Western world.	4–6 Technology proven in the lab, no demonstrator under construction.	2–3 Technological concept proven and first fundamental experiments conducted, technology not yet proven in the laboratory.
Commercialisation	First of a Kind (FOAK) under construction in Canada (commissioning approx. 2029–2030)[10] and the UK (commissioning in early 2030)[11]; NuScale already licensed in the USA; other demonstration plants under development	Prototypes in China / Russia; commercialisation expected from 2035; Terrapower: Construction scheduled to start in 2027	International Thermonuclear Experimental Reactor (ITER) demo until 2030s, commercial use from 2050 at the earliest

Table 2: Overview of innovation paths in nuclear power, split up into technology, power, safety, maturity and commercialisation

*Technology readiness level: Scale from 1-conceptual to 9-implemented

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[8] Sodium fast reactor (SFR), molten salt reactor (MSR), supercritical water-cooled reactor (SCWR), gas-cooled fast reactor (GFR), lead-cooled fast reactor (LFR), very high-temperature reactor (VHTR)
[9] Example: in-service inspection (ISI) for lead-cooled reactors
[10] World Nuclear News, 2025, Canada's first SMR project: How is CAD20.9 billion cost calculated?
[11] Lewis & Messenger, 2025, UK's first small nuclear power station to be built in north Wales

Deep dive: **Small Modular Reactors (SMR)**

SMRs are nuclear reactors with an electrical output of typically up to 300 MW.[12] "Modular" refers to the construction approach: Main components are prefabricated in factories and delivered to the site for assembly, rather than being built entirely on site. Most current SMR designs are based on Gen III+ technology and use proven reactor principles. Many Gen III+ designs already have passive safety functions (e.g. natural circulation, gravity feeds, pressure accumulators). Some SMR designs rely more on these passive mechanisms and simplified systems (integrated reactor pressure vessels), meaning that safety features are designed to be more inherently safe and less component-intensive.

Benefits of SMR

The modular design enables central components to be prefabricated in factories. This can reduce costs and reduce construction time, complexity and project risks compared to large-scale plants. Smaller initial investments per unit make financing easier and reduce capital commitment. Standardised modules also support parallel production, phased construction and consistent quality control. There are also fewer employees working on the construction site. SMRs require less space than large reactors and thus expand site options – an advantage for Switzerland, where potential sites such as Beznau and Mühleberg are limited in terms of space.

Current status and costs

As of 2025, the global rollout of SMR is at an early stage. In Western markets, no SMR design has yet fully completed the process of construction, commissioning and transition to regular commercial operation. The announced completion dates for FOAK plants have been repeatedly postponed, so reliable evidence of actual construction costs, schedules, and the electrical output achieved in commercial operations is accordingly limited.

FOAK SMRs tend to have higher levelised costs of electricity than large Gen III+ reactors. This is due to typical launch risks, lack of series and supply chain effects, and lower economies of scale. In addition, smaller units result in lower thermal efficiency and relatively higher operating and maintenance costs per unit of electricity generated. These disadvantages have to be compensated for through manufacturing efficiency, shorter implementation times and financing advantages. The economic reasoning depends to a large extent on whether standardisation and mass production of identical units lead to significant economies of scale.

Swiss context

Swiss SMR projects will only be competitive if there are already successful SMR programmes outside Switzerland. Switzerland alone does not have enough volume to build out these economies of scale itself, which is why it needs proven international experience in series production as a foundation. International production experience is expected to be available in the 2030s. Ontario Power Generation, for example, plans to commission the first BWRX-300 in Darlington towards the end of this decade. In the UK, the government has announced the construction of three 470 MW SMRs on the site of a nuclear power plant that has been decommissioned since 2015. The reactors are to be supplied by the UK company Rolls Royce and commissioned in the early 2030s. SMR technologies should be considered in the selection process, as the decision is not just a matter of cost: SMRs could be easier and faster to build and represent a lower cluster risk in the event of failure.

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[12] With an output of 470 MW, the Rolls-Royce SMR exceeds this usual SMR definition.

2.4

Suitable locations for new construction in Switzerland

In Switzerland, the locations of existing/decommissioned nuclear power plants are particularly suitable for building a new nuclear power plant: Gösgen, Leibstadt, Beznau and Mühleberg. The four locations differ with regard to factors such as available space, geology and seismology, cooling water availability[13], flood risks and grid connection.

An initial analysis shows that the locations differ significantly in terms of the available space, but are similarly suitable with regard to the other criteria. At Beznau and Mühleberg, the available space is very limited. The contiguous, freely usable areas for efficiently manoeuvring and assembling large components during the construction phase pose a challenge. In addition, the cramped conditions impose limitations on the construction due to the topology and increase the construction logistics risks. These sites are therefore likely to be more suitable for implementing SMRs.

In contrast, Gösgen and Leibstadt generally have sufficient land, provided that additional land can be purchased and the necessary clearing and zoning can be implemented in accordance with the final layout. Under these conditions, the necessary assembly, storage and crane areas can be set up.

In terms of size, a new nuclear power plant would be the biggest construction project in Switzerland for decades. Depending on the reactor design and the number of facilities on site, up to 10 000 people[14] could be on site at any given time during the peak phase, including assembly, construction, logistics, safety and technical planning teams. Such a high staff presence requires extensive temporary infrastructures: large installation sites, traffic and logistics corridors, parking and shuttle capacities as well as facilities for accommodation, catering and sanitation[15]. There has not been a project of this magnitude in Switzerland since the last new nuclear power plants were built in Gösgen and Leibstadt. The largest individual projects in transport, energy and building construction have significantly lower peak values. For example, the total number of staff on site at any one time across the entire NRLA programme (Gotthard and Ceneri Base Tunnels incl. access tunnels) was estimated at a maximum of 3 000–4 000 people, while the Linth-Limmern pumped-storage plant (1 000 MW, commissioned in 2016) reached peaks of around 1 500–2 000 people. Against this backdrop, it is clear that locations with sufficient contiguous space, excellent access (road/rail) and reserves for temporary installations offer a decisive advantage in terms of deadlines, costs and execution risks.

This results in a prioritisation of the sites in terms of construction and operational feasibility: 1. Gösgen, 2nd Leibstadt, 3rd Beznau, 4th Muehleberg

The criteria for site assessment are discussed in more detail below.

Space availability

The construction of Gen III+ reactors requires extensive storage space and space for crane swing radii, especially for manoeuvring massive components. Modern nuclear power plants consist of enormous components: For example, the reactor pressure vessel can weigh more than 500 tonnes, the steam generators around 350 tonnes and the turbine up to 400 tonnes. These components must be able to be transported, moved with special cranes, temporarily stored and precisely positioned, which requires large free areas without obstacles.

Based on the experience gained from recently built nuclear power plants in Flamanville or Okiluoto, the space requirements are estimated as follows:

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[13] All sites that can be equipped with hybrid cooling towers differ with regard to site-specific cooling parameters: flow volumes, water temperatures and discharge restrictions under environmental law. These parameters influence the thermal efficiency and availability of the plant and require site-specific design of the cooling circuit system.

[14] The specified figure refers to the case where two reactors would be built at one site. If only one reactor were implemented, the value would be correspondingly lower.

[15] EDF, 2026, Developing our workforce

- **EPR reactor**[16]**:** a single block requires around 48–60 hectares during the construction phase (equivalent to around 70–85 football pitches) and around 12 hectares in operation. A double block requires 86–110 hectares during the construction phase and 32 hectares in operation.

- **AP1000**[17]**:** a single block requires around 52[18] hectares in the construction phase and around 7 hectares in operation. A double block requires around 105 hectares during the construction phase and around 17 hectares in operation.

The major difference between the construction and operating phases is explained by the fact that during the construction period additional space is required for construction site equipment, material stores, crane installation areas, manoeuvring areas and assembly halls, which can be removed once completed.

In Beznau and Mühleberg, the available space would be limited and appropriate solutions that would enable construction with limited space would have to be further investigated. This could mean, for example, that components would have to be delivered in several smaller parts and assembled on site or that innovative construction methods would have to be developed with more compact crane setups. All this leads to higher costs.

In addition, land must be purchased at each location. Agricultural land and forest areas will probably also need to be used – the exact details will emerge from the later implementation planning and the site layout. This process requires (temporary) re-zoning of agricultural or forestry land in industrialised countries, which is governed by the spatial planning procedure.

Wildlife corridors[19] must also be taken into account. As a result, the usable construction area can be additionally affected by such corridors, as these ecologically important connections must be preserved. This means that power plant planning must be carried out in such a way that natural animal migration routes are preserved.

Geology and seismology

The geological and seismological prerequisites are met at all four locations. This means that the substrate is stable enough and the risk of earthquakes remains manageable, such that nuclear power plants can be operated safely there.

The precise seismological design of a new nuclear power plant requires a comprehensive analysis of all site-specific earthquake parameters. This includes historical and geological data as well as modelled scenarios, response spectra across the entire frequency range and the interaction between the ground and the structure.

A commonly used reference value is Peak Ground Acceleration (PGA), i.e. the maximum ground acceleration during an earthquake. Current analyses of existing Swiss nuclear power plant sites show that the PGA at the terrain surface for a 10 000-year event is between 0.30 g and 0.39 g, where “g” denotes the gravitational acceleration (ENSI 2015). For the EPR, the standardised, certified design is designed for a PGA of 0.25 g; for the AP1000 it is 0.3 g. This means that the standard design of these reactor types for Switzerland would have to be adapted to safely meet the local earthquake requirements.

However, the safety margins incorporated into the standard design mean that such moderate deviations from the standard design require only minor adjustments to the reactor design. For example, there are even higher seismic requirements[20] (0.56 g) in Slovenia for the Krško 2 (JEK2) project. A feasibil-

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[16] Internal: EDF Request for Interest (RFI) package

[17] Internal: Westinghouse Request for Interest (RFI) package information.

[18] The construction phase (52 ha) is divided into: on-site construction areas (11 ha), off-site construction areas (7 ha), storage areas (20 ha), permanent power plant (7 ha) and optional parking (6 ha). The temporary construction and storage areas will be dismantled after commissioning.

[19] Important migration routes for animals between different habitats.

[20] Jamsek & Planinc, 2024, An Overview of Seismic Design Parameters for Design of Nuclear Power Plants

ity study confirmed that both the AP1000 and the EPR reactor type are suitable for this site.

- **Westinghouse (AP1000):** “It is feasible to build an AP1000 reactor at the JEK2 site. […] Based on the available information, it has been assessed that any design changes would be minimal.”
- **EDF (EPR):** “The impact on the design is limited and manageable for the nuclear buildings and associated structures.”

These findings show that the Swiss sites are also technically feasible if appropriate reinforcement measures are implemented. This site-specific seismic design is common in the adaptation of standard reactors and leads to higher engineering and construction costs. Based on the moderate exceedance and the experience in Slovenia, it is assumed that the seismic requirements can be met easily and that additional costs will be low.

Cooling systems
Broadly speaking, a distinction can be made between flow-through cooling, wet cooling towers and hybrid cooling towers. Due to the legal requirements and for reasons of acceptance, a hybrid cooling tower is preferred. Further details on the justification can be found in section 2.8.

Flood risks
The risks of flooding can be controlled with suitable measures.

Grid connection
Suitable grid connections are available at all locations.

2.5
Safety of nuclear power plants

The safety systems of Gen III / III+ reactors have been greatly enhanced compared to previous reactor designs. In particular, the experience gained from the three reactor accidents has been taken into account: at Three Mile Island (1979, USA), operating errors and unclear indications led to partial nuclear meltdown. This led to the realization that better human system interfaces[21] and clearer emergency procedures are needed. The Chernobyl accident (1986, Ukraine) highlighted the importance of robust safety envelopes and inherently safe reactor designs. The failure of the electricity supply after the tsunami in Fukushima (2011, Japan) made it clear that reactors must be safe even in the event of station blackouts.

The AP1000 and EPR differ fundamentally in their safety philosophies:

AP1000 – The “passive” solution
The passive safety philosophy of the AP1000 relies on the laws of nature[22]: gravity automatically allows cooling water from tanks positioned above to flow into the reactor, while natural circulation ensures continuous cooling through the physical principle of rising warmer and falling colder water. In addition, accumulators pressurised with nitrogen automatically inject borated[23] cooling water when the pressure drops. This eliminates the need for an external electricity supply or operator intervention – even if all electrical systems fail, the reactor cools down automatically and safely. This design philosophy simplifies the system architecture. Compared to Gen II, around 50 percent of the valves, 35 percent of the pumps and 80 percent of the safety-rel-

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[21] Human-machine interface: includes all elements through which personnel interact with the system – displays, alarms, controls, communication systems and quality management procedures.
[22] Westinghouse, 2026, AP1000 Nuclear Power Plant – Passive Safety Systems
[23] Borated cooling water is water to which boric acid has been added. The substance boron helps to suppress / slow down the chain reaction in a nuclear power plant.

evant piping are omitted. Fewer components mean fewer potential errors and higher overall reliability. As a result, the AP1000 can be operated safely for over 72 hours even in the event of a complete blackout without any human intervention.

EPR – The "active redundant" solution

The EPR philosophy of active redundancy takes a different approach. It relies on four parallel security systems and thus achieves N+2 redundancy. With four safety trains, one may be out of service due to maintenance and another may fail; the remaining two are still available to perform the required safety functions, even if one of them is ineffective as a result of the triggering event. This philosophy has the advantage of preserving tried-and-tested engineering principles from decades of reactor experience – electric pumps, active cooling systems and computer-controlled safety systems that have proven themselves in practice continue to be used. Instead of replacing these technologies, the EPR systematically multiplies them. Where previous reactors had an emergency cooling system, the EPR has four identical ones. Where there was one emergency diesel generator, there are now four. This redundancy increases reliability exponentially. If an individual system has an availability of 99 percent, four systems operated in parallel achieve a total availability of 99.999999 percent. In addition, systematic physical and electrical separation effectively prevents common cause failures of a structural nature. This means that the four safety trains are located in separate, fire-protected parts of the building, have separate electricity supplies, separate cooling water pipes and even different manufacturers of critical components. A fire, flood or other local incident thus only damages one train, while the other three continue to work unimpaired. This separation goes so far as to ensure that even the cable runs are physically separated and that the diesel generators are housed in different buildings to ensure that no single incident can cripple several safety trains at the same time. The drawback is high operating and maintenance expenses due to the many systems.

Both safety philosophies also incorporate the management of serious accidents in the event that they actually occur. This means that they are not only designed to prevent accidents, but also to limit the impact of an ac-

cident and to prevent or minimise the release of radioactive materials. Probabilistic safety analyses (computer-aided calculations of numerous accident scenarios) show the impact of the measures on the accident risk:

- **Core damage frequency:** *What is the frequency of a reactor core being damaged?* The core damage frequency was reduced from 10^{-5} per reactor year to 10^{-7} for Gen III+ reactors. This means that, statistically speaking, core damage would occur only once in ten million years of operation.
- **Large releases:** *How often do radioactive materials end up in the environment?* Even more important for civil protection is the release of large quantities of radioactive substances. The probability of a release of radioactive materials into the environment is approximately once in a hundred million reactor years (10^{-8}). This low probability results from the fact that even in the case of core damage (10^{-7}), the conditional probability of a large release is only around 10 percent. In other words, modern reactors not only have less core damage, but even if when core damage does occur, the design prevents a large release in 90 percent of cases – a hundred times safer than the previous generation.

In addition, this is compliant with the ENSI guideline G14 dose requirement of 0.3 millisievert (mSv) per year[24], which is well below the legal limit of 1 mSv per year (Art. 22 RPO). This exposure is minimal compared to natural background radiation of 1.1 mSv on average per year in Switzerland.[25] By way of comparison: a transatlantic flight causes 0.08 mSv, a chest X-ray 0.1 mSv[26].

2.6

Nuclear power plants in conjunction with renewable energies

The load change, i.e. the change in power over a certain period of time, is becoming increasingly important due to the increasing amount of fluctuating renewable energies[27] in the power grid. Nuclear power plants are usually operated for base load supply in order to cover their high fixed costs through a large number of hours at full capacity. Technically, however, they are capable of providing load-sequence operation and frequency control; this is particularly useful or even necessary in power systems with a high proportion of renewable generation.

In addition to active capacity control, nuclear power plants increase grid stability through their rotating masses (turbines, generators). This mechanical inertia dampens frequency fluctuations and prevents abrupt frequency changes in the event of imbalances between generation and consumption. In power systems with a high proportion of inverter-based renewable energies, system-wide inertia decreases as solar and wind turbines do not generate rotating masses. This challenge must be addressed in a targeted manner to ensure system stability and may involve additional investments depending on the solution approach. For example, grid-forming inverters combined with battery storage can provide synthetic inertia and thus largely compensate for the lack of rotating mass found in conventional power plants[28].

The basic control principles for a load change are similar for the AP1000 and EPR. Rapid power changes occur primarily through control rod movements – these rods, made of

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[24] ENSI guideline G14 sets a generic source-related dose guideline of 0.3 mSv per year for all nuclear facilities on site (Art. 7 (3) RPO). The statutory limit in accordance with Art. 22 RPO is 1 mSv per year.

[25] Swiss Federal Nuclear Safety Inspectorate ENSI, 2021, Ten Years on from Fukushima (2/6): The radiological effects of the accident

[26] United Nations Scientific Committee on the Effects of Atomic Radiation, 2000, Sources and Effects of Ionizing Radiation; Annex D “Medical radiation exposures,” Table 35 (“Trends in average effective doses…”)

[27] Fluctuating renewable energies are renewable energy sources whose electricity production fluctuates depending on the weather and the time of day and therefore cannot be controlled continuously or according to demand. Typical examples are wind and solar energy.

[28] Hitachi, 2025, A Resilient Grid for a Renewable Future: How Grid Forming (GFM) Inverter Supports the Next Generation of Power Supply

neutron-absorbing material, are moved into or out of the reactor core in order to slow down the nuclear reaction or – from a state of partial-load operation – to increase it. Slower, longer-term reactivity adjustments are made via the concentration of soluble boron in the main coolant, which absorbs neutrons and acts as a "chemical brake" on the nuclear reaction.

This control allows the AP1000 to adjust the nominal power by ±5 percent per minute in both directions and to reduce it to 15 percent of the nominal power. There are two control zones for the EPR (valid for fuel burn-up < 80 percent): between 60 and 100 percent of the nominal power, the nominal power can be adjusted by ±5 percent per minute; between 25 percent and 60 percent only by ±2.5 percent per minute. In addition, an emergency shutdown (to 0 percent of nominal power) in seconds is possible at any time as a safety measure.

Another factor to consider is the number of cycles that can be performed with the equipment. Each load cycle – i.e. power up and down – places mechanical stress on the materials and contributes to material fatigue if repeated frequently. When the output changes, the temperature and pressure in the reactor change, causing metal to expand and contract. Since different components are heated at different speeds, mechanical stresses arise in the material.

Nuclear power plants are designed for a maximum number of cycles with large safety margins. In the upper load range (100 percent ⟷ 80 percent) the coolant temperature and pressure change only slightly. For this reason, the power plants are designed for up to 100 000 such cycles. Even with daily load changes (365 cycles per year), this goes well beyond the planned lifetime.

In the lower load range (25 percent ⟷ 80 percent), the loads are significantly higher due to larger temperature and pressure amplitudes; the permissible number of cycles in the lower load range are plant- and transient-specific and significantly lower than in the upper load range, which, however, is sufficient for more than ten deep load cycles per year over the lifetime – more than enough for seasonal adjustments. This robust design makes modern nuclear power plants a flexible and controllable source of power generation in the technical sense.

2.7

Disposal of spent fuel rods and radioactive waste[29]

Switzerland has developed a comprehensive legal framework for the management of radioactive waste based on an important principle: anyone who generates radioactive waste is also responsible for ensuring that it is handled and disposed of safely at their own expense. The waste minimisation principle also applies. Operators of nuclear facilities are obliged to operate and decommission them in such a way as to generate as little radioactive waste as possible.[30]

Radioactive waste must be disposed of in a deep geological repository in Switzerland. A deep geological repository is located in a suitable rock formation ("geological barrier") which, together with the waste containers ("engineering barrier"), prevents the radioactive waste from becoming a hazard to humans and the environment during the decay phase. Spent fuel rods and high-level waste must be safely sealed for a period of 100 000 years. Prior to final disposal of the radioactive waste in the deep repository, it is stored in the central interim storage facility in Würenlingen and in the interim storage facility in Beznau.

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[29] Swiss Federal Nuclear Safety Inspectorate ENSI, 2024, Joint convention on the safety of spent fuel management and on the safety of radioactive waste management

[30] Art. 25 (2) Radiological Protection Act

Switzerland maintains a comprehensive register of all radioactive waste that provides full transparency about existing waste and where it is stored. Waste is divided into three categories, depending on its level of radiation and hazard:

- **High-level waste:** spent fuel rods; fission products produced during the reprocessing of spent fuel rods.
- **Alpha-toxic waste:** materials with high concentrations of alpha emitters, hazardous only if inhaled or swallowed.
- **Low-level and intermediate-level waste** comprises the other radioactive materials that are not assigned to the previous categories.

More than 1 700 tonnes of high-level waste and around 7 700 cubic metres of low- and intermediate-level waste are stored in Switzerland (as of 2023), mostly at ZWILAG in Würenlingen.[31]

Today’s waste volumes are the result of more than 50 years of nuclear energy use in Switzerland and consist of two different sources: between the 1970s and 2006, Switzerland followed a policy of reprocessing spent fuel rods. Approximately 1 139 tonnes of spent fuel rods were transported to France and the United Kingdom for reprocessing. In this process, recoverable materials such as uranium and plutonium were extracted, which can be reused for energy generation. The highly radioactive residues created during reprocessing were vitrified[32] and returned to Switzerland.

Reprocessing has been prohibited under Swiss law since 2006. All spent fuel is now treated as waste domestically and stored in interim storage until it can be finally disposed of in a deep geological repository. In addition to political considerations, the reasons for the ban are, in particular, safety concerns, as reprocessing entails the risk of accidents during transport and processing. Economic considerations also play a role, as reprocessing is technically complex and costly and the costs are disproportionate to the potential benefits. Consequently, current stockpiles consist of two sources: the recycled waste from reprocessing and the fuel rods that have been treated directly as waste since 2018.

Switzerland operates a multi-stage system of interim storage facilities. Each nuclear power plant has on-site facilities for conditioning and storing operational waste. After several years of cooling in spent fuel pools, spent fuel is transferred to dual-purpose containers, which are designed for both transport and long-term dry storage. These robust containers offer multiple safety barriers against the release of radioactivity and have proven themselves in operation.

ZWILAG in Würenlingen is the centre of Swiss interim storage and has been in operation since June 2001. It has conditioning facilities and a plasma furnace that reduces the volume of low- and intermediate-level waste. After the volume has been reduced, the remaining material is shaped into a form suitable for final storage. Additional capacity for further processing and storage is available directly in the respective nuclear power plants.[33]

When a deep geological repository is commissioned, this waste will transported there and permanently stored. General licence applications were submitted in 2024 for the location of the Nördlich Lägern deep geological repository and the fuel element packaging plant in Würenlingen next to ZWILAG, which are sufficiently equipped for the existing Swiss nuclear power plants in the planned scope. For illustration purposes: the total volume of around 90 000 m³ of packaged waste

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[31] High-level waste, such as spent fuel, is measured in tonnes of heavy material (tHM), as this unit is related to radioactivity and heat generation. The volume cannot be determined, as it depends on the subsequent conditioning. In contrast, low- and intermediate-level waste (L/ILW) is already packaged and conditioned, which is why the physical volume is the key factor for warehouse capacity planning. The different units result from the nature of the waste: tHM for monitoring radioactivity and volume for storage.

[32] “Vitrified” refers to a technology for the safe storage of radioactive waste, in which the waste is converted into a glassy substance.

[33] ZWIBEZ Beznau with dry storage for fuel in dual-purpose containers and hall for SMA; Gösgen with wet storage building for spent fuel rods; Leibstadt with sorting facilities and storage of large components.
Long-term interim storage of packaged SMA/MMA and dry-stored fuel rods takes place at ZWIBEZ (Beznau) and ZWILAG (Würenlingen).

for final disposal – consisting of low-, intermediate- and high-level radioactive waste – would fill almost two-thirds of the historical main hall of Zurich's main station.[34]

Switzerland has put in place a comprehensive financial framework to ensure that sufficient funds are available for the management of radioactive waste and the decommissioning of facilities. Two separate funds guarantee future financing. The Waste Disposal Fund covers all costs associated with the disposal of radioactive operational waste and spent fuel rods, including the construction and operation of the deep geological repository. The Decommissioning Fund will bear the costs of decommissioning the nuclear facilities and the disposal of the resulting waste. The operators of the nuclear power plants make regular payments into these funds up to the 50th year of operation of their plants based on detailed cost estimates updated every five years. The funds are managed independently of the operating companies and ensure that the waste disposal costs are borne by the polluters. The separate fund structure ensures that sufficient financial resources are available for the full fulfilment of all disposal obligations up to final disposal in geological repositories.

2.8

Cooling systems of nuclear power plants

Like any thermal plant, nuclear power plants generate large amounts of waste heat during electricity generation, which must be continuously dissipated to ensure that the plant remains safe and efficient and does not overheat.

Different cooling systems can be used depending on the location. For domestic locations such as Switzerland, closed cooling circuits with cooling towers are the standard solution. Here, hot water is fed from the steam turbine's condenser to the cooling tower, where it is cooled and then returned. Only as much water is withdrawn from the river as is lost through evaporation or is needed for occasional flushing.[35] Accordingly, with this cooling system, the flow is only slightly heated, and rising temperatures due to climate change are not problematic for continuous heat dissipation.

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[34] NAGRA, 2026, Quantity of radioactive waste

[35] A flushing system keeps the cooling water clean so that no deposits or microorganisms form; this water is treated in a controlled manner and only returned to water bodies in compliance with environmental regulations.

03

Acceptance

The population’s attitude is polarised.

In brief

- In order to build a new nuclear power plant in Switzerland by 2050, there must be a social consensus in addition to the lifting of the ban on new construction; projects are effectively infeasible without broad social acceptance.
- Popular initiative “Stop the blackout”: The Federal Council rejects the initiative, but proposes an indirect counter-proposal that lifts the ban on new construction in the NEA. Political support is mixed.
- Surveys show that people’s attitudes are polarised: about half in favour of nuclear power, the other half against it.
- For further information on the political process of lifting the ban on new construction, please refer to section 8 Policy.

3.1
Popular initiative “Stop the blackout”

The ban on the construction of new nuclear power plants is a key element of the Swiss Energy Strategy 2050, which was adopted by 58.2 percent of voters in a vote in 2017. There is no statutory time limit for existing nuclear power plants, as Parliament has waived a corresponding regulation. The power plants can be operated as long as they are deemed safe by the regulator. For the operators, it goes without saying that profitability is also a criterion for the operation. A separate initiative that would have imposed a 45-year limit on the operating life was rejected by 54.2 percent of voters in 2016.

The ban on new construction and the gradual phasing out of nuclear power have repeatedly faced criticism. In February 2024, a popular initiative “Electricity for everyone at all times (stop the blackout)” was submitted with the aim of lifting the ban by amending the constitution. The initiative is rejected by the Federal Council. However, in an indirect counter-proposal, it proposes the lifting of the ban on new construction in the Nuclear Energy Act, thus addressing a key concern of the popular initiative. According to a Tamedia survey carried out in October 2025, 56 percent of those surveyed are in favour of lifting the ban on new construction.[36]

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[36] Energie Club Schweiz, 2025, 56 percent of the population wants new nuclear power plants

3.2

Acceptance of nuclear power in the general population

In Switzerland, it is not possible to implement infrastructure projects in the area of energy supply without public support. The legally prescribed approval procedure and the political system with its federal structures and expanded co-determination rights subject the legitimacy of projects to constant review. Specific infrastructure projects can only be realised if they enjoy broad socio-political acceptance.

The background report "Prospects for nuclear power in Switzerland"[37] provides a comprehensive overview of the development and current status of the Swiss public's attitude towards nuclear power. Around half of citizens are in favour of nuclear power, while the other half are against it.

While this division has proved to be exceptionally stable in recent years, specific events have repeatedly shaken social acceptance of nuclear power. Serious accidents such as Chernobyl (1986) and Fukushima (2011) drastically reduced acceptance and led to the abandonment of the planned replacement nuclear power plants for Beznau, Gösgen (Niederamt) and Mühleberg and the ban on new construction by referendum following Fukushima.

Future external events such as major reactor accidents may continue to have a critical impact on public opinion in the short term. This significantly increases investment risks and planning uncertainty, as the planning and construction of a new nuclear power plant takes a good two decades and a referendum is highly likely to follow once the general license has been granted.

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[37] Neu, et al., 2025, Perspektiven für die Kernenergie in der Schweiz. Grundlagenbericht

04

Law and regulation

In order to implement a new nuclear power plant in Switzerland by 2050, the framework conditions must be significantly adjusted.

In brief

- In order to build a new nuclear power plant in Switzerland by 2050, the ban on new construction must be lifted.
- The total duration of the project is currently 21–29 years, including project development, approval, construction and commissioning.
- In Switzerland, there is a three-stage approval process: general license, building permit and operating license. An optional referendum can be held against the granting of the general license, and appeals can be lodged against the building permit and operating license.
- Following the lifting of the ban on new construction, a suitable framework is also needed that would enable investments in new nuclear power plants.
- Adjustments to the approval process are needed to speed up procedures and reduce the risk of delays. Possible measures include exemption from the general license for existing sites, enabling site preparation before the building permit is granted, and reducing the impact of appeals on the start of construction and commissioning.
- A nuclear power plant cannot be built without risk sharing between the public sector and private investors as well as subsidies. For starters, government support is needed for project development. For construction and operation, instruments such as the so-called RAB approach and the combination of an investment contribution and sliding feed-in premium are conceivable. In addition, government guarantees are likely to be needed for tail risks.
- Regulatory changes during the construction phase entail the risk of substantial design adjustments. While the design must not be rigid and additional safety requirements must remain possible, measures are needed to reduce the likelihood and impact of adjustments. In Switzerland, plants under construction could be regulated in the same way as existing ones.

4.1
Current status

The construction and operation of nuclear power plants in Switzerland requires a framework licence in accordance with Art. 12 NEA. Current law prohibits the granting of such general licences for new nuclear power plants and for modifications to existing nuclear power plants (Art. 12a and Art. 106 (1^{bis}) NEA). Unless this prohibition is lifted, new projects or substantial adjustments to existing plants are legally prohibited.

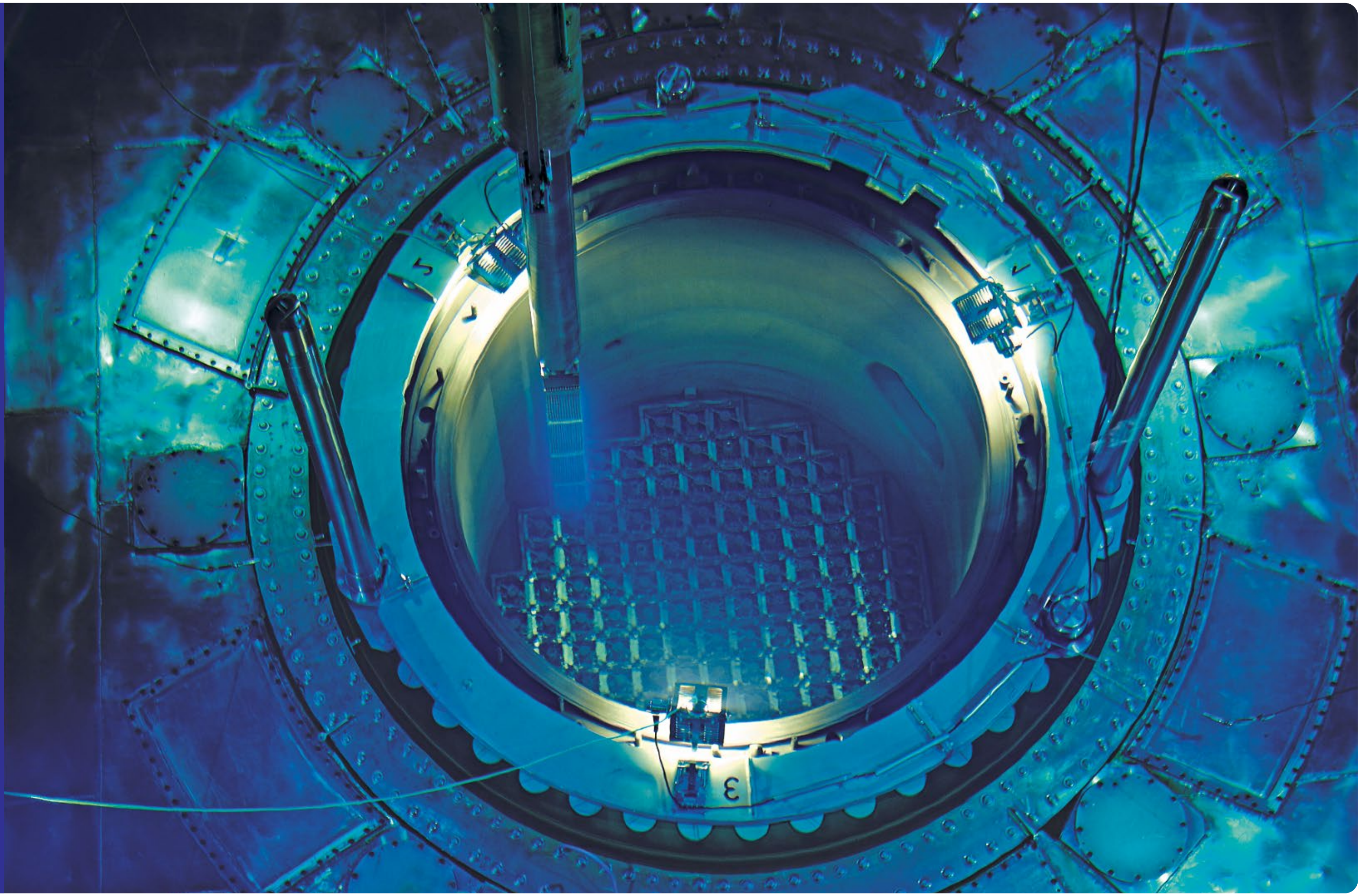
Should the ban be lifted, the Nuclear Energy Act (NEA) and the Nuclear Energy Ordinance (NEO) already set out the corresponding procedures for obtaining a general license, building permit and operating license. Switzerland currently has one of the most comprehensive approval procedures for nuclear power plants in the world (see Focus: Comparison of international approval periods).

Statutory deadlines exist for only a few selected procedural steps, and there is no statutory limit to the duration of the entire approval process. No reliable empirical values

Focus: **Comparison of international permit periods**

In 2021, the OECD-NEA published a comprehensive analysis of the permit periods (excluding construction periods) for new nuclear power plants.[38] The results show significant differences between the countries: France has the shortest overall duration at around 4 years, followed by the Czech Republic at around 4.5 years. Switzerland has a total duration of 12 years, the United States around 11 years and the United Kingdom around 8 years.

For countries with generically approved reactor designs, such as the USA and the United Kingdom, it should be noted that a large part of this period is attributable to the initial review of the reference design; for follow-up projects with certified reference designs, the actual approval time is therefore significantly shorter than these average values.



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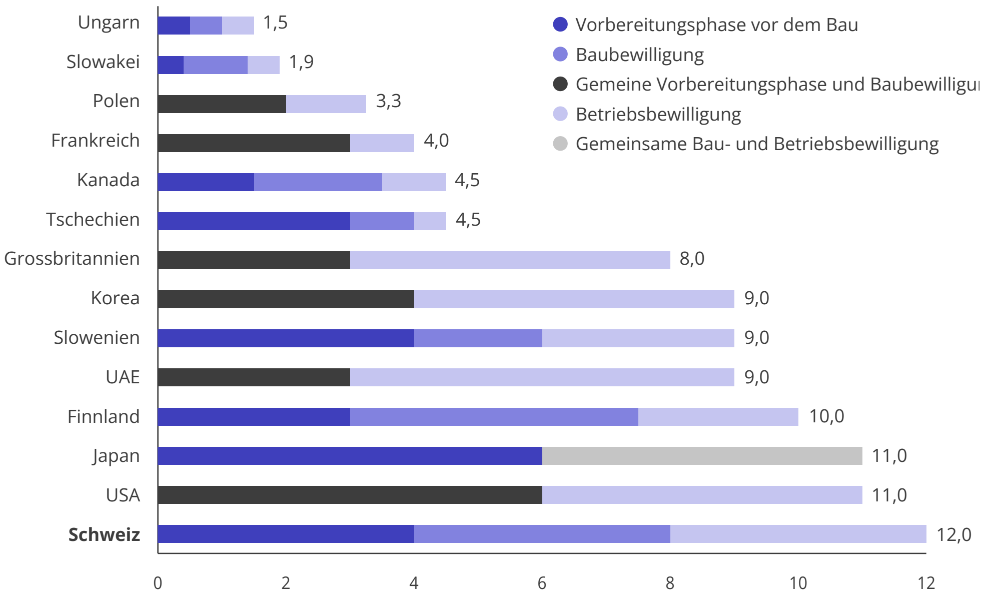
[38] OECD, 2021, Summary Report on the Licensing Process of New Reactor Applications Table 1. Average time for licensing before construction and commissioning

are available for estimating the time required; therefore, plausibility-tested assumptions must be used. An overall project duration from project initiation to the start of construction of around 13 to 19 years can be assumed. The subsequent construction phase will take another 8 to 10 years. As the operating license procedure can be carried out in parallel with the construction phase, the total project duration is 21 to 29 years. This period of time makes it challenging to complete a nuclear power plant by 2050. However, the process can also be significantly shorter if the competent authorities are equipped with the necessary resources and if there is a clear political will and public support.

The Swiss approval procedure is divided into three approval levels: general license, building permit and operating license. The NEA and the NEO define the corresponding procedures.

Average duration for permits



Three regulatory steps are involved:

- **Preparation phase before construction:** Comprises all administrative and technical preparations before the building permit is granted. This includes environmental and site assessments and, in countries with generically approved reactor designs, the initial review and approval of a reference design. In Switzerland, this step essentially corresponds to the procedure for granting the general licence, in which the site and safety principles are comprehensively assessed.
- **Building permit:** Corresponds to the procedure for granting the building permit.
- **Operating licence:** Corresponds to the procedure for granting the operating licence

Not all countries follow a three-step procedure. France, for example, combines the preparatory phase before construction with the building permit.

Figure 4: Average duration of permits before construction and commissioning in years

General license

Unlike many other countries, the granting of the general licence in Switzerland is characterised by the strong involvement of the federal government, the cantons and the general public. The Federal Council grants the general license, but must submit its decision to the Federal Assembly for approval, including the possibility of an optional referendum against the Parliament's decision. The general license focuses on site suitability and key impacts, not technical details. There is no legal entitlement to the granting of a general licence (Art. 12 (2) NEA).

Several documents are required for an application for a general licence.[39] The scope and level of detail of the documents were defined for the approval process launched by RESUN/KKN in 2008 and provide a basis for new applications, which reduces the preparatory workload. The lead authority for the process is the SFOE.

Once the application for a general licence has been submitted, the further procedure can be divided into four simplified steps:

- **Preliminary review, expert reports, statements:** The SFOE checks the application for completeness and obtains the necessary expert opinions, in particular from ENSI and the Federal Nuclear Safety Commission (NSC)[40]. The cantons and the responsible federal departments are invited to submit their comments. Mandatory consultations must be held with the canton in which the site is located, neighbouring cantons and neighbouring countries.

- **Public consultation, objections/appeals and reconciliation procedure:** The application, statements and expert opinions are published publicly for a period of three months. Objections and appeals may be raised during this period.[41] The cantons, specialist bodies and experts comment on objections and appeals. In the event of differences within the Federal Administration, a reconciliation procedure is carried out.

- **Decision of the Federal Council:** The Federal Council decides on the application as well as on objections and appeals.

- **Parliamentary approval and referendum:** The Federal Council must submit its decision to the Federal Assembly for approval. The decision of the Federal Assembly to approve a general license is subject to an optional referendum.

According to the applicable rules, it is assumed that in a favourable scenario, the general license procedure will take around 3–4 years from submission to granting of the license (if granted), but could take 5–6 years if delayed. The main risk is of a political nature. The lengthy process is necessary in order to give political legitimacy to the decision.

The necessary internal ramp-up phase (internal decisions, development of project organisation, founding of companies) lasts around three years, starts before the application for the general license is submitted and is not included in the above-mentioned period. If the right resources are available, it should take no longer than one year to prepare a general licence application, provided that it is based on existing sites.

Building permit

The second step in the current approval procedure is obtaining the building permit. Once this is available and the construction site is prepared, construction can begin (commencement of construction (CoC)).

There is a legal entitlement to the granting of the building permit if all requirements have

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[39] safety and security report, environmental impact report, disposal certificate, decommissioning concept and a spatial planning report

[40] The NSC is an independent, scientific administrative commission of the federal government. It advises the Federal Council, the DETEC department and the nuclear supervisory authority ENSI on matters relating to the nuclear safety of nuclear power plants.

[41] Legally, a distinction must be made between objections and appeals. An appeal is a formal remedy conferring party rights and is reserved for authorised, directly affected persons.
Objection is a comment on the substance of the matter that does not confer party right sand is generally open to all.

been met. When the building permit is granted, all permits required under federal law are issued. Cantonal (and municipal) permits and plans are not required. However, cantonal law must be taken into account insofar as it does not disproportionately restrict the project (Art. 49 (3) NEA).

The lead authority for the process is the SFOE, the licensing authority is DETEC. Although the building permit can be contested, the procedure is more technical and less political than the general license procedure. Nevertheless, the building permit procedure remains complex and requires extensive work.

The preparatory phase such as engineering, procurement and commercial activities must be completed before the planning application is submitted. These activities are resource-intensive, but can be carried out in parallel with the general license procedure, so the planning application can be submitted as soon as the general license is available.

The documents required for the planning application are set out in the Nuclear Energy Ordinance (NEO). The details and scope of the documents were discussed at the time of RESUN / KKN, and ENSI intended to draft a policy on this. Such a policy is to be expected if a new application is submitted.

Once the application has been submitted to DETEC or the Swiss Federal Office of Energy (SFOE), the further procedure can be divided into four simplified steps:

- **Preliminary review, expert reports, statements:** The planning application is first checked for completeness. ENSI, the NSC, federal departments and the cantons concerned provide their comments.

- **Public consultation, appeal and reconciliation procedure:** The application is then made public. Parties and municipalities affected by the application may lodge an appeal. In the event of differences within the Federal Administration, a reconciliation procedure is carried out. In addition, the canton in which the site is located is consulted, which has the right to lodge an appeal if the building permit is granted despite its refusal.

- **DETEC decision:** DETEC grants approval and decides on all appeals. It is important to note that, Approval has already been granted at this stage, but it only becomes legally binding once the appeal period has expired without any action being taken or once any appeal proceedings have been concluded.

- **Appeals procedure:** Appeals against the granting of the building permit can only be lodged with the Federal Administrative Court (FAC) by persons with party standing. The appeal has suspensive effect, i.e. the start of construction may be delayed as a result. An appeal against the ruling of the FAC can be lodged with the Federal Supreme Court (FSC). As a rule, appeals to the Federal Supreme Court do not have a suspensive effect. The appeals procedure postpones the start of construction and is fraught with a high degree of uncertainty.

The process takes around three to four years in a favourable scenario, but could be extended to five years or more if there is a significant delay. The main risk lies in the appeals procedure.

Operating licence

As soon as construction has begun, the applicant can submit the application for an operating license. The documents required for this are set out in the NEO. The operating license procedure is identical to the building permit procedure.

There is a legal entitlement to the granting of an operating licence if all requirements have been met. When the operating licence is granted, all permits required under federal law are issued. Cantonal (and municipal) permits and plans are not required, as federal law exclusively regulates the field of nuclear power. However, cantonal law must be taken into account insofar as it does not disproportionately restrict the project (Art. 49 (3) NEA). The lead authority for the process is the SFOE, the licensing authority is DETEC. The main risk is once again in the appeals phase. However, if the operating license is well coordinated, it can ideally be granted before the completion of the construction work. The is desirable because it sets out the various steps involved in commissioning and facilitates their preparation.

An ENSI system for approvals is required in order to approve the successive steps of commissioning following the granting of the operating license, such as the first delivery of nuclear fuel, the first fuel load and the initial start-up of the reactor. These commissioning steps should take around a year.

According to Art. 20 (2) NEA, the operating license can be issued at the same time as the building permit (combined building permit and operating license) if the advance requirements for safe operation can already be conclusively assessed at this point in time. The procedural steps for a joint permit follow the building permit procedure, but with a longer safety evaluation phase by ENSI (approx. 3 years). By concentrating the appeals procedure, this approach would reduce risks and increase planning certainty.

4.2

Creation of an appropriate regulatory and legal framework for the construction of a new nuclear power plant

The statutory ban on new construction must be lifted before a nuclear power plant can be commissioned. The counterproposal to the blackout initiative is expected to be definitively discussed in Parliament by mid-2026 at the latest. If the counterproposal is adopted by Parliament, a referendum is expected in early 2027.

Following the lifting of the ban on new construction, a suitable framework is also needed that would enable investments in new nuclear power plants. The legal basis for this would have to be created first. It can be assumed that the political process here would start after the referendum and would be completed in 2031–32.

The content of such an appropriate framework is outlined in this section. Section 4.2.1 describes how the current approval procedure can be adapted in order to ensure the commissioning of a new nuclear power plant in Switzerland by 2050. Section 4.2.2 describes tools required for risk sharing and subsidies during project development, construction and operation. Chapter 4.2.3 examines the special topic of regulatory changes during the construction phase and the associated adaptations to the reactor design.

Figure 5 illustrates two possible timelines for the construction of a new nuclear power plant in Switzerland: Figure 5a) shows the schedule without further measures; Figure 5b) shows further measures.

a) without measures affecting the schedule

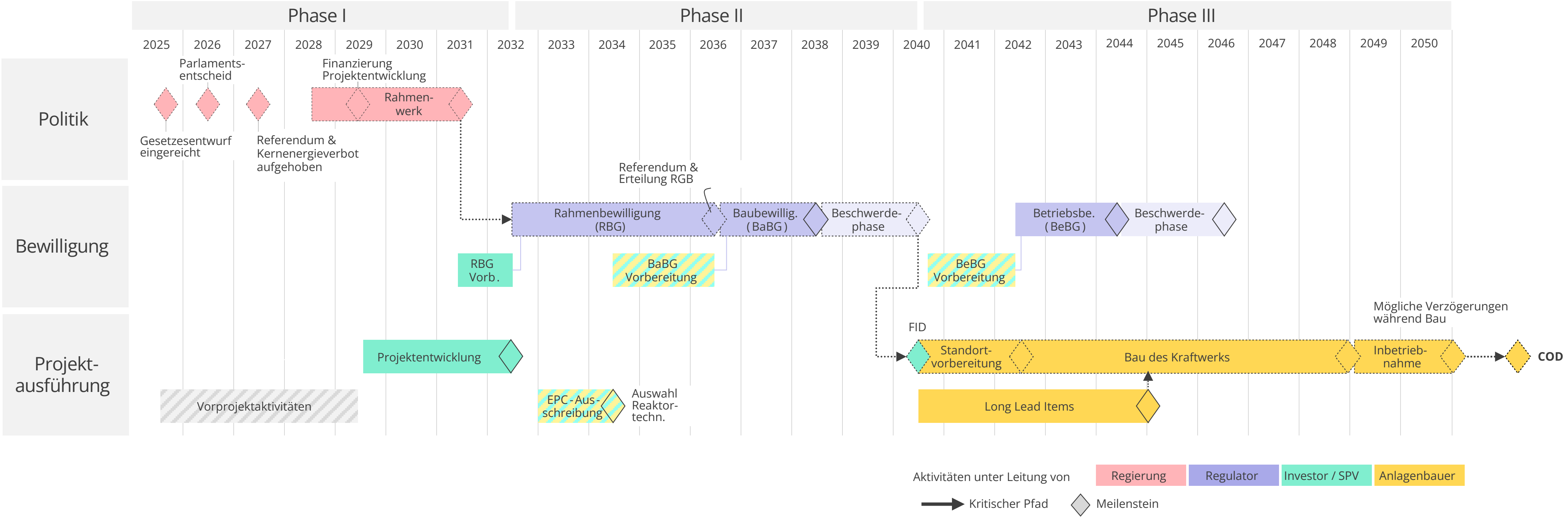

Figure 5a: Timetable for construction of a new nuclear power plant, integrated measures in b):

1. Site preparation brought forward with general permit as site preparation permit;
2. Lifting of the suspensive effect of complaints about building permits and operating permits allows construction to begin and operations to start despite ongoing complaint procedures;
3. Plants under construction are assessed according to the “state of the art in retrofitting technology” in the same way as completed plants.

b) With measures

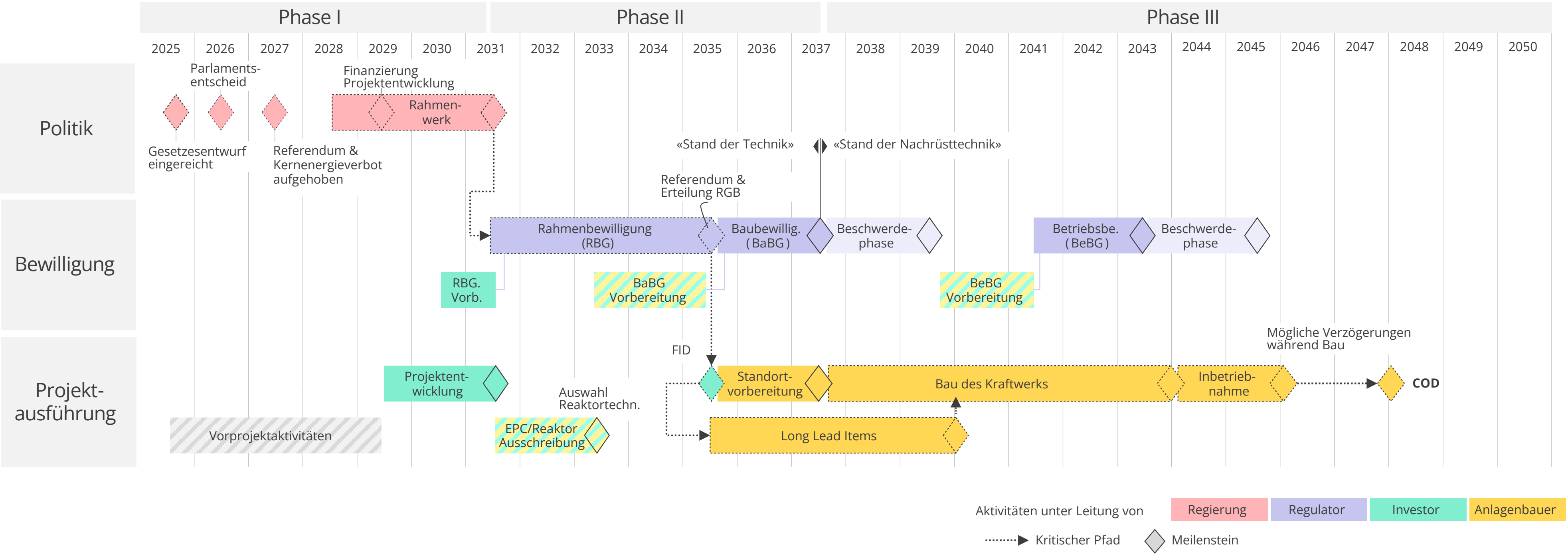

Figure 5b: Timetable for construction of a new nuclear power plant, integrated measures in b):

1. Site preparation brought forward with general permit as site preparation permit;
2. Lifting of the suspensive effect of complaints about building permits and operating permits allows construction to begin and operations to start despite ongoing complaint procedures;
3. Plants under construction are assessed according to the “state of the art in retrofitting technology” in the same way as completed plants.

Focus: **Timeline for a new nuclear power plant for Switzerland**

The timeline for a new nuclear power plant consists of three phases (see Figure 5). This does not take into account the political process of creating an appropriate regulatory and legal framework.

Phase I

Preliminary project and project development

In this phase, the technical and economic readiness for decision-making is gradually built up. Specifically, this means: Together with the manufacturers, the feasibility of various internationally proven reactor designs – such as AP1000 or EPR – are examined and their strengths and weaknesses compared in terms of profitability and feasibility. It is also assessed whether these designs comply with Swiss safety and regulatory requirements. This includes, but is not limited to, protection against external events (e.g. earthquakes, floods), the design of passive and active safety systems, emergency power supply, fuel and waste management, and decommissioning and dismantling requirements. At the same time, the site-specific requirements are defined – including the geological, hydrological and ecological framework conditions, options for covering cooling water demand and the environmental and spatial planning requirements to be taken into account. Due to site- and country-specific differences, adjustments to the basic design are typically necessary. These changes must be identified together with the manufacturer and the regulator in order to assess the impact on the timeline and costs. As project development costs amount to almost CHF 100 million, suitable financing must be freed up for this purpose.

Phase II

Approval and procurement

Once the legal and regulatory framework comes into force, the schedule is accelerated by means of parallel processes: Reactor design and engineering tenders, engineering, procurement, and construction (EPC), the general license process and the preparation of the building permit submission are done at the same time. The selection of the reactor design and the EPC vendor must be completed in order to start the preparation of the planning application as this requires detailed design information. Once the general licence has been granted and the subsequent final investment decision (FID) has been made, the key components with long procurement periods (long-lead items, LLI, e.g. reactor pressure vessel or steam generator) are ordered with a view to avoiding production bottlenecks.[42] If the general license also serves as a site preparation permit, the site preparations can begin immediately after the general licence has been granted.

[42] In view of the many new construction projects planned, it must be checked whether production slots need to be reserved in advance in order to be able to keep the schedule.

Phase III

Construction & commissioning

Once the building permit has been granted, the requirements are in place for the construction to proceed with clear regulatory specifications and low technical risk. The EPC partner begins work in earnest; LLI materials ordered at an early stage are arrive on time and ensure adherence to the construction schedule. During the construction phase, no further changes should be made to the reactor design as this greatly increases time and costs. This can be prevented by assessing assets under construction – as well as existing ones – according to the "state of the art in retrofitting technology" so that the probability and scope of possible adjustments are minimised. Commissioning is carried out step-by-step according to a clear testing programme – from individual system inspections to overall plant tests and initial power runs – and is closely aligned with the operating licensing process to ensure that the plant is demonstrably safe and that the transition to regular operation can take place quickly.

Within the schedule, there is a critical path. This is defined as the longest sequence of interdependent tasks and determines the minimum overall duration of the project – and thus the earliest possible commercial operation date (COD). If there is a delay of a task in the critical path, the entire project is delayed for the same period of time unless countermeasures are taken. Thus, the critical path in the timeline proceeds as follows without further measures (see Figure 5a):

- **Political process for lifting of the ban on new construction**
  (today–2027)
- **Political process for a new framework**
  (2028–2031)
- **General license approval process**
  (2031–2036)
- **Building permit process**
  (2036–2040)
- **Construction and commissioning**
  (2040–2050)

4.2.1

Acceleration of the approval process and reduction of possible delays

The commissioning of a new nuclear power plant by 2050 is feasible – provided that there is broad political and public support and the approval procedures are carried out efficiently. Nevertheless, we recommend targeted measures through adjustments to the rules in order to speed up procedures and reduce the risk of delays. Unplanned delays can massively increase costs. If, for example, a completed power plant cannot go into operation because an appeal against the operating licence is pending, there is a risk of losses in the order of several hundred million euros per year.

Without additional measures, the political decision-making processes and approval procedures in particular (see Figure 5a) are difficult to predict. An appeal against the building permit can be settled quickly – or, as is also the case with wind power projects, can drag on for years. This is particularly serious in the nuclear sector, as significantly more resources are tied up during the approval and project development phase.

Below, we outline four possible adjustments. The twofold aim is to shorten the critical path and reduce unplanned delays and thus reduce the probability of cost overruns. Whether and which of these options should be implemented largely depends on political and public acceptance. Assessing this is not the responsibility of Axpo; it must be elaborated as part of the political process. Table 3 provides an assessment of the advantages and disadvantages of these adaptation options.

1. Exemption from the general license for existing sites

One way of shortening the process is to waive the general licence for existing (or former) nuclear power plant sites. For these sites, the basic suitability for nuclear power plants has already been proven on the basis of an approval procedure for the existing plants[43]. Geological conditions, cooling water availability,

Possible adjustments to the approval process

Adjustment option	**Advantages**	**Disadvantages**
1. Exemption from framework permit for existing sites	● Elimination of uncertainty surrounding a possible referendum ● Acceleration of the process by one year	● Lack of political legitimacy could lead to public opposition
2. Start site preparations before building permit is granted	● Speeds up the process by two to three years	● Low residual risk of “sunk cost”
3. Reducing the impact of complaints at the start of construction	● Speeds up the process by two to four years ● Reduces the probability of delays at the start of construction	● Residual risk of “sunk cost,” as construction starts without a valid building permit (if the suspensive effect is lifted) ● Restriction of the current democratic process could lead to public opposition (if the scope of the complaint is limited)
4. Reducing the impact of complaints against the operating licence	● Speeding up the process only in the case of a lengthy complaint procedure ● Significant risk reduction of delays during commissioning	● Restricting the current democratic process could lead to public opposition

Table 3: Overview of advantages and disadvantages of adjustments to the approval process

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[43] The approval process has changed since the existing systems were approved.

earthquake resistance and other site-specific factors have already been extensively reviewed and approved. The necessary infrastructure such as power lines, access roads and safety equipment is already in place or can be expanded more easily. The general license approval process takes three to six years. If the general licence were waived at locations already in use, the procedure could probably be accelerated by one year[44], avoid the uncertainty of a possible referendum and become more attractive for investors.

One possible disadvantage of this adjustment is that waiving the general license could reduce the political legitimacy of the project and possibly even trigger public resistance. As explained above, the general license approval procedure in Switzerland is primarily political in nature. If there is a public perception that key decisions are being made without sufficient debate and participation, this could call into question the acceptance of the whole project. Accordingly, policy implications must be carefully weighed against the benefits of speeding up proceedings and minimising risks.

2. Start site preparations before building permit is granted

A number of activities[45] need to be carried out to prepare the site for actual construction. Preparing the site for new construction in Switzerland takes around two to three years. The current process assumes that site preparation is only possible once the building permit has been granted. However, if it were possible to start site preparation in advance, the construction time of the plant would be shortened accordingly.

Site preparation could be brought forward through the following possible actions:

- Extending the subject matter of the general license would enable site preparation and turn the general license into the site preparation permit;
- Site preparation can be carried out via advance partial building permits without changing the scope of the general license. A change in the law is not absolutely necessary, but would increase legal certainty; the effort remains low because the general licence would remain unchanged.
- It is to be expected that an appeal will be lodged against the granting of the building permit. If an appeal is lodged, the building permit, although granted, does not yet become legally binding; the appeal therefore has a suspensive effect (see section 4.1). Site preparations must therefore be delayed until the appeals process is concluded (see option 3: Reducing the impact of appeals on the start of construction). A pragmatic solution would be to remove the suspensive effect of appeals against site preparation. In this case, site preparations could start even though the building permit is not yet legally binding. In contrast to the previous measures, site preparation would still only be possible once the building permit (which is not yet legally binding) has been granted.

One disadvantage of this possible adaptation is that additional resources are tied up in site preparations even though the final construction decision is still pending. If the building permit is ultimately not granted with legal force, the work already carried out would not be recoverable (sunk cost). However, this risk appears low, as there is a legal entitlement to the granting of the building permit.

3. Reducing the impact of appeals on the start of construction

As explained, appeals against the building permit cannot be ruled out. These generally have suspensive effect before the FAC. An appeal against its ruling can in turn be filed with the Federal Supreme Court; however, as a rule, appeals to the Federal Supreme Court

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[44] The process cannot be accelerated by the full five to six years, as the reactor / EPC tender and the preparation of the building permit are on the critical path if the general license is omitted.

[45] Activities include, for example, construction of access control measures, clearing of vegetation, excavation and levelling of the site, installation of services and utilities, construction of administrative and physical support facilities within the future protected area, construction of monitoring and environmental mitigation systems, construction of flood and erosion control measures.

no longer have suspensive effect. A lower probability of delays at the start of construction enables more reliable planning and thus more efficient coordination of resources such as human resources, construction companies and materials. This avoids, for example, the need for personnel to remain idle due to appeal-related delays.

We see two measures to reduce the delaying impact of appeals

- The FAC may revoke the suspensive effect. However, this is at the discretion of the court and is not guaranteed. Although there is no automatic suspensive effect before the Federal Supreme Court, it can be granted on application. Exclusion of the suspensive effect in these proceedings can be started immediately after the building permit has been granted, thus avoiding probable delays of two to four years (for handling the appeal).
- Limiting the scope of the appeal to formal legal review (i.e. examination of legality and procedural fairness, excluding any substantive review): However, this would require a change in the legal situation. Such a restriction could at least be considered for the Federal Supreme Court, based on Art. 83 (z) FSCA (limited possibilities for appeals in the case of wind power plants of national interest).

Much like with the advance site preparation (see 2.), a disadvantage of eliminating the suspensive effect is that construction will continue to proceed even though the final construction decision is still pending and there is therefore a residual risk of sunk costs. In the case of limiting the scope for appeals, it is similar to the case of waiving the general licence (see 1.), i.e. that the rights of co-determination could limited and public acceptance compromised as a result.

4. Reducing the impact of appeals against the operating licence
Appeals can also be lodged against the granting of an operating licence. However, if the operating licence procedure is started early, an appeal with suspensive effect does not necessarily have to delay the project. It only becomes critical if an appeal is still pending at the time of completion of construction. The plant would then be ready for commissioning but would not start the process – with a significant impact on the timeline and costs.

Similar to the building permit, the measures to eliminate the suspensive effect and to limit the scope of the appeal could effectively reduce this risk, with the same disadvantages.

An additional measure would be the introduction of a joint building permit and operating licence (see Section 4.1, Operating licence). Politically, resistance is to be expected, as the merging of the building permit and operating license could be seen as a weakening of democratic co-determination. Critics will insist on a clear separation and further review. It would therefore make sense, even if a combined permit/licence were theoretically already permissible under the current regulatory framework, to clearly define the conditions for a joint permit/licence.

Case study: **Sweden increases efficiency of the approval process**

In August 2022, the Swedish government commissioned the Radiation Protection Agency SSM to review the regulatory framework for new nuclear power plants. In August 2023, SSM presented a final report with proposals for more efficient licensing procedures without lowering the level of security.

The central suggestion is an upstream design review, in which reactor concepts are assessed from a safety perspective before site-specific requests are made. As a result, basic questions can be clarified at an early stage and across designs. In addition, a coordinating authority is to manage the entire approval process.

SSM expects significant efficiency gains, but points out that the actual procedure time depends heavily on the state of development of the respective technology and the international recognition of the design.

4.2.2
Risk sharing and subsidies

As with all other electricity generation technologies, a nuclear power plant cannot be built economically without government support (see section 5). However, the characteristics of nuclear power require support mechanisms specifically geared to nuclear power plants. The main differences lie in the time dimension, capital intensity and risks for investors. In the following, we discuss risk sharing in project development, subsidisation mechanisms for construction and operation, and the necessary guarantees to hedge specific risks.

4.2.2.1
Risk sharing for project development

The costs of project development up to the granting of the general license are considerable; in Switzerland, expenditures of just under **CHF 100 million** would be expected. However, these costs would be low compared to a completely new project development because existing sites and extensive preparatory work from RESUN could be used. This includes, in particular, the preparations for the general licence and the EPC tender that were started at the time. In addition, technical preliminary studies (FEED studies) would be required[46] with reactor manufacturers such as Westinghouse (AP1000) and EDF (EPR), as well as external support from financial and insurance consultants, and an “owner’s engineer”, i.e. a team of experts who provide the client with technical support and additional resources for project development.

The challenge with these project development costs is that they are incurred before the final investment decision is made and are therefore difficult to bear from an investor’s point of view. Above all, the probable referendum on the granting of the general licence is an uncontrollable risk. This is why appropriate risk sharing is required during project development.

A structured public-private partnership (PPP) should be established for the purpose of such risk sharing. A PPP enables contractually regulated collaboration between the state and private-sector companies in which roles, responsibilities and specific risks are deliberately allocated. While such a model in the project development focuses in particular on the assumption of regulatory and political risks by the state, risk sharing – depending on the chosen structure – can also extend beyond project development and include financing, construction and operation. Along this PPP continuum, three feasible design options can be distinguished for Switzerland, which differ mainly in terms of the leadership role, the extent of government involvement and the degree of risk assumption:

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[46] for RESUN, a tender for “pre-engineering contracts” was drawn up. This can be adjusted accordingly.

- **Government programme leadership / ownership:** In the case of government programme leadership with ownership, the state is not only responsible for project development, but also acts as the building contractor and, if necessary, the (co-)owner throughout the entire project life cycle. The project companies are state-controlled, which reduces capital costs through government creditworthiness. At the same time, it ties up significant public funds over several years and shifts political and project-specific risks to the government balance sheet. See the Netherlands case study for a country that has chosen this path.

- **Development programme with risk assumption by the government:** In the development programme with risk assumption by the government, the state's role focuses specifically on project development. A central public entity bears the risks and costs of project development until the project is ready for approval and tendering, sets standards (site criteria, reference design frameworks, procurement processes) and makes the project financially viable. From the final investment decision, ownership of the results generated during the pre-FID phase is transferred to private or mixed-economy investors. This will mitigate early-stage risks and mobilise private capital on better terms, while the government limits its long-term capital commitment.

- **Private leadership with government co-financing:** In the case of private leadership with government co-financing, the operational responsibility for project development clearly lies with private sponsors. The state plays a supportive and risk-sharing role without assuming programme leadership. Public funds are linked to clearly defined results (such as site and environmental studies, safety analyses, basic engineering, tender documents). Repayments may be contingent upon the final investment decision being made or upon commissioning. In the event of regulatory failure without fault, a (partial) waiver is possible. This structure provides entrepreneurial incentives, leverages private capital and limits the direct burden on the government's budget much more heavily than government programme leadership or a government development programme.

Case study: **Netherlands – State programme management**

The Netherlands decided to finance new nuclear power plants largely with public funds after private investors did not wish to bear the risks within the existing regulatory framework. Previous governments had aimed for at least two new large-scale reactors at or near the existing Borssele site, with initial commissioning around 2035. When it became apparent in the years 2024–2025 that risk-sharing models between the state and private investors were unsuccessful, the government changed course. In 2025, it decided to establish a new state-owned company, the Nuclear Energy Organisation Netherlands (NEO NL)[47], which will develop, build and operate up to four new reactors.

NEO NL acts as a state-run project developer, owner and future operator and starts with an organisational budget of around €45 million. NEO NL conducts site audits, environmental assessments, prepares permit documents, holds supplier discussions and the entire project planning without private investors being involved in this phase. The state therefore covers the early and high-risk preparation costs for new nuclear power plants. In addition, €14.5 billion will be allocated from the national climate fund for specific nuclear energy projects – such as the lifetime extension of the Borssele nuclear power plant and the preparation of new units.[48] For further financing, NEO NL will act as the borrower. As the Dutch government can borrow much more cheaply than a private project company, this approach will reduce the total cost of capital.

The government is still defining the revenue structure for the plants in operation. Regardless of the model chosen, however, market and political risks will largely be borne by the public sector. For example, NEO NL will assume the risk of cost overruns during the construction phase. The government has also acknowledged that the original target of commissioning in 2035 is no longer realistic. While the Commission intends to streamline procedures and coordinate permits more closely at national level, up to now no accelerated approval process exists.

4.2.2.2
Subsidy for construction and operation

As a rule, the construction period of a nuclear power plant extends over several years. For Switzerland, we assume that the construction period – including preparation and commissioning of the site – could take around ten years. This long construction phase means that capital is tied up over many years without generating any revenue. In addition, the investment volumes of a new nuclear energy construction project are several orders of magnitude higher than those of an individual wind or solar farm. Together, these two fundamentally change the financing requirements due to the high (cluster) risks and reduce the number of investors who can provide such sums of money.

In addition, the 60-year operating life of nuclear power plants extends the market and revenue risks well beyond the 20 to 30 years typical of renewable energy plants. On the electricity market, prices fluctuate depending on supply, demand, weather, political decisions and technological developments – over a period of several decades. Today, no one

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[47] World Nuclear News, 2025, Netherlands aims to extend operation of Borssele plant
[48] Ministerie van Klimaat en Groene Groei, 2025, Ontwerp-Meerjarenprogramma Klimaatfons 2026 Chapter 6.1

can reliably predict how high electricity prices will be in 30 or 50 years' time. In order to hedge market and revenue risks, what are known as bankable revenue instruments are required with regard to financing. These are contractual mechanisms that guarantee the operator stable or guaranteed revenue over a certain term. Examples include long-term fixed-price power purchase agreements or funding instruments such as the sliding market premium (also known as Contract for Difference (CfD)), where the government compensates for the difference between the market price and an agreed reference price. Without such instruments, the project remains too risky for investors.

There are currently no plans for subsidies for nuclear power plants in Switzerland. Building on international experience and taking into account the Swiss regulatory context, two funding mechanisms that appear to be suitable for Switzerland are presented below. Both approaches have proven their suitability in comparable markets and can be adapted to Swiss requirements:

- The first option is the **"regulated asset base"** (RAB, see case study: United Kingdom) model, as implemented in the United Kingdom for new nuclear power plants. In this model, the Swiss Confederation or the regulatory authority determines the regulated revenue, which corresponds to the eligible investment expenses plus an agreed return on capital during construction and operation. These regulated revenues are passed on to electricity customers on an ongoing basis (such as via an additional tariff). It is also conceivable that revenue could be generated for investors during the construction phase in order to reduce financing costs (similar to project costs for renewables). The model has certain similarities with cost regulation in today's Swiss basic healthcare system.

- The second option is a **combination model from an investment contribution and a sliding market premium** (see case study: Sweden), which builds on existing Swiss support mechanisms for renewable energies. The model provides for the payment of an investment contribution, which ultimately reduces the remuneration rate in the sliding market premium. The investment contribution reduces the financing costs, while the sliding market premium reduces the market price risk. Paying out part of the investment contribution during the construction phase could further reduce the project risks.

Two possible funding mechanisms: RAB and combination model

	RAB	Combination model
Pro	• Low operational risk for plant operators, resulting in lower capital costs • Payment of subsidy during the construction phase	• Payment of subsidy possible during the construction phase • Ties in with current Swiss funding mechanisms
Contra	• Full investment volume to be borne by the investor • Operational risk is largely borne by the government	• Investor bears operational risks and thus has higher capital costs • High funding costs for the state at the start depending on the amount of the investment contribution

Table 4: Comparison of RAB and combination model

Comparing the two models, there are differences in risk allocation and hence in the capital costs of the power plant operators (see Table 4). As the payment under the RAB model is independent of production, the government assumes more operational risks in this case. The lower risk profile of power plant operators is reflected in lower capital costs, so that the need for subsidy requirements by the government also decreases. In the event of a combination of investment contribution and sliding market premium, the operative risk for operation (availability) remains entirely with the power plant operator. Even a sliding market premium only results in subsidies if the power plant is producing. Regardless of the model chosen, the amount of subsidies paid ultimately depends heavily on market price trends.

When designing the combination model, market price risk and financing costs must be weighed up. The higher the proportion of the investment contribution (and thus a lower sliding market premium), the higher the electricity market price risk remaining with the investor, but at the same time the capital requirement is lower due to the earlier payout of the investment contribution.

In both cases, a source of funding for the funding instruments would also have to be introduced. The current grid surcharge fund, which is fed to end users via a tariff, is limited and intended for renewables.

Case study: **United Kingdom (Sizewell C) – RAB model**

Sizewell C consists of two EPR reactors each with 1630 MWe, to be built in Suffolk. The project uses the same design as its predecessor, Hinkley Point C. The final investment decision was made in July 2025, together with a financing package of over £38 billion (price basis 2024)[49]. Commissioning of the first unit is expected in the mid-2030s. Both units are scheduled to be connected to the grid before 2040.

The project is being developed and maintained by Sizewell C Company. The UK government (Department for Energy Security and Net Zero) is the largest shareholder with a stake of 44.9 percent. EDF holds 12.5 percent and acts as a strategic industrial partner, leading engineering and construction based on the experience gained from Hinkley Point C. Other private sector investors hold the remaining shares[50].

During project development, EDF bore the bulk of the costs, which included site investigations, environmental impact assessments, permit and planning applications[51]. Subsequently, the government committed £2.4 billion to further funding before the final investment decision[52]. Private sector investors only became involved once key uncertainties (planning approval, RAB legislation, state equity participation) had been clarified. If the project had been cancelled, both EDF's and the government's contributions would have been deemed to be "sunk cost".

After Hinkley Point C was funded with a CfD, Sizewell C is now being funded with a **RAB**. A report by the UK government shows that this change can substantially reduce overall costs. A RAB enables investors to receive revenue during the construction phase (for example, via a direct tariff at the expense of the end user) instead of only when it is commissioned. The regulator approves the capital ex-

[49] Sizewell C, 2025, Final Investment Decision reached for Sizewell C – the biggest British clean energy project in a generation
[50] Centrica, 2025, Sizewell C Regulated investment with predictable returns
[51] World Nuclear News, 2022, UK government takes 50 percent stake, confirms backing for Sizewell C
[52] Sizewell C, 2026, Funding Sizewell C

penditure and other costs. It sets a guaranteed return that is passed on to consumers via regulated tariffs.

With the RAB model, investors can, in principle, pass on all costs recognised by the regulator. In order to create incentives for cost efficiency, a three-step mechanism for dealing with cost overruns can be applied (see Table 5):

- **Level 1 – (Baseline):** The planned project costs plus the risk buffer will be allocated in full to the RAB. Financing is provided by standard debt and equity of the investors. Investors receive regulated revenue from the start of construction (based on the RAB attributed) and thus a reliable return – which significantly reduces the property financing risk.
- **Level 2 – (funding cap):** If the construction costs exceed the baseline, they are not allocated in full to the RAB, but only up to a defined funding cap on a pro rata basis. A certain, defined percentage (X percent) is not attributed to the RAB and has to be fully funded by the investor's equity – this provides incentives to control costs.
- **Level 3 – (remote overrun costs):** In the event of rare, massive overruns beyond the funding cap, the regulator will decide whether certain compensation payments will be made to the investors. In this case, additional government equity would be provided.

Early revenue streams significantly reduce the capital costs compared to conventional project financing. However, the federal government and the electricity consumers, through tariffs, bear the risk of paying for a power plant before it produces electricity.

For Sizewell C, the consumer surcharges are approximately £1 per household per month from the start of construction. In addition to the RAB, the UK government is providing additional support, for example in the form of expected state guarantees.

	Capital costs	RAB allocation	Financing
Level 3: Remote overrun costs	Rare, massive overshoot of the upper limit	Regulatory authority decides on compensation payments	Additional government equity required, or project will be terminated
		+	
Level 2: Funding cap	Cost overrun →	X% excluded →	Equity
	→	X% is attributed to the RAB →	Debt and equity
		+	
Level 1: Baseline	Risk buffer Project costs	Investment costs up to the baseline will be allocated to the RAB	Debt and equity, investors are entitled to returns from start of construction

Table 5: Overview of how the RAB works

Case study: **Sweden – Sliding market premium**

Following the Tidö Agreement[53] in 2022, Sweden changed its electricity target from “100 percent renewable” to “100 percent fossil-free,” thus opening the door for new nuclear power plants. The government’s roadmap presented in November 2023 envisages the construction of around 2.5 GW of new nuclear power plants by 2035 and around 10 GW by 2045. A law was passed in 2025 allowing state aid for investments in new nuclear power plants. To coordinate the planned expansion, the government set up the Nuclear Energy Programme Implementing Organization (NEPIO)[54].

The sliding market premium is a key instrument of planned state aid but has not yet been further defined. In general, a sliding market premium guarantees the operator a fixed remuneration over a long period of time. The state and the operator agree on remuneration or a “strike price,” however, alternatively this can be determined by auctions. Irrespective of market price fluctuations, the operator effectively receives this remuneration, as a combination of market revenues and a difference payment by the Swiss Confederation.

Figure 6 shows how this compensation mechanism works: The black horizontal line shows the remuneration rate, while the red line shows the reference market price. If the market price is below the remuneration rate, the state pays the difference as subsidies; if it is higher, the operator pays the difference back to the state. Example: CHF 100 / MWh remuneration rate. For an electricity market price of CHF 50 / MWh, the operator receives an additional CHF 50 / MWh from the state; with an electricity market price of CHF 120 / MWh, the operator pays back CHF 20 / MWh. Consumers pay the compensation payments indirectly via their electricity bill – in Switzerland this is financed via the grid surcharge. After a certain period of time, the contract ends, after which the operator bears the full market risk.

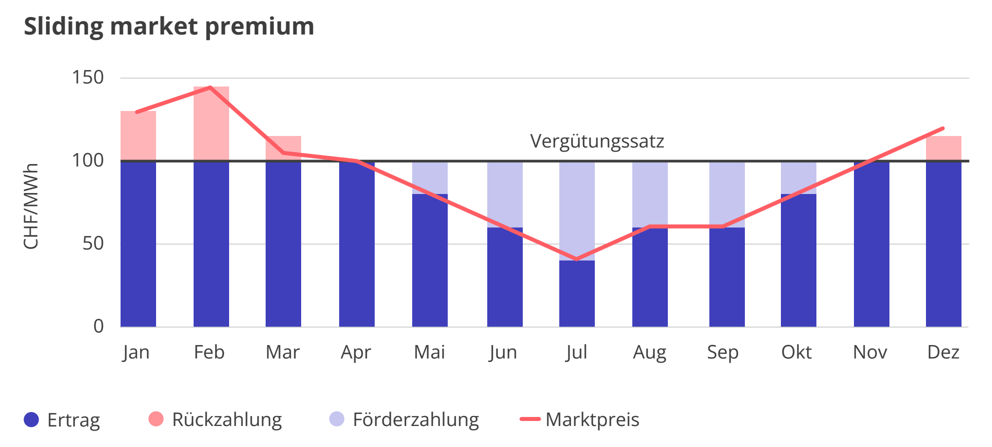

Figure 6: Explanation of sliding market premium based on the comparison of market price and income.

In addition, the state aid in Sweden includes two other instruments[55]:

- **Credit guarantees:** Companies can apply for state loans for the planning, construction and testing of new reactors. After commissioning, the plants can be refinanced with private debt capital. The government expects the first funding

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[53] World Nuclear News, 2023, Swedish nuclear: Government moves to change the law

[54] Regeringskansliet, 2024, En nationell samordnare för utbyggnad av kärnkraft

[55] Lagen.nu, 2026, Act (2025:587) on State Aid for Investments in New Nuclear Power

agreements to be concluded in the years 2026–2027.

- **Risk and profit sharing:** In Sweden, risk and profit sharing between the state and the investor is used for new nuclear power plants. A yield corridor is set, and if the actual return on equity is later higher, the investor transfers part of the profits to the state. If it is lower, the state compensates part of the losses. This way, both sides share the risks and opportunities of the project.

In Sweden, development costs are borne exclusively by investors, but credit guarantees reduce costs. If a project fails before commissioning, the costs remain with the investors, unless renegotiations are carried out. There is no guarantee that the state will cover all sunk costs.

4.2.2.3
Necessary guarantees to hedge additional risks

Investments in nuclear energy projects involve specific risks that go beyond the usual market and project risks of other power generation technologies. These risks are not fully covered by existing support mechanisms such as investment contributions or sliding market premiums. At the same time, they exceed the risk-bearing capacity of private investors in some cases. Complete internalisation of such risks through a higher rate of return is neither efficient nor realistic, as it would massively increase financing costs and thus fundamentally call projects into question. In light of this, the question arises as to which risks are already addressed by existing national and international regulations and where additional instruments, such as government guarantees or risk-sharing mechanisms, might be necessary.

- A risk arises from **politically motivated interventions in the operation of a nuclear power plant.** This includes, for example, early shutdown or a significant shortening in the term, based on safety considerations and not on political reasons. In Switzerland, the ownership guarantee of the Federal Constitution and the respective expropriation case law apply in such cases: If an operator is prevented from using their system economically without a safety-relevant reason, a basic entitlement to remuneration exists. Explicitly politically motivated decommissioning without remuneration is considered unlikely in Switzerland due to the constitutional framework conditions.

- The **risk of stricter safety regulations** is less clearly regulated**.** Particularly after serious accidents abroad – such as Chernobyl or Fukushima – safety standards may be re-evaluated and require substantial upgrades or adjustments. Tighter regulations can cause significant additional costs for operators or even lead to indirect economic decommissioning. As these measures are generally classified as necessary with regard to security regulations, there is no entitlement to remuneration. Until now, this risk has been borne entirely by the operator and is not addressed by liability law. Models such as risk-sharing, stability clauses or state guarantees can be used to reduce the risk of tighter safety regulations. In the RAB funding mechanism described above, this risk can also be cushioned to some extent by including additional investments in the regulated asset base and passing those costs on to end customers.

Liability for nuclear damage that may occur as a result of a nuclear incident inside or outside the plant is comprehensively regulated by an established, internationally coordinated liability and compensation system. Switzerland is a contracting party to both the Paris Convention on third-party liability in the field of nuclear power as well as the Brussels Supplementary Convention. These conventions establish internationally harmonised minimum standards for liability, insurance and remuneration. They are based on principles such as channelling liability to the owner of the nuclear plant, mandatory insurance cover and clear responsibilities for the legal treatment of claims. With the Nuclear Energy Liability Act (NELA), Switzerland has supplemented and implemented these requirements. Owners of nuclear installations in Switzerland are liable for unlimited amounts and irrespective of fault (causal liability). They must reserve a liability insurance with a sum insured in excess of EUR 1.2 billion, plus an additional 10 percent for interest and costs awarded by the courts, which is a mandatory requirement for an operating licence. In the event of a claim, this will be supplemented by EUR 300 million from the Brussels Supplementary Convention.

If the statutory insurance cover on the market cannot be procured in full, the Swiss Confederation will cover the missing insurance cover on a subsidiary basis. However, this does not constitute an assumption of liability by the state: Liability remains unrestricted with the operator; the Swiss Confederation merely ensures that the required sum insured is available. The risk of accidents is thus clearly regulated and does not represent an existential uncertainty for investors.

As an accompanying measure to reduce the capital costs, the supplying country of the reactor technology can arrange financing through its Export Credit Agency (ECA). This financing usually requires a solvent and creditworthy client and, in most cases, a government guarantee. Export credits can be offered at attractive conditions in OECD countries. Up to 85 percent of the value of the goods exported from the supplier country (imported into the project) can usually be financed. Lower interest rates are not necessarily to be expected, but a repayment-free period and / or a repayment period longer than with pure market financing can be achieved.

4.2.3

Excursus: Challenge of regulatory changes during the construction phase

Regulatory changes due to stricter safety requirements, for example, have a particularly strong impact during the construction phase. While regulatory adjustments in operations typically only have to be implemented after a transitional period, new requirements during the construction phase lead directly to planning stops, delays and additional costs. As a result, commissioning is delayed, construction and financing costs increase, and the overall profitability of the project is significantly affected.

In accordance with Art. 4 para. 3 NEA, all precautionary measures that are required based on experience and the “state of the art” must be implemented when a new nuclear power plant is constructed in Switzerland, in addition, measures must be taken that enable the risk to be further reduced provided they are appropriate. This means that the best available safety-related knowledge and the best possible technology must be applied at all times. If new safety findings – for example based on international experience – lead to adjusted regulatory requirements during the construction phase, this may lead to extensive changes being required in the power plant design.

To reduce the likelihood and impact of design adjustments during construction, we recommend that plants under construction should be valued in the same manner as existing plants. Furthermore, to issue the building permit, it would need to be demonstrated that the reactor design meets the “state of the art”. During the construction phase, the power plant would then be evaluated in the same manner as an existing plant according to the “state of the art of retrofit technology”. This distinction between the “state of the art” and the “state of retrofit technology” is enshrined in Swiss nuclear energy law and enables existing plants to continue operation with adequate safety standards, even if the “state of the art” continues to develop.

With this measure, it remains the responsibility of the regulator to impose additional requirements in the event of external safety incidents or fundamental new scientific findings. In order to keep the need for modifications as low as possible, the plant is planned from the outset with generous collateral and performance reserves so that it remains compliant during the construction phase even where stricter rules come into force. If, for example, an accident occurs elsewhere and the regulator then adapts the requirements, the first step is to check whether the existing reserves are sufficient to comply with the new regulations. If this is the case – or if standardised retrofits can be used – the basic design can be retained, saving time and money. Otherwise, the design needs to be adjusted.

Evaluation according to the "state of retrofit technology" already works today. For example, all existing Swiss nuclear power plants have been continuously retrofitted since being commissioned. In Beznau alone, more than CHF 2.5 billion was invested in retrofitting and renovation investments. All security precautions therefore comply with the latest standards, the operating systems are protected on a redundant basis and all regulatory security requirements are met.[56]

Focus: **International findings**

Regulatory changes during the construction phase are a common challenge in the construction of nuclear power plants. No country defines a design absolutely; all countries reserve the right to impose additional safety requirements as scientific knowledge evolves or new operating experiences become available. However, other countries have developed clear systems to ensure that changes are controlled and that costs and schedules are better adhered to:

- In the **USA**, the complete technical reactor design is comprehensively reviewed and approved as part of the Design Certification process prior to actual construction, resulting in a largely fixed reference design. During the construction or operation phase, the "backfit regime" additionally protects this approved design: New requirements may only be imposed if the supervisory authority demonstrates that the increase in safety clearly justifies the effort. This results in a highly stable, plannable system in which later design changes are rarely and strictly justified. In contrast, Switzerland does not have such a licensing system for the reference design. The building permit defines the plant concept, but many technical designs are only examined in detail during the construction phase. ENSI can impose new requirements at any time, without requiring a cost-benefit analysis and without formal hurdles as in the US backfit regime.
- **In the UK**, the initial approach is similar to that of the US. With the "Generic Design Assessment," the complete reactor design is checked and largely stabilised prior to the start of construction and independently of the specific project. The European Pressurised Water Reactor underwent this test in 2012 in connection with Hinkley Point C and the tested design was re-used in the Sizewell C follow-up project. During construction, the "Permissioning Frame-

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[56] Axpo, 2026, Beznau nuclear power plant

work" takes effect, which structures the construction process into clearly defined intermediate stages ("hold points"). In principle, the design remains fixed, but adjustments can be made at these defined hold points specifically and in a controlled manner without having to reopen the entire design. In Switzerland, on the other hand, the design remains open to new ENSI requirements throughout the entire construction phase.

- In the **Netherlands**, too, the reactor design needs to be largely finalised before the state project developer even applies for building and operating permits. The selected reference design requires a complete security dossier and is then subsequently "frozen" for the approval process. In contrast to the US, however, the reference design is less strictly protected: While the US backfit regime stipulates that the safety gains resulting from additional requirements clearly justify the cost, the Dutch principle also allows adjustments to be demanded during the construction phase, if international knowledge so requires.
- In **Finland**, the regulator sets out very detailed and prescriptive technical safety requirements with the "YVL Guidelines" that apply for all nuclear installations – both for new and existing projects or those under construction. New or updated guidelines come into force automatically and need to be implemented by operators based on structured transition periods and implementation plans. This creates a system with clear, transparent and predictable regulations that combine technical rigour with plannable processes. Compared to Switzerland, the Finnish approach is considerably more formalised and binding. While Finland uses specific technical specifications with regulated mechanisms for introduction, Switzerland works with open concepts such as the "state of the art in science and technology" and the "state of retrofit technology". ENSI can, for example, impose new requirements at any time without the fixed transitional mechanisms that exist in Finland.

What all these approaches have in common is that they set clear limits on when and how the design can be changed during the construction phase, while simultaneously preserving the regulator's powers to respond to safety concerns.

05

Profitability

A new nuclear power plant is only economically viable with financial subsidies.

In brief

- The construction costs (excluding financing costs) for a new nuclear power plant in Switzerland are currently estimated at CHF 7 100–10 830$_{2024}$ / kW. The high cost margin allows for a substantial adjustment of the design during the construction phase.
- Precise estimation of construction costs is difficult given the limited number of recently completed nuclear power plant projects in Europe and North America, which have been characterised by first-of-a-kind challenges. However, many of these FOAK problems could be overcome by the time construction starts in Switzerland.
- The range of the average levelised cost of electricity / LCOE is CHF 80–155 / MWh, CHF 108 / MWh is expected in the medium scenario. The largest factors influencing the levelised cost of electricity / LCOE are the construction and financing costs.
- Market revenue would probably cover CHF 64 / MWh[57], in other words, 41–80 percent of the total costs. The rest would need to come from risk-sharing instruments.
- Around 55 percent of electricity production from nuclear power plants in Switzerland is produced in the winter half-year (planned overhauls take place during the summer half-year). This means that the subsidy requirement under reference assumptions is CHF 80 / MWh.
- Appropriately designed instruments for government risk sharing and subsidies can help to reduce the capital costs. As both construction and operating times are longer than other power generation technologies, the cost of capital rate (WACC) for nuclear power has greater leverage.

5.1
Costs and revenue

5.1.1
Assumptions for construction costs in the reference scenario

The costs of building a nuclear power plant are comprised of the “Overnight Construction Costs” (OCC)[58] and the capital costs. The OCC describe the total investment required to complete a nuclear power plant up to commercial commissioning, assuming immediate construction and excluding interest during construction (IDC).

Typically, projects are compared using the OCC, as the capital costs depend on the respective political and regulatory environment. We assume that the OCC for a new nuclear power plant in Switzerland would amount to CHF 8530 2024 / kW. This value

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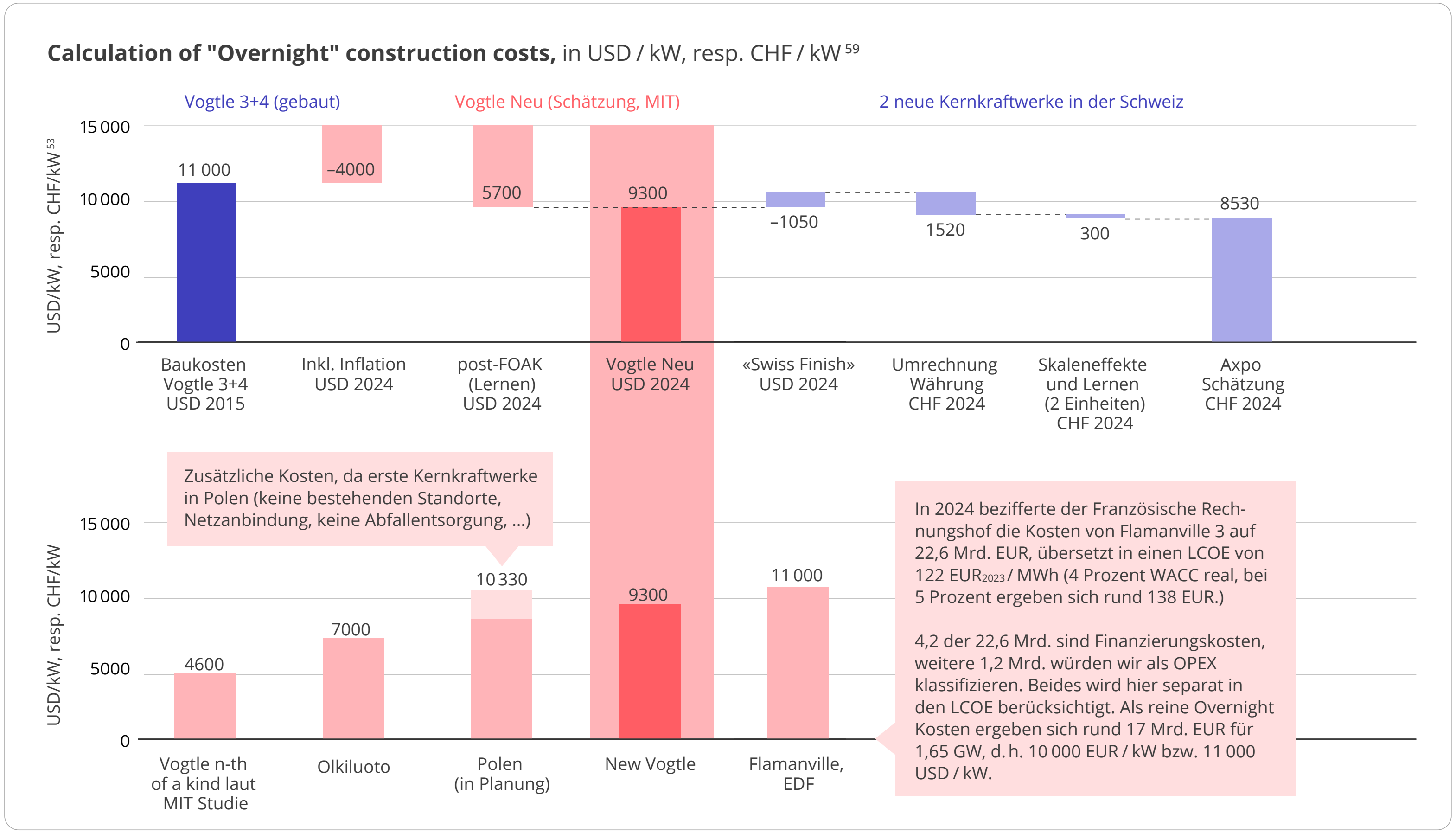
[57] Mean value of the capture price core of the two calculated scenarios.

[58] The costs comprised in the OCC include: Supplier costs (EPC contracts, reactor systems, turbine island, balance of plant, civil engineering), owner costs (permits, land acquisition, project management, regulatory interfaces, construction insurance), on-site grid connection (switchboard, transformers, internal transmission to connection), fuel first charge (fuel for start-up and early operational phase), commissioning and testing (hot and cold commissioning, fuel loading, system validation), unforeseen events (a reserve for design changes, procurement uncertainties or regulatory requirements). Costs excluded from the OCC are:
Operating equipment inventory (OPEX inventory: spare parts, process chemicals, consumables), fuel inventory beyond first charge, working capital requirements, nuclear waste disposal costs, off-site grid reinforcements, interest during construction period (IDC).

takes into account a risk buffer of 15 percent for unforeseen events. The breakdown of costs is as follows (see Figure 7):

The cost estimate for new nuclear power plants in Switzerland is based on the cost estimates for an AP1000 reactor[60] in the USA of 9 300 USD$_{2024}$/kWe published by the Massachusetts Institute of Technology (MIT). This estimate is significantly lower than the actual construction costs of the Vogtle Electric Generating Plant 3+4, which cost 11 000 USD$_{2024}$/kW and 15 000 USD$_{2024}$/kW respectively. The main reason for this cost difference is that Vogtle, like FOAK projects, struggled with typical initial problems, delays and cost increases[61], while lower costs can be expected for a new construction.

A comparison with other recently built nuclear power plants in Europe shows that the MIT cost estimate lies in the middle of the spectrum. Flamanville 3 was more expensive at


Calculation of "Overnight" construction costs, in USD / kW, resp. CHF / kW [59]

Zusätzliche Kosten, da erste Kernkraftwerke in Polen (keine bestehenden Standorte, Netzanbindung, keine Abfallentsorgung, …)

In 2024 bezifferte der Französische Rechnungshof die Kosten von Flamanville 3 auf 22,6 Mrd. EUR, übersetzt in einen LCOE von 122 EUR$_{2023}$/ MWh (4 Prozent WACC real, bei 5 Prozent ergeben sich rund 138 EUR.)

4,2 der 22,6 Mrd. sind Finanzierungskosten, weitere 1,2 Mrd. würden wir als OPEX klassifizieren. Beides wird hier separat in den LCOE berücksichtigt. Als reine Overnight Kosten ergeben sich rund 17 Mrd. EUR für 1,65 GW, d. h. 10 000 EUR / kW bzw. 11 000 USD / kW.

Figure 7: Calculation of “overnight” construction costs

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[59] Sources for cost comparison: Olkilutoto: OECD, Nuclear Energy Agency, 2020; EU Commission; New Vogtle: MIT, US Department of Energy; Flamville: EDF, French Court of Auditors

[60] Three AP1000 units. This is a Generation III+ reactor developed by Westinghouse. The design is characterised by modular construction, a comparatively short construction time and a smaller power unit with a net capacity of 1157 MWe.

[61] Furthermore, the design of Vogtle 3+4 had not yet been finalised when construction began and the feasibility study had not yet been completed; in addition, Westinghouse went through bankruptcy proceedings and the construction phase was delayed due to the Coronavirus pandemic.

11 000 USD_{2024}/kW[62], while Olkiluoto 3 was already below these price estimates at 7000 USD_{2024}/kW. Initial estimates from the new construction project in Poland show costs of USD 10 300_{2024}/kW, although the costs of setting up the entire infrastructure are also included here, as these are the first nuclear power plants in Poland (no existing sites, grid connection, no waste disposal). The costs for the power plant without these additional costs is estimated at < 8 000 USD_{2024}/kW.

Special Swiss features such as higher labour and material costs as well as stricter regulatory requirements were taken into account by means of a “Swiss Finish” surcharge of 11.3 percent[63]. This results in OCC of USD 10 350_{2024}/kW and, if converted to Swiss francs (exchange rate 0.85 CHF/USD), of CHF 8 800_{2024}/kW. This puts the assessment at the upper end of the Swiss studies. Züttel et al. (2024) estimate the costs at CHF 6800–10 300_{2024}/kW and Manera & Pautz (2024)[64] at CHF 4000–7000_{2024}/kW.

Previous cost estimates are based on the construction of an individual nuclear power plant. However, if several nuclear power plants are to be built in one programme, this will lead to additional cost reductions through synergies and learning effects, which must be taken into account. There are three main cost-cutting effects: The first is the “multi-unit effect,” which enables cost savings through shared infrastructure if multiple reactors are built on the same site. Examples include shared administration buildings, common security systems, a single grid connection and common storage areas. The second effect is the series effect, which increases efficiency throughout the programme through standardised processes, optimised supply chains, and improved project organisation across the entire construction programme. The third effect is the learning effect, which enables cost reductions by repeating similar tasks. Construction teams, engineers and project managers become more efficient and make fewer mistakes with each project.

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[62] The French Court of Auditors estimated the total cost of Flamanville 3 in 2024 at €22.6 billion, of which €4.2 billion are to be classified as financing costs and another €1.2 billion as operating costs (OPEX), which are taken into account separately in the LCOE. Pure overnight costs result in around EUR 17 billion for 1.65 GW, in other words, EUR 10 000/kW or USD 11 000_{2024}/kW.

[63] Weighted average of four individual surcharges for labour (+27 percent), concrete (+15 percent), steel (+2 percent), equipment (+5 percent). Based on input from Burg Capital

[64] Swiss Federal Office of Energy SFOE, 2024, Technology Monitoring

Overnight costs for nuclear power plants in Switzerland

Power plants	Net power (MWe)	OCC (USD bn)	OCC (CHF billion)	OCC (CHF/kWe)
Total 1 unit	**1157**	**12.0**	**10.2**	**8800**
Unit 2 (different site)	1157	11.3	9.6	8270
Total 2 units	**2314**	**23.2**	**19.7**	**8530**
Unit 3 (same site)	1157	9.0	7.6	6600
Total 3 units	**3471**	**32.2**	**27.4**	**7890**

Table 6: OCC for nuclear power plants in Switzerland, split up into 3 units

Assuming two power plants are built at different sites, the assumed cost reduction for the second reactor is 6 percent. The estimated average OCC for the two units would therefore amount to CHF 8530$_{2024}$/kW. If, in addition, another power plant is built at the same site as the first or second unit, this will lead to further savings: For the third reactor, the assumed cost reduction is a further 19 percent, as the “multi-unit effect” is also taken into account in addition to the other learning effects. For three units, the estimated average OCC would be 7890 CHF$_{2024}$/kW, with each unit involving different costs based on the various applicable effects.

Adjustments to the power plant design after the start of construction can significantly increase construction costs. The construction cost assumptions include a 15 percent risk buffer (contingencies) for unforeseen events. This means that minor design adjustments can be covered – or even larger design adjustments, provided these are made before the start of construction. In the event of a late, time-consuming design adjustment, we assume an increase in the OCC of CHF 1150$_{2024}$/kW in the case of “high costs” (corresponds to approx. 15 percent of the OCC for three units). Please note that this is a very conservative surcharge for the average of three power plants. Due to the staggered construction, it is unlikely that a design change would affect all three power plants at the same time during the construction phase. Design adjustments prior to the start of construction can be implemented much more cost-effectively. The estimate should therefore be understood as a worst case scenario.

5.1.2

Cost scenarios reflect uncertainties and variability

Depending on the site, plant type, project progress and project-specific challenges, costs can be higher or lower. For this reason, a cost range is determined: Costs with reference assumptions and a more expensive and less expensive option in each case (see Table 7).

In view of the few nuclear power plants completed in recent years in Europe and North America, the significance of the available cost data is limited. The basic costs of Gen III/III+-reactors are known from international projects and will mainly differ in Switzerland in terms of transport costs and regulatory differences. However, a “Swiss finish” is to be expected for project planning, site work and other activities within Switzerland, which means that construction in Switzerland is more expensive than, for example, in comparable European projects (see previous chapter).

Reference assumption

A “reference assumption” is defined for the analysis – a scenario with moderate site conditions, moderate costs and a regulatory framework that is considered the minimum requirement for implementing nuclear power plant projects. Based on a final investment decision around 2035, it is assumed that nuclear power plants of the same reactor type are already ordered or under construction in several other European countries at this time. This enables additional operating and project experience as well as learning effects with the respective reactor type to be taken into account.

Specifically, it is assumed that the ban on new construction has been lifted and that the schedule outlined in Chapter 4.2 – including adjustments to the approval process – implemented successfully. The reference assumptions also take into account the fact that a power plant under construction will be assessed in the same way as existing power plants according to the “state of the art of retrofit technology”. In addition, suitable sites for the plants must be selected and moderate installation and plant costs achieved. These assumptions serve as the basis for analysing which subsidies are required so that nuclear power plant projects in Switzerland can be implemented economically and realistically (see Chapter 4 “Law and regulation”).The reference assumption forms a realistic basis that serves as a starting point for further cost sensitivities, which take into account, for example, lower capital costs or higher costs due to major design adjustments.

Low and high costs

In order to analyse the cost range, scenarios with low and high cost assumptions are taken into consideration in addition to the reference assumption. For this purpose, key parameters such as the availability and service life of the plants as well as the number of nuclear power plants built in Switzerland are varied. In addition, different regulatory conditions with varying advantages are assumed, which are reflected in the respective risk profile of the projects and thus in the WACC. For example, an RAB funding model can cover additional risks compared to a combination of a sliding market premium and investment contribution.

Costs of nuclear power plant projects in Switzerland

Parameter	Low costs	Reference assumption	High costs
LCOE in CHF/MWh	80	108	155
Availability (%)[65]	90	85	80
Term in years	80	60	60
Plant type and power	3 x AP1000 (1.16 GW each)	2 x AP1000 (1.16 GW each)	1 x AP1000 (1.16 GW)
OCC/pure construction costs (CHF/kW)	7100 (3 units; –10%)	8530	9680 (1 unit; +10%)
OCC include buffer of (%)	15%	15%	15%
Operating costs (OPEX, CHF/MWh)[66]	16	16	16
Fuel costs[67] (CHF/MWh)	7.3	7.3	7.3
Costs for decommissioning and disposal[68] (CHF/MWh)	11.8	12.7	12.7
Retrofitting after 30 years of operation (CHF/kW)	1000	1000	1000
WACC (%)[69]	4%	5%	6%
Surcharge for design adjustments during construction phase (CHF million/kW)	Design adjustments before start of construction or minor adjustments included	Design adjustments before start of construction or minor adjustments included	Major design adjustment required: +1150

Table 7: Costs of nuclear power plant projects in Switzerland with reference assumptions and high and low costs with commissioning by 2050.

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[65] The AP1000 reactor is capable of achieving over 90 percent availability under typical operating conditions, which is consistent with the performance of other Gen III+. For Switzerland, however, a more conservative value of 85 percent is assumed, which reflects specific market and operating conditions in Switzerland. The availability of the existing power plants is between 80 and 89 percent (see Chapter 2.1 Current expansion).

[66] For comparison purposes: slightly above the middle of the range given by MIT (2024)

[67] For comparison purposes: KKG & KKL average 2006–2023 according to annual reports: around CHF 5/MWh

[68] For comparison purposes: KKG & KKL 2006–2023 according to annual reports: around CHF 11/MWh; evaluations of the Swiss Nuclear Waste Disposal Fund (2023–2024): CHF 12–13/MWh)

[69] Weighted Average Cost of Capital: Corresponds to the capital costs rate/return on capital. The average capital costs are assumed to be one percentage point higher than for the other technologies considered.

The following LCOE is based on previous assumptions:

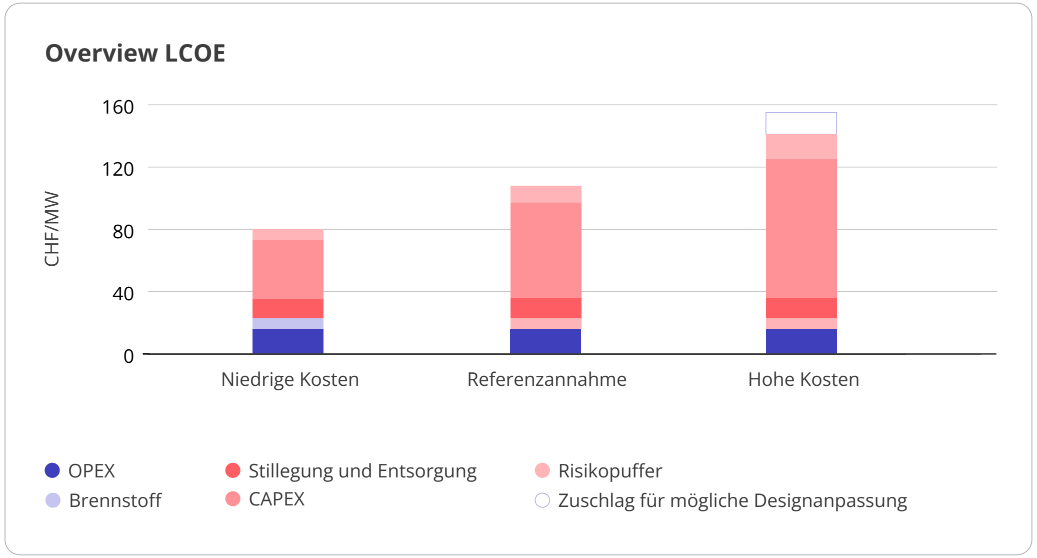

Figure 8: Overview of LCOE in CHF / MWh

Various different parameters are varied between reference assumptions and the variants with the high and low costs. Table 8 shows the effects on the LCOE if only one parameter is adjusted at a time. Key findings:

- The **capital costs** (Weighted Average Cost of Capital, WACC) has the greatest leverage on the costs of nuclear power plants due to their long operating lives and long capital commitment periods. In the reference assumptions, the WACC of 5 percent[70] leads to capital costs of around CHF 55 billion over the 60-year life of two nuclear power plants – significantly more than the pure construction costs of around CHF 20 billion or around half of the total costs of around CHF 110 billion.[71] Well-designed funding can help to reduce the WACC and thus reduce costs. This assumption was made for the case with low costs (WACC 4 percent). A reduction in the WACC by one percentage point can reduce the LCOE by CHF 13/MWh and the capitals costs by CHF 13 billion.
- In addition to the WACC, the **construction period** has a significant impact on the capital costs. If, for example, challenges in the approval process during the construction phase lead to a delay of two years, the LCOE will increase by CHF 6/MWh and thus the capital costs by around CHF 6 billion.

Comparison with Flamanville

In our reference assumptions, we assume an OCC that is around 5 percent lower than in Flamanville, including the Swiss Finish and a learning rate of two units; construction costs are therefore expected to be somewhat lower. The LCOE specified by the Court des Comptes (French Court of Auditors) for a real WACC of 4 percent is EUR 122/MWh, and for a 5 percent real WACC, as assumed here in the reference assumptions; this results in EUR 138/MWh for Flamanville (equivalent to CHF 131/MWh, exchange rate 0.95) compared to the CHF 108/MWh assumed for Switzerland under reference assumptions. According to this metric, the cost estimate below the reference assumption is therefore 17.5 percent lower. While the pure construction costs at Flamanville (EUR 10 000/kW, compared to CHF 8 530/kW) are only responsible for around half of this difference, the high capital costs of Flamanville, due to the very long construction time of around 17 years (reference assumptions 10 years), also play a decisive role.

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[70] Due to the long capital commitment period, the WACC was selected at one percentage point higher than for the other technologies: 5 percent (real) vs. 4 percent (real)

[71] Total costs can be calculated as 108 CHF/MWh * 8760 h * 85 percent availability * 60 years runtime * 1160 MW * 2 units = 112 billion CHF

Sensitivities of the reference scenario

	Change to the reference assumptions	Impact on the LCOE (CHF/MWh)
WACC (real)	+ 1% – 1%	123 (+15) 95 (–13)
OCC	+ 10% – 10%	116 (+8) 101 (–7)
Construction period	+ 1 year – 1 year	111 (+3) 106 (–2)
Number of power plants	– 1 unit + 1 unit or multi-unit at one site	111 (+3) 103 (–5)
Availability	– 5% points + 5% points	112 (+4) 105 (–3)
Surcharge for design adjustments during construction	+ 1150 CHF/MWh	119 (+11)
Term	+ 20 years	105 (–3)

Table 8: Sensitivities of the reference scenario

- The higher the **number of power plants** that are built at one site, the stronger the impact of economies of scale and learning effects on investment costs. In particular, multi-unit concepts – in other words, the construction of several reactors at the same site – enable significant cost advantages. For example, if two units were built together at one site instead of two separate sites, the LCOE could fall by around CHF 5/MWh.

- Higher **availability** leads to more kilowatt hours produced while keeping fixed costs the same, which reduces the levelised cost of electricity/LCOE. However, the impact of this factor on the LCOE is manageable.

5.1.3

Market revenue from nuclear power plants and impact of availability

The revenue of a nuclear power plant in Switzerland depends primarily on two aspects:

- **Technical availability:** The technical availability of the nuclear power plant has a direct impact on the achievable annual production of the plant. Higher availability leads to more kilowatt hours produced and thus to higher revenues. However, fluctuations in annual availability often balance each other out over the entire life of a plant – at least this is the experience of the existing power plants.

  From an economic point of view, it can make sense to reduce the production of a nuclear power plant in times of very low electricity market prices. This applies in particular if prices fall below the variable fuel costs over an extended period of time (around CHF 7/MWh) and the load change itself does not incur any higher costs.[72]

A load change is possible for the AP1000 and EPR reactor types considered here. For the period from 2050, we see hourly pricing structures in our scenarios in which it is worth reducing production from nuclear power plants between 5 and 15 percent of the time. Due to the lower production volume, the LCOE will increase by 5–15 percent, while revenues per MWh will increase due to the omission of low-price hours. Subsidy requirements in relation to year-round production is increasing slightly, while it is decreasing in relation to winter electricity production. The background to this is as follows: In absolute terms and when viewed on an annual basis, the situation improves because if reduced, costs fall more than revenues. As we no longer expect negative hourly prices after 2050, the economic improvement is small and the required annual funding will fall by less than 1 percent. The subsidy requirements per MWh of winter electricity also reflect the economic improvement resulting from the reduction of the power plants and falls in equal amounts. This shows that the view per MWh of winter electricity makes more economic sense – whether or not a power plant is producing at prices close to zero (in other words, close to oversupply) is not important from a system perspective.

- **Electricity market prices:** The price achieved defines how much revenue a plant achieves per kilowatt hour of electricity generated. In order to calculate future electricity prices, detailed Europe-wide fundamental market simulations were carried out (see info box).

The revenue achieved by a given generating technology is referred to as “capture price”. This means that revenue varies depending on the technology: The electricity price is subject

Where do electricity prices come from?

Nobody knows the future price of electricity. To gain insight into the question, we work with different scenarios, each of which outlines a possible direction in which the markets might develop. As a rule, fundamental models are used for the long-term perspective – they are not based on historical data, but explicitly map future power plants and load development and simulate today’s market mechanisms and pricing. Since we do not know the future, we work with different scenarios and estimate a range of possible developments, prices and thus also revenue.

Our fundamental model simulates the electricity market of European countries, including Switzerland, for the period 2025–2060. The development of renewable energies, demand, cross-border import and export opportunities, as well as other important market factors such as future prices for gas and CO_2 emissions are taken into account. This can be used to derive hour-by-hour future price scenarios, as well as power plant operations and hourly imports and exports per country.

Two scenarios are considered for other European countries. From this, we determine a range of possible revenues. The average revenue is the average of the results. The two scenarios differed as follows:

- In the first scenario, decarbonisation of the global economy makes progress, but is not yet fully achieved. The electricity sector in Europe will achieve 90 percent decarbonisation by 2050. Thermal power plants will serve as a backup. Carbon capture and storage and hydrogen will be used, but only to a limited extent. Electricity demand will grow moderately.
- In the second scenario, global climate policy adopts a new pragmatism and will achieve 80 percent decarbonisation by 2050. Renewable energies will dominate power generation; gas will be the most important backup power source. Elec-

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[72] However, it is not clear whether a reduction in power actually leads to fuel cost savings. As a rule, fuel elements are changed at fixed inspection times. Effective savings are therefore only achieved if the reduction actually delays the replacement of the fuel elements and thus measurably prolongs fuel usage.

tricity demand will rise less than in scenario 1, due to lower demand from hydrogen electrolysis.

For Switzerland, a net zero scenario is assumed in which decarbonisation increases demand; for gas-fired power plants, various decarbonisation options are available. Details can be found in the Gas Report and the Synthesis Report.

The prices for gas, CO_2 emissions and other primary energy sources are based on the Announced Pledges (AP) and Stated Policies (SP) of IEA's World Energy Outlook.

Validation was carried out in a study together with the FEN – the Research Center for Energy Networks at ETH Zurich.

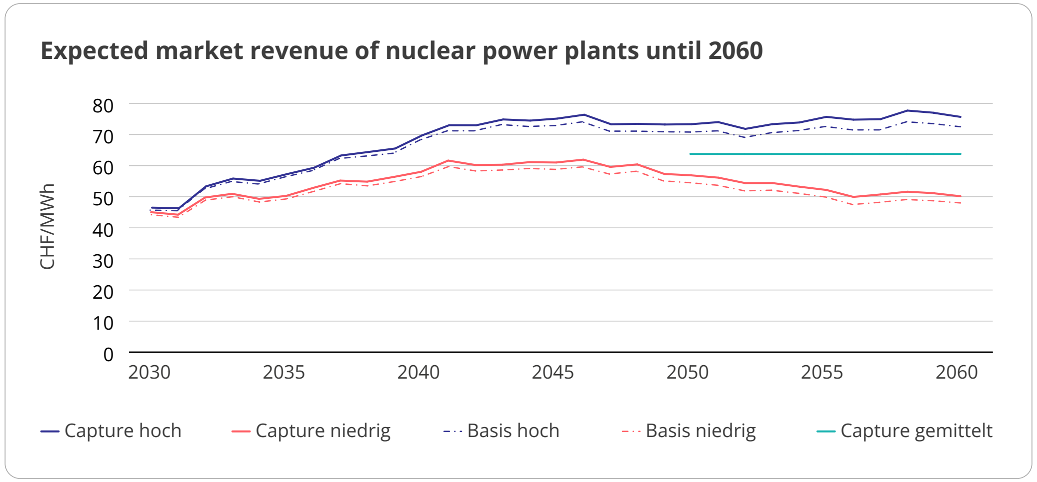

Figure 9: Expected market revenue from nuclear power plants and base price (annual average of electricity prices); presentation up to 2060

to hourly fluctuations, depending on supply and demand. If a plant runs for almost the entire year, its average revenue is roughly equal to the annual average of the electricity price. For the sake of simplicity, we refer to revenue below. Extensive fundamental market simulations have been carried out to calculate future electricity prices.

Unlike renewable energies such as wind or photovoltaic systems, which depend on the weather, nuclear power plants can generate electricity continuously and on a predictable basis. This leads to important differences in market revenue: Due to their continuous production, nuclear power plants generate revenues very close to the base price (annual average of electricity prices). Due to the slightly winter-heavy production (higher availability in the winter half-year), nuclear power plants even achieve revenue slightly above the base price.

The modelling shows that nuclear power plants in Switzerland are expected to achieve market revenue of around CHF 64/MWh. These revenues are the average of the low and high price scenarios, considered from 2050 onwards. Revenues are relatively stable over time, since nuclear power plants, as base load producers, are less affected by price fluctuations, continuous production leads to an even distribution over all price hours, and the winter-heavy mode of operation (higher availability during overhauls in summer) has a slightly positive effect.

Figure 9 shows the development of revenue through the electricity market price and the capture price of nuclear power in Switzerland. The figure illustrates that the capture price of nuclear power plants is consistently slightly above the base price in both the low and high scenarios. Nuclear power plants benefit from above-average market prices in hours with low wind and solar feed-in, thus achieving a robust but small capture premium. Towards the end of the 2040s, this premium will flatten out somewhat, but will, however, remain in place.

Switzerland as a price-taker

For each technology, we have considered an extreme case ("corner case") in which it is assumed that this one technology is used in Switzerland almost exclusively. For the rest of Europe, the assumptions remain unchanged. The aim was to analyse how much revenue changes in extreme cases.

The result: Even when the penetration of a technology in Switzerland is very high or very low, the price fluctuates much less than intuitively expected – the price range is surprisingly small and even narrows as penetration of renewables increases abroad. In other words: The production mix in Switzerland has a negligible impact on the price.

The reason for this is Switzerland's close connection to the European electricity market. The Swiss power grid is highly interconnected with neighbouring countries and has significant import and export capacities. Thanks to imports and exports, Swiss electricity prices largely align with those in neighbouring countries. As a result, the expansion of an individual technology in Switzerland itself only has a small impact on the price level. What is decisive for the value of photovoltaic electricity, for example, is rather how supply and demand develop in the European market as a whole.

5.2
Subsidy requirements to achieve profitability

To assess whether a nuclear power plant is financially worthwhile, the expenditure (such as construction, maintenance and operation) is compared with the revenue (from the sale of the electricity generated). If the revenue is higher than the costs, the plant is economically viable.

Figure 10 illustrates that regardless of whether the reference assumptions are low or high, the revenue from electricity sales is not sufficient to cover all costs in all cases. As is

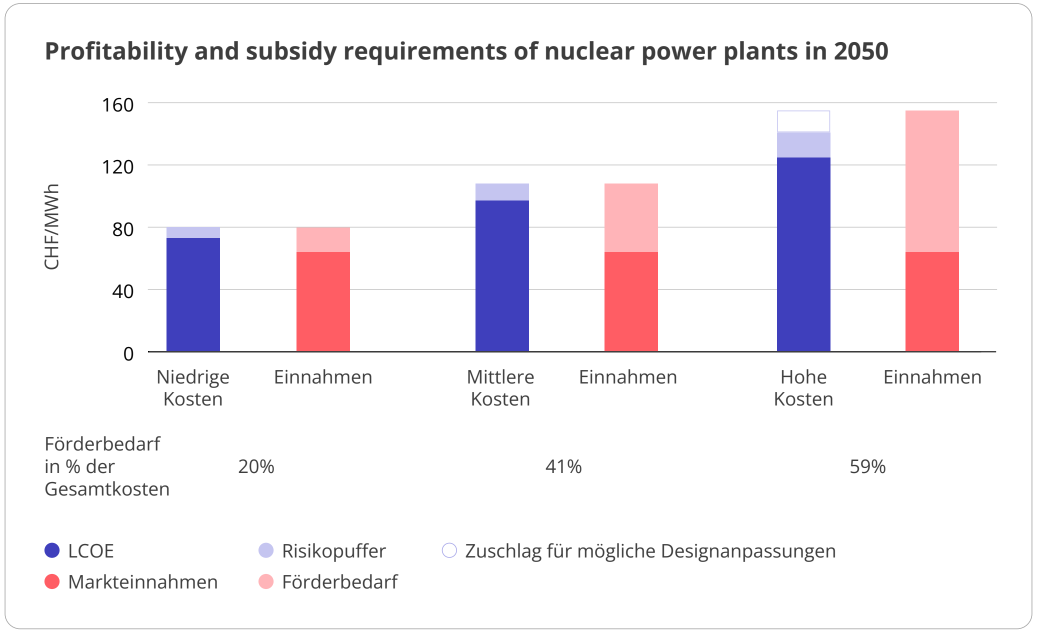

Figure 10: LCOE core, market revenue and subsidy requirements for 2050

currently the case with all other electricity production technologies in Switzerland, government subsidies are therefore indispensable for the profitability of a new power plant.

The subsidy requirements for new nuclear power plants in Switzerland is – depending on cost and revenue assumptions – between CHF 16 and CHF 91 / MWh or between 29 and 59 percent of the total costs. With regard to possible funding mechanisms in Switzerland, this would correspond, for example, to a sliding market premium of CHF 80 to 155 / MWh over the entire lifetime of the nuclear power plant or, alternatively, to an investment contribution of 36 percent to 77 percent.[73] If the two instruments are combined, as proposed in the combination model (see Chapter 4.2), the respective funding levels could be correspondingly lower.

Additional risks as described in Chapter 4.2.3, such as regulatory adjustments, are not taken into account when calculating the profitability. These would have to be additionally covered by state guarantees.

5.3
Subsidy requirements for winter electricity

The expansion of the domestic winter power supply is a key requirement for the reliability of the power supply. The subsidy budget should be used efficiently. It is therefore important to understand the level of subsidy requirements for each technology used in winter power generation. This funding efficiency helps to use the available funds systematically and effectively. In other words, if the SFOE were to focus the subsidies only on the winter half-year, the technology examined would have to receive the calculated subsidy correspondingly per MWh generated in the winter half-year. Mathematically, the subsidy requirements are divided by the share of winter electricity for this purpose.

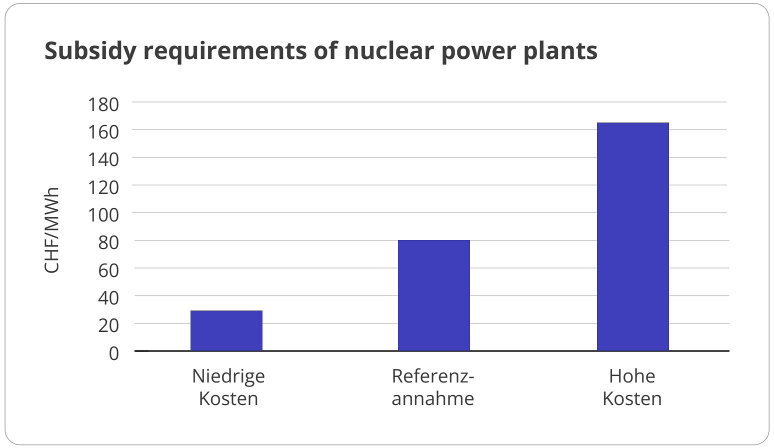

Figure 11: Subsidy requirements of nuclear power plants based on reference assumption, low and high costs where the required subsidies are distributed across the amount of electricity produced in winter.

As around 55 percent of the production of nuclear power plants in Switzerland takes place in the winter half-year (planned overhauls take place in the summer half-year), the subsidy requirements per winter electricity are between CHF 33 and 162 / MWh.

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[73] The investment contribution relates only to the investments / CAPEX. These are CHF 45 / MWh for low costs, CHF 72 / MWh for reference assumptions and CHF 119 / MWh for high costs. With the low costs, subsidy requirements are correspondingly converted into an investment contribution, CHF 16 / MWh subsidy requirements / CHF 45/MWh CAPEX = 43 percent investment contribution.

06

Economic value added and employment

Nuclear power plants have a domestic economic value added share of 74 percent and create 293 full-time equivalents per TWh.

In brief

- Investments in power plant components and expenditure for fuel elements account for 22 percent of the costs and are largely spent abroad; however, the remaining expenditure is almost entirely domestic. 77 percent of the total costs are incurred in Switzerland.
- Individual countries are highly dependent on fuel elements and require a specific procurement strategy. Import dependency is reduced by uranium's long shelf life, which also contributes to the security of supply.
- For a new nuclear power plant in Switzerland, a domestic economic value added share of around 74 percent of the total costs is generated over its entire operating period. If the subsidy is deducted from this, the domestic economic value added share is 29 percent.
- Over its lifetime, a nuclear power plant generates altogether 144 200 FTEs, 3 079 FTEs per year under construction and 1 859 FTEs per year in operation.

6.1
Economic value added chain

The economic value added chain for the construction of a nuclear power plant can be split up into planning, financing, manufacturing, construction / installation, operation, fuels and dismantling (see Table 9: Expected market revenue of nuclear power plants until 2060). For each of these steps, the respective share of costs can be recorded and split up into domestic and imported shares: Planning, financing, construction / installation, operation and dismantling take place predominantly in Switzerland and account for around 78 percent of the costs. The manufacture of key components, such as the nuclear plant component and the turbine plant, as well as fuel procurement, takes place primarily abroad and incur 22 percent of the costs. Throughout the entire lifetime, 77 percent of the total costs are incurred in Switzerland.

Methodological note

The macroeconomic aspects of the generating technologies considered in the Axpo Energy Reports were analysed and processed by Swiss Economics. For detailed information, please refer to the analysis, available separately.

For the analysis, we consider a nuclear power plant with an installed capacity of around 1.1 GW and an annual output of 8.2 TWh as a reference. The costs of this investment correspond to the assumptions described for a reference plant in Chapter 5.

Economic value added chain of a nuclear power plant

	Planning	**Financing**	**Production**	**Construction/ installation**	**Operation**	**Fuels**	**Decommissioning**
Economic value added steps	🔵 Planning 🔵 Engineering 🔵 Feasibility studies 🔵 Safety clarifications	🔵 Financing (equity and debt) 🔵 Depreciation	🔴 Nuclear plant section 🔴 Turbine system	🔵 Preparatory work on the construction site 🔵 Building construction 🔵 Plant balance 🔵 Transport 🔵 Grid connection	🔵 Human Resources 🔵 Maintenance and inspection 🔵 Spare parts 🔵 Insurance 🔵 Electricity and consumables 🔵 ENSI fees	🔴 Fuel assemblies 🔴 Disposal	🔵 Dismantling the nuclear power plant
Cost share	5%	41%	19%	19%	11%	3%	2%
of which nationally	85%	99%	21%	85%	79%	51%	80%
Provider	Internal planning by Swiss operators, project development also carried out by foreign companies	Financing by Swiss banks and operators (50:50%)	Reactors from French manufacturers, various international manufacturers for other components	Predominantly Swiss construction companies and installation technicians, some European providers for specialised tasks	Maintenance and replacement also often by foreign manufacturers, other expenses with Swiss companies and authorities	Imported uranium fuel elements, disposal in Switzerland, imported fuel tanks	Certain dismantling services and tools from foreign OEMs
Significant dependencies abroad			Components are manufactured in various countries			43% of uranium production from Kazakhstan, 3-4 other high-production countries	

🔵 Local 🔴 Abroad

BAK Economics (2009), NREL (2024), SFOE (2025)

Table 9: Economic value added chain and the associated Swiss/foreign cost shares of a new nuclear power plant in Switzerland.

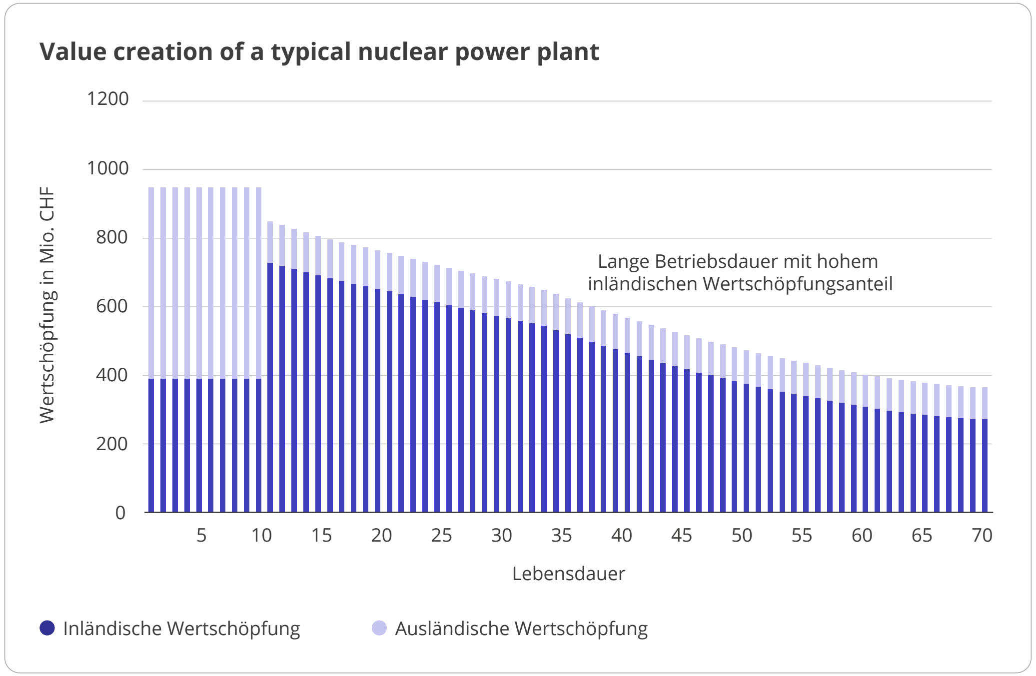

Figure 12: Economic value added of a typical nuclear power plant seen over 70 years, divided into domestic and foreign shares.

Within the economic value added chain, dependence on individual countries for fuel elements is particularly critical. Kazakhstan, Canada, Namibia and Australia together account for 80 percent of the world's uranium production, with only a few other countries accounting for the remainder. This strong concentration leads to significant dependencies on suppliers and increases geopolitical risks – particularly in politically unstable regions. Diversification and specific bilateral procurement strategies are therefore crucial for a long-term security of supply. For example, Axpo adjusted its procurement strategy following the start of Russia's war of aggression against Ukraine with the aim of diversifying its suppliers and eliminating Russian suppliers throughout the supply chain.[74] In addition, uranium fuel can easily be stored on a temporary basis compared to other fuels. In practice, the site typically holds an inventory of fresh fuel elements for around three years of normal operation.[75]

Economic value added and subsidies

Funding instruments typically cover a significant proportion of electricity generation costs in Switzerland. If the necessary subsidies are subtracted from the reported economic value added, the actual market-driven share of economic value added is correspondingly lower. In other words: A significant part of economic value added is made possible only by government support. If the corresponding subsidies are deducted from the economic value added, the domestic economic value added of the reference project under consideration is reduced by around CHF 33 billion to CHF 13 billion. The share of domestic economic value added in the total costs then falls from 74 percent to 29 percent.

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[74] Axpo, 2025, Axpo signs new fuel contracts for nuclear power plants

[75] Generation III+ reactors have a typical fuel cycle of 18 months.

6.2
Economic value added

To calculate domestic economic value added, all costs incurred within Switzerland are assigned a corresponding multiplier based on the stage of the economic value added. This multiplier is used to subtract foreign inputs in the corresponding stage of the economic value added. Depending on how many foreign inputs are needed in a sector, more or less domestic economic value added is generated for the same amount of Swiss francs. This is why the same expenses do not generate the same economic value added across different economic value added chains. For a new nuclear power plant in Switzerland, a domestic economic value added share of around 74 percent of the total costs is generated over its entire operating period.

As shown in Table 9, economic value added is spread over different stages of the plant's life cycle. To put it simply, it is assumed that all expenses for planning, manufacturing the power plant components, construction and installation are incurred during the ten-year construction phase. The 60-year operating phase then begins, during which operating costs including disposal costs, fuel costs, fund contributions for decommissioning and dismantling, as well as financing costs (capital costs and depreciation) are incurred. As the expenses during the operating phase also take into account fund payments for decommissioning and dismantling, the economic value added effect of dismantling (with a domestic share of 80 percent) also occurs during the operating phase. The dismantling is therefore not explicitly shown in the figure. While the domestic economic value added share during the construction phase accounts for 41 percent, this reaches 82 percent in the operating phase. Based on the total costs of CHF 46 billion, the reference nuclear power plant with an installed capacity of 1.1 GW would generate domestic economic value added of CHF 34 billion – split up into CHF 4 billion under construction and CHF 30 billion under operation.

6.3
Employment

Investments in a new nuclear power plant create jobs, measured in full-time equivalents (FTEs), which are needed over the entire life cycle of the plant. A reference nuclear power plant in Switzerland generates a total of 144 200 FTEs over its lifetime, which equates to 2 031 FTEs per year or 293 FTEs per TWh. Employment is unevenly distributed across construction and operations. During the ten-year construction phase, an average of 3 079 FTEs are required per year, while operations require 1 859 FTEs per year. Similar to the economic value added described in Chapter 6.2, employment from dismantling is already taken into account during the operation of the plant and is not reported separately.

07

Environmental impact

Nuclear power plants produce few emissions, but generate radioactive waste.

Methodological note

The Paul Scherrer Institute (PSI) analysed and processed the environmental impacts of the generating technologies considered in the Axpo Energy Reports. For detailed information, please refer to the analysis, available separately. For the analysis, as in the previous chapter on macroeconomic impacts, we take into consideration a reference nuclear power plant with an installed capacity of around 1.1 GW and an annual output of 8.2 TWh.

Five indicators are taken into consideration to assess the environmental impact of the technologies studied. The indicators are then quantified using a prospective life cycle assessment (LCA), which takes into account the environmental impacts of construction, operation and dismantling, including their supply chains.

The environmental impact of nuclear power plants is particularly evident in the amount of radioactive waste generated during operation (see Figure 13), more details on the disposal of spent fuel elements and radioactive waste can be found in Chapter 2.7). When looking at the indicators on greenhouse gases, land use or damage to the ecosystem, the environmental impact is lower than with all other technologies. Hazardous waste and the need for critical metals are also comparatively small. Apart from the impact caused by the space requirements of the power plant, these environmental impacts are also caused mainly by the supply chain abroad.

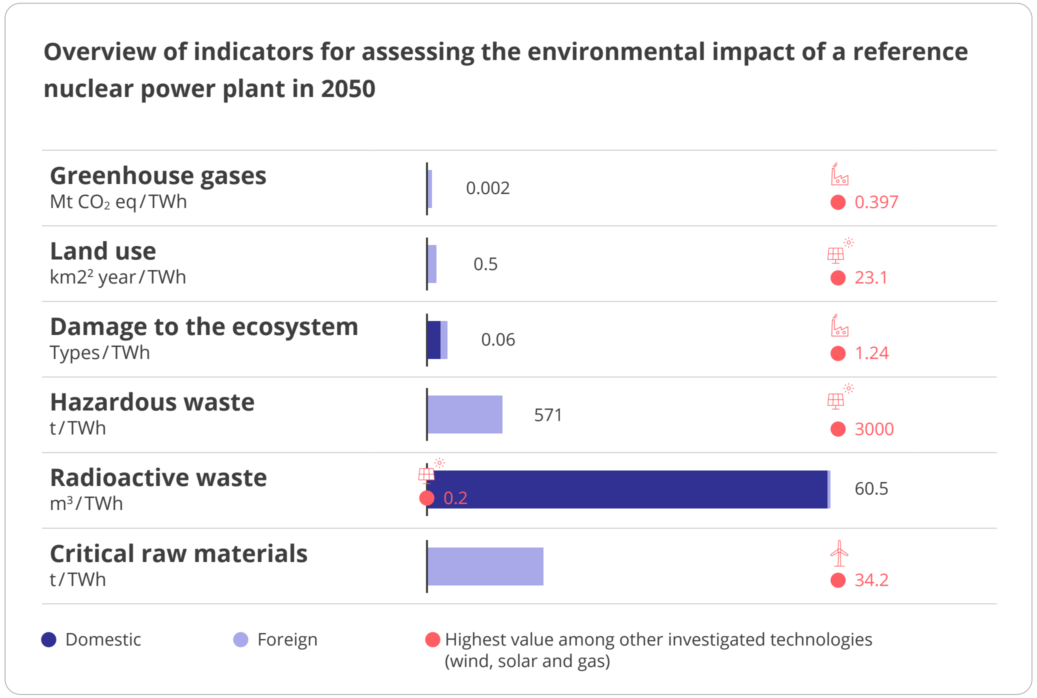

Figure 13: Overview of indicators for assessing the environmental impact of a reference nuclear power plant in 2050 compared with the maximum values of other technologies.

Key findings:

- The most important source of greenhouse gas emissions with all power generation technologies is the combustion of fossil fuels. In the case of gas-fired power plants, direct CO_2 emissions from combustion during operation are the predominant factor. With all other technologies, emissions are mainly generated indirectly when fossil fuels are used in the different stages of the life cycle, such as in the manufacture of power plant components. Although it is assumed that the share of fossil fuels in the energy system as a whole will decline in the future and that such indirect emissions will also decline accordingly, it will not fall all the way to zero globally by 2050. Over its entire life cycle, nuclear power achieves the lowest greenhouse gas emissions of all technologies considered.

- The land use is the total area that a technology occupies directly on site or in its upstream supply chains. Ground-mounted photovoltaic systems take up the most space. Nuclear power, on the other hand, requires a moderate land use, because both the extraction and processing of uranium as well as the plant itself require only a small area.

- Damage to ecosystems is caused by a variety of pressures and impacts, including, for example, pollutant emissions into air, soil and water, land and water use, and the effects of climate change. The sources of these impacts and damage are often spread over the entire life cycle of power generation technologies. Natural gas-fired power plants are at the upper end due to high emissions from operations. Nuclear power has a moderate impact on the ecosystem, partly due to low CO_2 emissions. The domestic impact stems mainly from the land use of the power plant and repository, as well as the electricity consumption for their construction and transport.

- Hazardous waste includes non-radioactive waste that must be disposed of in underground landfills due to its hazardous properties and cannot be disposed of through waste incineration plants, for example. Here, ground-mounted photovoltaic installations rank worst due to the high proportion of copper in the components. Nuclear power has low values for hazardous waste.

- Radioactive waste comprises weak to medium as well as highly radioactive residues that have to be stored at deep geological repositories. Nuclear power generates the largest amount of such waste. For other technologies, the amount of radioactive waste is negligibly small and results only indirectly from the supply chain – e.g. from the share of nuclear energy in the electricity mix of the countries where components are manufactured.

Nuclear power plants require a very low amount of critical metals throughout their entire life cycle. The use of materials is dominated by steel, while the demand for cobalt, lithium and neodymium occurs only in very small quantities, most of which are generated indirectly.

08

Politics

Parallel to the debate on the lifting of the ban on new construction, political processes on the safe long-term operation of the existing nuclear power plants and the realisation of the deep geological repository are under way.

In brief

- The popular initiative “Stop the blackout” aims to lift the ban on new construction at constitutional level. The Federal Council rejects the initiative, but proposes an indirect counterproposal, which in particular provides for lifting the ban on new buildings in the Nuclear Energy Act.
- The consultation procedure shows mixed support and the deadlines in the parliamentary process are tight. Parliamentary debate on the counterproposal is expected to be completed by mid-2026 and a referendum is likely to be held in early 2027.
- A reliable framework enabling investment in new nuclear power plants (see Chapter 4.2) is currently not being considered in the political process.

At the same time as the parliamentary debate, two other political processes are under way:

- The requested Federal Council report on Burkart’s postulate (long-term operation and risk sharing) is due by Q1 2026 and is intended to outline the required regulatory and financial framework conditions for safe long-term operation.
- The general licence application for the deep geological repository has been submitted; a decision by the Federal Council and subsequent approval by the Federal Assembly is expected for the period around 2030 and is ultimately subject to optional referendum.

Parallel to the debate on the lifting of the ban on new construction (Chapter 8.1), political processes on the safe long-term operation of the existing nuclear power plants (Chapter 8.2) and the realisation of the deep geological repository (Chapter 8.3) are under way.

8.1
Popular initiative “Stop the blackout”: Indirect counterproposal

The Federal Council rejects the popular initiative. However, it believes that the energy, climate and geopolitical framework conditions have changed to such an extent that the initiative’s core concern to once again generally allow new nuclear power plants is justified. The Federal Council is therefore opposing the popular initiative with an indirect counterproposal that would abolish

- Art. 12 para. 1, second sentence, NEA,
- Art. 12a NEA,
- Art. 106 para. 1 bis NEA

. This would lift the ban on new construction as well as the ban on making changes to existing facilities that require a general licence pursuant to Art. 65 NEA.

The consultation period has expired. The Federal Council has taken note of the feedback and submitted the counterproposal unchanged to the parliamentary process. As certain deadlines must be observed when dealing with popular initiatives, a resolution is expected in Parliament by August 2026 at the latest.[76] A subsequent referendum seems likely and would be expected by the end of 2026 / early 2027.

The relatively tight deadlines limit the opportunities for successfully introducing additional concerns into the consultation process. Up to now, there are no plans to address the concern for a reliable framework enabling investments in new nuclear power plants (see Chapter 4.2) within this given time frame.

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[76] Popular initiative “Stop the blackout” was submitted on 16 February 2024. If a counterproposal is submitted by the Federal Council, Parliament must decide whether to accept or reject the initiative within 42 months of its submission.

An evaluation of the opinions of relevant political stakeholders shows only weak support for the indirect counterproposal. Whether the Federal Council's counterproposal will stand up to parliamentary debate and a referendum remains difficult to assess.

8.2
Long-term operation and Burkart's postulate

In the indirect counterproposal, the Federal Council exclusively confines itself to the lifting of the ban on new construction. The indirect counterproposal does not include funding, financial aid or an adjustment to the approval procedure.

The indirect counterproposal to the "Stop the blackout" initiative does not address the long-term operation of existing nuclear power plants either. However, the SFOE sent out a survey to the operators of the existing plants in 2022 to clarify what plans are in place for long-term operation and what framework conditions may be necessary for this. The results of the survey were published in July 2024.[77] The SFOE's conclusion is as follows:

"Because the required bases, in particular for the decision on long-term operation well in excess of 60 years, are not yet in place, the SFOE deems it too early to consider legislative measures to support potential long-term operation beyond 60 years."

At the same time, SR Thierry Burkart (FDP / AG) submitted the postulate "Enabling the continued operation of existing nuclear power plants"[78]. The motion calls for a report

- on the regulatory and financial framework conditions for safe long-term operation;
- for example, to relieve the cost structure of operators or to provide additional financial incentives for phases of low prices
- and the regulatory framework for replacing the core components of a nuclear power plant.

The postulate was transferred by the SR in March 2024. The Federal Council must submit the required report within 2 years. It cannot be completely ruled out that the concern to address the long-term operation of KKG and KKL may be raised in the indirect counterproposal during the parliamentary debate.

8.3
Sectoral plan for deep geological repository

The sectoral plan for a deep geological repository defines the procedure and tasks for locating a deep geological repository to dispose of radioactive waste. In the completed stages 1 and 2, the Federal Council determined the geologically suitable areas and the sites for the surface facilities. In the current 3rd stage, the remaining sites have been further narrowed down. At the end of 2024, the NAGRA

Long-term operation of the existing Gösgen and Leibstadt nuclear power plants

The long-term operation of the existing nuclear power plants in Gösgen and Leibstadt over 70 to 80 years would secure a significant proportion of the Swiss electricity supply in the coming decades. The requirements for this are the safe operation of the plants and ongoing compliance with the requirements of the supervisory authorities.

Three reasons for long-term operation
Long-term operation of existing plants can create some leeway to plan, approve and implement the construction of new nuclear power plants. The construction of new nuclear power plants is a complex and time-consuming process that requires careful planning, comprehensive approval procedures and high investments. With this in mind, long-term operation can serve as a transitional option until new capacities are available.

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[77] Swiss Federal Office of Energy SFOE, 2024, Memo Long-term operation of nuclear power plants
[78] Burkart, 2023, Enabling continued operation of existing power plants

The levelised cost of electricity/LCOE of long-term operation are lower than those of new power generation plants, making the continued operation of existing nuclear power plants one of the most cost-effective options for generating power during the winter half-year. Nevertheless, it can be assumed that even long-term operation is unlikely to be economically feasible without government support due to the necessary investment in retrofitting. Since decisions on long-term operation have to be prepared at an early stage (at least ten years before the planned end of operation; taking into account the preparation and process for obtaining the decommissioning order as well as decommissioning work), it is advisable to start the political debate on the design and implementation of suitable subsidies for existing nuclear power plants in good time.

The continued operation of existing plants will contribute to acquiring technical expertise and operational skills in nuclear power. A decline in operations could make it more difficult to transfer knowledge and experience in the long term.

International examples of long-term operation and new construction

In countries such as the USA, France and the Netherlands, long-term operations are pursued alongside new construction projects:

- **USA:** Many nuclear power plants in the USA have already received permits to operate over 60 years, with some plants being permitted for up to 80 years. At the same time, active investments are being made in the construction of new reactors.
- **France:** France is pursuing a dual strategy of long-term operation of existing reactors and the construction of new EPR reactors. Long-term operation secures supply while new technologies are being developed and implemented.
- **The Netherlands:** The Netherlands is also investigating long-term operation of the existing nuclear power plant and, at the same time, has plans for the new construction.

finally submitted the general licence applications for the deep geological repository and the fuel element packaging plant. Following an examination by the relevant federal agencies (especially the SFOE, ENSI, NSC, FOEN and ARE) and by an international team of experts, the cantonal comments have been obtained and all documents have been made publicly available, the Federal Council is expected to decide on the general licence applications towards the end of the 2020s and submit its decisions to the Federal Assembly for approval. This approval, which is expected in the period around 2030, is subject to an optional referendum.

Around the same time, negotiations between the operators and the local communities regarding voluntary settlements and compensation have also begun. The aim is for a contractual regulation to be in place when the general licence applications are made publicly available and the consultation procedure for Stage 3 begins.

Negotiations on the “Stop the blackout” initiative and the indirect counterproposal are ongoing throughout the parliamentary debate and can have a significant influence on the debate.

The NAGRA has announced that new nuclear power plants are not included in the deep geological repository, as new construction is currently prohibited. At the same time, NAGRA also says that theoretically there would be “enough space for a larger volume” at the current site. The question of what impact new nuclear power plants would have on disposal would “have to be taken up again if there are to be specific new construction projects in the future”.[79] The discussion about the disposal of radioactive waste from existing power plants and the discussion about potential new power plants should not be conflated.

If the ban on new construction is lifted and nuclear power plants in Switzerland are promoted, the following implications will arise.

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[79] NAGRA, 2026, Are new nuclear power plants included in the deep repository?

09

Conclusion

New construction by 2050 is possible, but requires early political decisions on permit adjustments and suitable funding instruments

In addition to lifting the ban on new construction, a suitable legal and regulatory framework is required to enable investments in new nuclear power plants.

This framework includes changes to the approval process, funding instruments and additional mechanisms for risk sharing between public and private investors.

Switzerland is faced with one of the slowest approval procedures in the world. The current approval procedure makes it difficult to commission promptly, as it is lengthy, entails regulatory uncertainties and involves cost risks. Specific measures are required to speed up procedures and reduce the risk of delays. Unplanned delays can massively increase costs. If, for example, a completed power plant cannot go into operation because an appeal against the operating licence is pending, there is a risk of losses in the order of several hundred million Euros per year. Possible measures to adapt the approval procedure include exemption from the general licence for existing sites, starting site preparations before the building permit is granted and reducing the impact of complaints against building and operating permits. In addition, we recommend that nuclear power plants that are already under construction should for technical reasons be considered in the same way as existing plants, in order to avoid substantial modifications to the reactor during the construction phase.

Like all other power generation technologies, nuclear power plants cannot be operated economically without government funding. The high investment costs and long construction times call for innovative financing models. The most promising approaches are the UK RAB model or a combination of investment contributions and a sliding market premium. The RAB model offers the advantage of significantly lower capital costs, as more risks are passed on to the government / electricity customers during the construction phase. A Swiss solution would require creating an additional financing channel, as the existing grid surcharge is reserved for renewable energies.

In addition, appropriate risk sharing between the public sector and private investors must be established, especially for the early project phases exposed to risk. For example, project development can hardly be financed by the private sector, as the probable referendum on subsidies and the granting of the general licence represents an uncontrollable risk.

A new building by 2050 is possible, but will require early political decisions.

The political process for the required legal and regulatory adjustments should be started immediately after the ban on new construction has been lifted, so that commissioning by 2050 remains realistic. This framework should enter into force by the beginning of the 2030s at the latest to allow the authorisation process to start on time. Delays at this stage are almost impossible to make up for later.

The first step would be to introduce a suitable risk-sharing tool during project development. This phase is required to prepare for the general licence and to gradually build up the technical and economic readiness for decision-making. Specifically, this means: Together with the manufacturers, the feasibility of various internationally proven reactor designs – such as AP1000 or EPR – are examined and their strengths and weaknesses assessed in terms of profitability and feasibility. The aim of these analyses is to plan project costs and construction process realistically, to identify risks at an early stage and to specify the framework conditions such that later delays or design adjustments are minimised. As project development costs amount to almost CHF 100 million, suitable financing must be provided for this purpose.

The construction of a large Gen III+ nuclear power plant in Switzerland is technically and logistically feasible.

Today, Generation III / III+ reactors form the basis for almost all new building decisions worldwide. Two technologically advanced reactor types in particular can be considered for Switzerland: the AP1000 from Westinghouse (USA) and the EPR series from Framatome / EDF (France). Both designs have extensive international operating experience and comply with the safety and regulatory requirements relevant for a new Swiss building.

Generally speaking, Gen III+ power plants can be built at existing nuclear power plant sites. However, the analysis shows that Gösgen and Leibstadt offer the best conditions for new construction due to their availability of space, development and construction logistics requirements. Beznau and Mühleberg remain potential alternatives, but face greater structural and logistical challenges due to their limited available space.

SMR technologies are an additional option and should continue to be closely observed. They could offer advantages, especially in space-limited locations, and create flexibility through modular construction methods. However, SMR concepts first need to prove their economic and operational promise in commercial use. International series production experience would be a necessary requirement for a Swiss first-time construction.

A new building generates a high level of domestic economic value added and creates long-term, qualified jobs at the sites.

The construction of a new nuclear power plant generates high domestic economic value added and creates thousands of jobs during the construction phase as well as long-term employment in subsequent operation. However, the associated human resources aspect poses a significant organisational challenge. At peak times, up to 10 000 people can work simultaneously on the construction site – a project that has been unprecedented in Switzerland for decades. For comparison purposes: At the NRLA, a maximum of around 3 000–4 000 people were deployed simultaneously, while at the Linth-Limmern pumped-storage plant it was around 1 500–2 000 people. At the same time, Switzerland has shown that it can successfully implement challenging large-scale projects.

Extending the operating life of existing nuclear power plants until new plants are commissioned would be preferable for reasons of security of supply.

An orderly transition between existing and new plants not only prevents an abrupt slump in winter electricity production, but also ensures the preservation of nuclear expertise and operational skills in Switzerland. Furthermore, extending the life of existing plants is generally more cost-effective than building new generating capacities, as the main investments have already been made and the existing plants have a high rate of availability. However, such an extension is by no means guaranteed – not even up to a service life of 60 years. Their continued economic operation is likely to require additional funding measures, especially if substantial investments are required for safety retrofits or increased regulatory requirements. Although an extension of the term is technically and economically feasible, it requires clear framework conditions and early political clarification.

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