Bridging the supply gap in the Nordic electricity system

Providing international perspectives on upcoming nuclear lifetime extensions in Sweden and Finland

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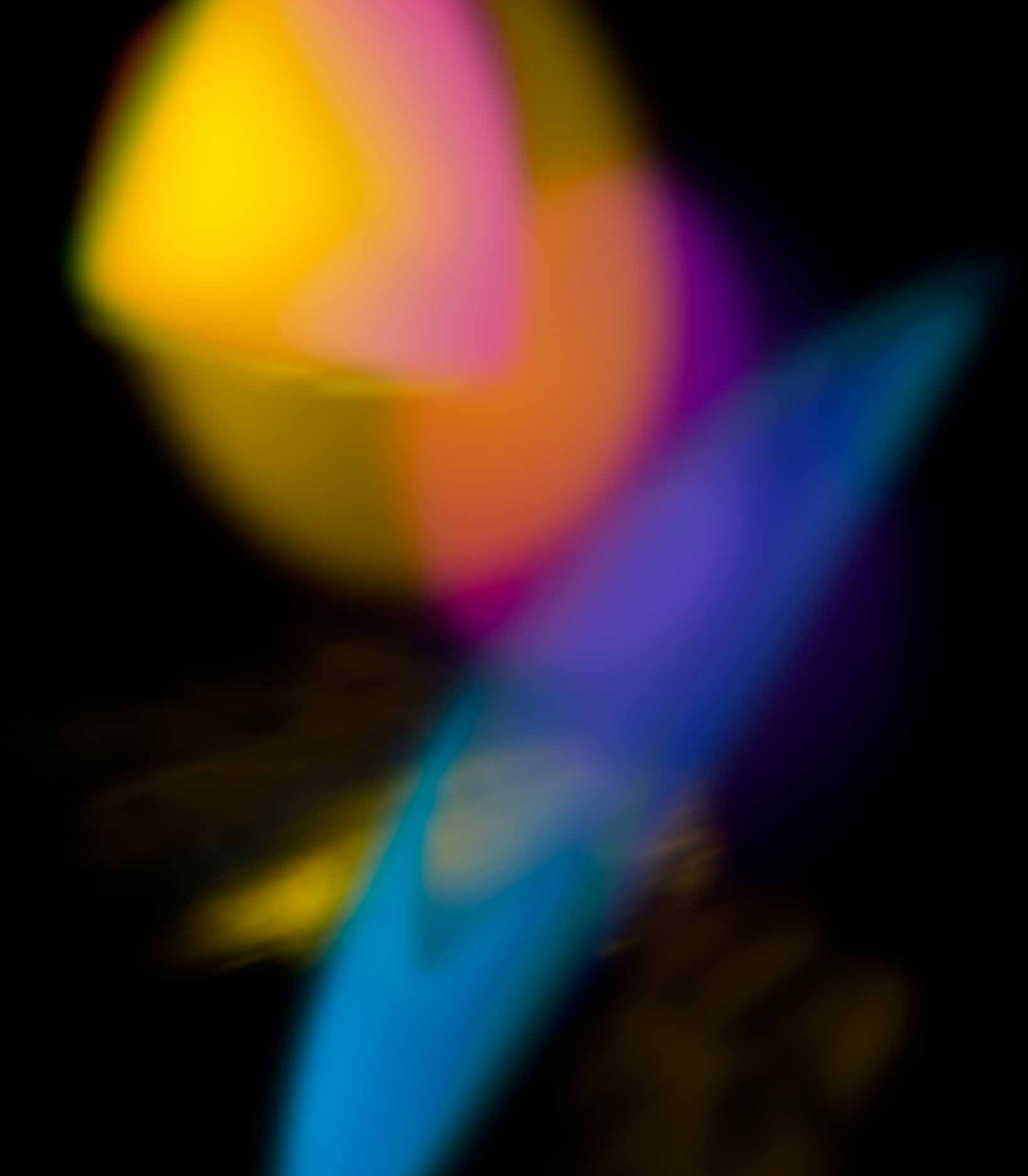

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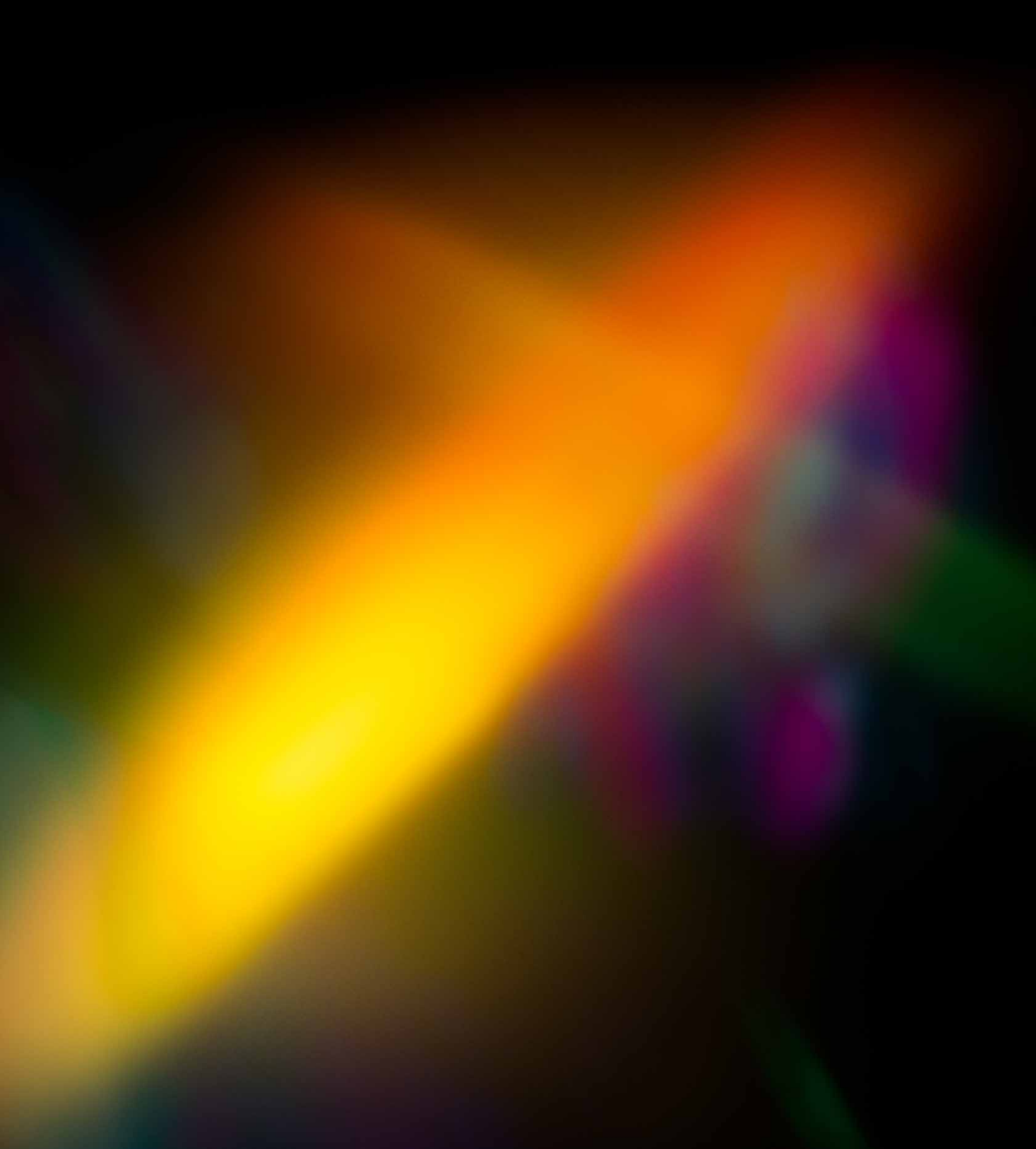


Abstract

Electricity demand in Sweden and Finland is expected to increase over the coming decades as a result of electrification of industry, transport, and new electricity-intensive activities such as hydrogen production and data centers. To meet defined electrification forecasts, there is an expected need for additional generation capacity of 122 TWh in Sweden and 155 TWh in Finland by 2045 – up from today's 140 TWh and 83 TWh, respectively. At the same time, most of the existing nuclear fleet will reach the end of its current operating lifetime within the next 10 to 20 years. If the lifetimes of existing nuclear reactors are not extended, the resulting generation gap would increase to 175 TWh and 180 TWh, respectively, by 2045.

In addition to its contribution to annual electricity generation, nuclear power can be seen to provide additional value to the electricity system through being a plannable and available technology. These attributes are considered to contribute to reduced electricity price variability, strengthened security of supply and more efficient utilization of the electricity grid.

If reactor lifetimes are not extended, the resulting capacity gap would need to be addressed through investments in new generation. Newbuild generation would entail higher system costs, which are ultimately borne by electricity consumers. Higher costs would affect individual consumers, weaken industrial competitiveness and limit employment growth in both countries.

This report has been developed jointly by Energiforsk and member firms of the global EY organization and describes how decisions on nuclear lifetime extensions (LTEs) have been taken in other countries. The study is based on interviews with owners, public authorities and industry associations across several markets. The report focuses on the initial stages of the decision-making process for lifetime extensions, with particular emphasis on business logic and financing conditions.

The report includes case studies of LTE investment decisions in Belgium, France, Canada and the United States. These case studies show that LTEs have been decided based on predictable revenue frameworks, political signals regarding the role of nuclear power in the energy system, and risksharing arrangements between the state and owners. In several cases, arguments related to climate objectives, cost efficiency, socioeconomic benefits and security of supply have been used to justify different forms of public involvement. At the same time, some interviewees highlight that uncertainty regarding future electricity prices, demand development and policy direction can delay or complicate investment decisions, particularly in deregulated electricity markets.

Swedish and Finnish nuclear operators are operating in deregulated electricity markets, have lower revenue potential for fossil-free electricity generation and lack dedicated support mechanisms for LTEs. As a result, investment decisions in Sweden and Finland are taken under greater economic uncertainty than in the countries selected for the case studies.

The purpose of the report is to provide Swedish and Finnish decision-makers – including policymakers, public authorities, system operators and owners – with international perspectives to support their efforts to develop the prerequisites for nuclear LTEs.

Foreword

This report examines the role of nuclear lifetime extensions in meeting future electricity demand in Sweden and Finland. It has been developed jointly by Energiforsk and member firms of the global EY organization, drawing on interviews with public and private nuclear operators, policymakers and industry professionals, as well as a review of recent international market reports.

Electricity demand in Sweden and Finland is projected to rise over the coming decades. Over the same period, multiple existing nuclear reactors will approach the end of their current planned operating times. Decisions on whether to extend the lifetimes or decommission these assets will have an impact on the future electricity system.

The report focuses on the initial step of the pathway toward Final Investment Decision (FID) for nuclear lifetime extensions, in line with the EY approach to infrastructure maturity assessments. It concentrates on business case development and financing conditions, assessing how market structure, revenue stability and risk allocation influence lifetime extension investment decisions. Subsequent elements of the assessment framework – such as engineering, licensing, project delivery and operations – are not the primary focus of this study.

Through comparative case studies from selected markets, the report highlights the investment structures, policy frameworks and public rationales that have supported lifetime extension decisions under different conditions. While conclusions from other markets cannot fully be transferred to either Swedish or Finnish settings, this analysis puts the Swedish and Finnish market conditions into context. Additionally, Swedish and Finnish decision-makers can learn from the decision-making process in other markets. The report is intended to support Swedish and Finnish decision-makers, including policymakers, nuclear owners, public authorities and grid system operators, in assessing the prerequisites for LTE investments in Sweden and Finland.

The findings and conclusions reflect insights from interviews and analysis conducted by Energiforsk and member firms of the global EY organization and do not necessarily represent the institutional views of either organization or any individual interviewee.

This report forms the results of a project performed in cooperation between Ernst & Young AB (EY Sweden) and the Energiforsk Outlook & Technology Program, which is financed by Vattenfall, Uniper, Fortum, TVO, Skellefteå Kraft and Karlstads Energi.*) The author(s) are responsible for the content

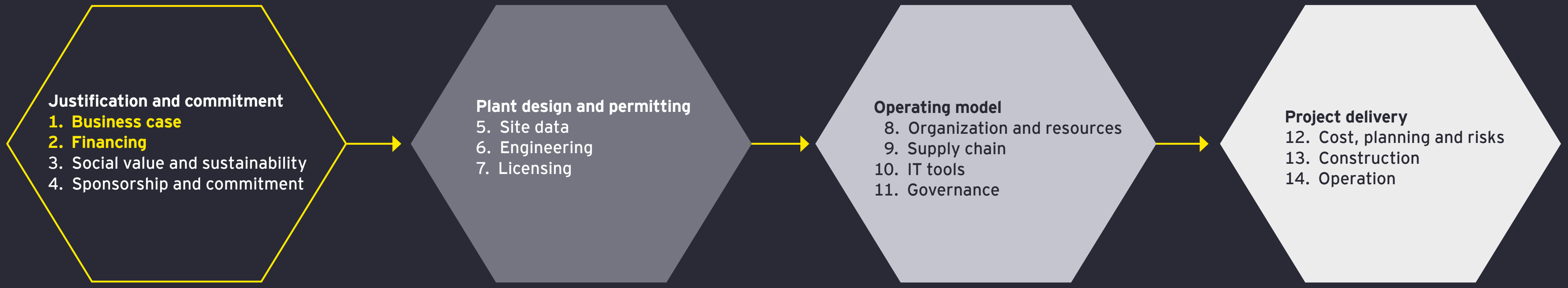
Stockholm June 2026

Victor Hammar
Partner, Energy Sector, Ernst & Young AB (EY Sweden)

*) https://energiforsk.se/program/nuclear-power-outlook-and-technology-development/

Scope of the report

The study focuses on the first two steps of an investment assessment – 1. Business case and 2. Financing



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Introduction

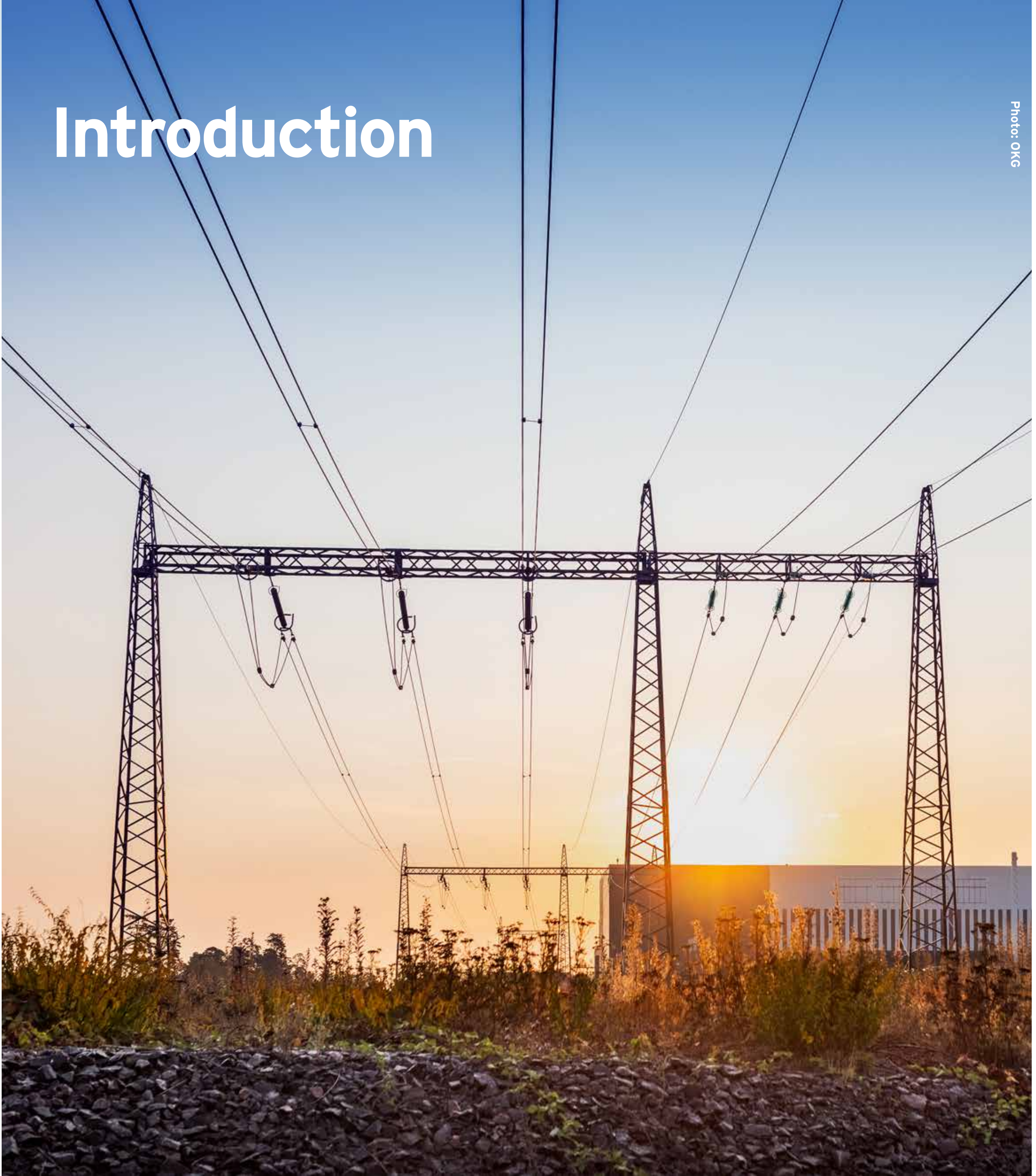

Photo: OKG

The Nordic and European energy systems are undergoing a period of structural change, marked by a shift from fossil fuels to decarbonized value chains, utilizing low-emitting technologies such as solar, wind and nuclear power. As part of the broader energy transition, electricity demand is projected to increase in the Nordics. The Swedish and Finnish Transmission System Operators (TSOs) both project demand growth of 50%-100% by 2045, driven by industrial electrification, electromobility, hydrogen and efuel production, and data centers. To meet this increase in demand, the build-out of electricity generation will need to close the gap to higher demand levels and replace generation assets that have reached the end of their lifetimes, see Figure 2.[1 2 3 4 5]

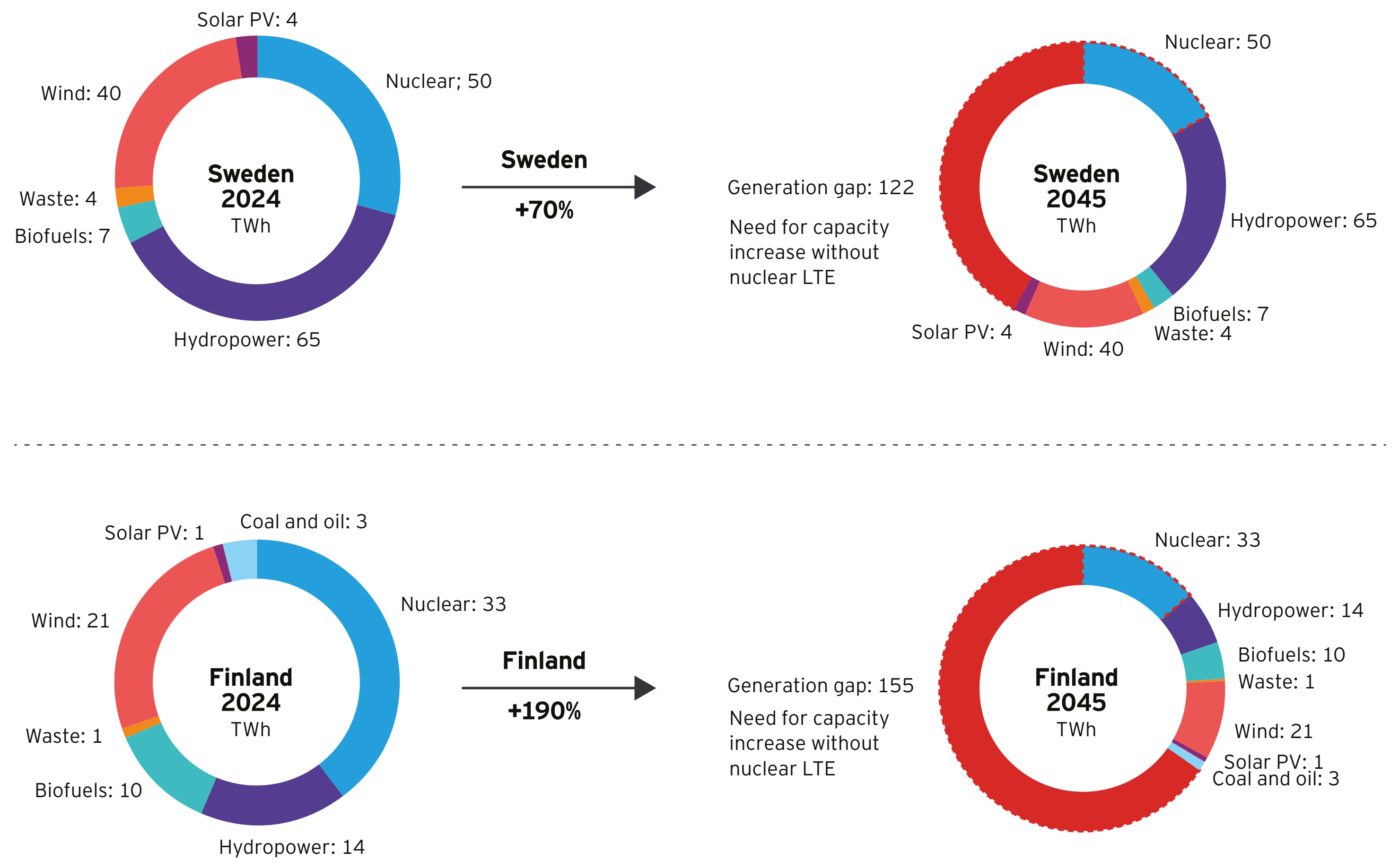

Figure 2: Average projected generation (including exports) 2025 and the necessary new power production 2045 to satisfy demand scenarios from Svenska kraftnät and Fingrid – assuming the current electricity output from the existing fleet remains unchanged. Note that, as interviewees have stated, other generating assets such as existing wind power will also reach their planned lifetimes by 2045. Therefore, the necessary build-out of power production is expected to be even greater.

1 In Sweden, Svenska kraftnät projects consumption to rise from around 140 TWh today to 205-241 TWh by 2045, and up to 344-347 TWh under high electrification scenarios. In Finland, Fingrid projects electricity demand to increase from around 83 TWh today to 104-159 TWh by 2035. Projected demand growth is driven by industrial electrification, hydrogen and e fuel production, and data centers.
2 https://www.svk.se/49006b/siteassets/om-oss/rapporter/2024/lma_2024.pdf
3 https://www.fingrid.fi/globalassets/dokumentit/en/news/fingrid_electricity_system_draft_scenarios.pdf
4 https://www.iea.org/countries/sweden/energy-mix
5 https://www.iea.org/countries/finland/energy-mix

Looking at the nuclear power fleet in Sweden and Finland, several reactors will reach the end of their currently planned operating time within the next 10 to 20 years. In 2024, these reactors generated 50 TWh and 33 TWh in Sweden and Finland, equaling 29% and 40% of total generation, respectively. The projected gap between electricity generated and consumed of 122 TWh and 155 TWh by 2045, would increase to 175 TWh and 180 TWh, respectively, if reactor lifetimes are not extended.[6] Nuclear LTE decisions taken in the coming years will determine whether these assets will continue to supply electricity or be decommissioned from the system.

Country	Plant	Units	Reactor technology	Electricity supplied (2024)	Age (as of 2026)	Currently planned operating time (age)
Sweden	Ringhals	R1	BWR	-	Decommissioned in 2020	
		R2	PWR	-	Decommissioned in 2019	
		R3	PWR	8 TWh	45 years	2041 (60)
		R4	PWR	9 TWh	43 years	2043 (60)
	Forsmark	F1	BWR	8 TWh	46 years	2040 (60)
		F2	BWR	7 TWh	46 years	2041 (60)
		F3	BWR	6 TWh	41 years	2045 (60)
	Oskarshamn	O1	BWR	-	Decommissioned in 2017	
		O2	BWR	-	Decommissioned in 2015	
		O3	BWR	11 TWh	41 years	2045 (60)
Finland	Loviisa	L1	PWR (VVER-440)	4 TWh	49 years	2050 (73)
		L2	PWR (VVER-440)	4 TWh	45 years	2050 (69)
	Olkiluoto	O1	BWR	7 TWh	47 years	2038 (60)
		O2	BWR	7 TWh	44 years	2038 (58)
		O3	PWR (EPR)	10 TWh	3 years	2083 (60)

Figure 3: The Swedish and Finnish nuclear power fleet in 2026. Note: The planned lifetime for the plant is targeted to support the safe and efficient operation of the plant. This lifetime must be longer than the time needed to reach profitability but shorter than the technical lifetime.

6 Assuming 2024 generation volume and that Loviisa – producing 8 TWh yearly – will operate until 2050

An LTE refers to the refurbishment of an existing nuclear power plant to support safe and efficient operation for decades beyond its current design life. The types of reactors present in Sweden and Finland were originally, typically, designed for an operational lifetime of around 40 years, and the technical feasibility of LTE needs to be assessed per reactor. Several interviewees state that, through refurbishment, lifetimes can be extended to 80 or even 100 years.

Depending on the scope of refurbishment required, LTE is seen as a resource-efficient way of maintaining electricity generation capacity compared with alternatives such as constructing new generation. From a Finnish perspective, the Finnish Ministry of Economic Affairs and Employment published **Options for Promoting Nuclear Energy Production, Costs, and Electricity Market Impacts** in 2026 where different scenarios for the Finnish electricity system from 2040 to 2060 were assessed. The report stated that LTE provides significant net benefits in all scenarios considered, as it would lower electricity prices.[7] From a Swedish perspective, the Confederation of Swedish Enterprise ordered the study Power System 2050 in 2025, which stated that a scenario without nuclear power is unlikely if Sweden is to succeed in reaching its climate targets and carrying out electrification.[8]

Beyond its contribution to electricity volumes, the Confederation of Swedish Enterprise states in its study that nuclear power is the alternative that can deliver stable, fossil-free power generation on a large scale. A former Swedish energy policy advisor has emphasized that dispatchable electricity generation in southern Sweden – such as nuclear power – can address many domestic challenges. These include limited transmission capacity, low regional self-sufficiency, security of supply concerns, and insufficient electricity preparedness, including the ability to operate independently from the grid (island mode) and to perform black-start recovery.[9]

Nuclear operators in Sweden and Finland have previously implemented multiple LTEs. However, upcoming LTE decisions will be taken under different market conditions. Today's electricity markets are, according to nuclear sector representatives in Sweden and Finland, characterized by uncertainty with regard to the forecasted supply and demand of electricity. This yields uncertain price forecasts and, in the end, uncertain business cases for investments in electricity production, including LTE.

”

In this volatile electricity market, it is more difficult to make these [LTE investment] decisions. And still, LTE is more needed than ever.

Juha Poikola, Public Relations Manager, TVO

7 https://afry.com/fi-fi/uutiset/uutinen/afryn-selvitys-tarkastelee-ydinenergian-tuotannon-edistamisen-vaihtoehtoja-ja
8 https://www.svensktnaringsliv.se/sakomraden/sakerhet-och-risk/8qsj6r_uppdrag2045_rapport_kraftsystem_robost_300twh_v002pdf_1231985.html/Uppdrag2045_Rapport_Kraftsystem_Robost_300TWh_V002.pdf
9 https://www.tn.se/naringsliv/36015/hjarnan-bakom-regeringens-nya-plan-for-elsystemet-vi-har-varit-naiva/

> LTE is not a given. To support LTE, we must reduce the risk exposure from an electricity market with uncertain future demand and volatile prices by securing our future revenues through PPAs [power purchase agreements], CfDs [contracts for difference] or other measures.
>
> **Johan Svenningsson, Sweden CEO, Uniper**

This report draws on recent international experience to examine how nuclear owners and operators in other markets have structured and assessed LTE investment decisions. It complements previous Swedish and Finnish system studies by highlighting the business case parameters of LTE decisions through an international market outlook. The objective is to identify relevant insights for Swedish and Finnish decision-makers, including policymakers, nuclear owners and other industry actors.

The report provides an overview of recent LTE projects; it describes four selected markets for case studies and compares the conditions prevailing in these markets to those in Swedish and Finnish. The report concludes with implications for decision-makers in the Swedish and Finnish market.

Market outlook of nuclear lifetime extensions

Photo: TVO

There is global momentum for nuclear power, driven by the energy transition and a wish for energy sovereignty. Based on the interviews conducted for this report, countries pursuing LTEs appear to share several motivations, including lower costs, climate benefits, socioeconomic benefits and energy security.

Expansion of nuclear power and the role of lifetime extensions

According to the recent EY study **"Making investments in the nuclear value chain attractive"**, the nuclear sector is globally projected to double its capacity from approximately 420 GWe to approximately 820 GWe over the next 25 to 50 years. The projection is primarily driven by the wider energy transition and the wish for sovereignty across world economies.[10] LTEs, being a cost-effective generation alternative, are expected to be carried out and support the increase. Over 60 reactors are expected to have their lifetime extended over the coming five years, covering nearly 15% of the global nuclear fleet, according to the International Energy Agency (IEA).[11]

Stated benefits of nuclear lifetime extensions

Countries pursuing LTEs appear to share several motivations, as summarized by the Nuclear Energy Agency.[12] A selection of stated benefits of LTEs is described below:

LTE offers low costs and supports low electricity market prices: LTE projects generally require refurbishment of components such as steam generators or turbines. However, the IEA states that LTE costs are "competitive" compared with those of other generation technologies. The IEA has also stated that the comparison of different generating technologies needs to take operational characteristics and relative value to the overall electricity system into account – where nuclear energy is dispatchable and plannable to a higher degree than intermittent renewable energy. Considering this, the IEA has developed a value-adjusted cost metric (VALCOE) for one of its 2040 scenarios, as seen in Figure 4.[13]

10 https://www.ey.com/content/dam/ey-unified-site/ey-com/fr-fr/insights/energy-resources/documents/ey-making-investment-in-the-nuclear-value-chain-attractive-18122025.pdf
11 https://iea.blob.core.windows.net/assets/b6a6fc8c-c62e-411d-a15c-bf211ccc06f3/ThePathtoaNewEraforNuclearEnergy.pdf.pdf
12 https://www.oecd-nea.org/jcms/pl_114405/status-report-on-long-term-operation-of-nuclear-power-plants-beyond-60-years?details=true
13 https://www.iea.org/reports/the-path-to-a-new-era-for-nuclear-energy

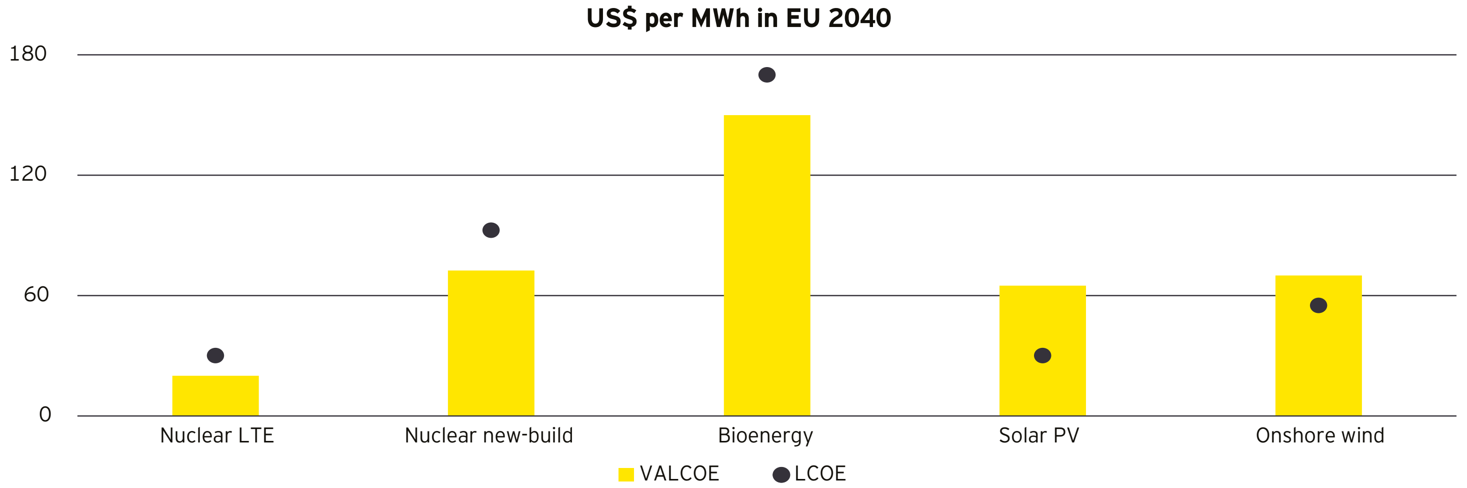

Figure 4: Average estimated costs of different generation technologies in the EU in a defined 2040 scenario. Note that costs and expected power output from generating assets are dependent on multiple prerequisites, including geographical position, which may differ within the EU. LCOE = levelized cost of electricity; VALCOE = value-adjusted LCOE. The IEA has developed the VALCOE to "quantify several of the key considerations, taking account of the energy mix at a given point in time and the specific contributions to energy, capacity and flexibility of each technology". However, certain aspects – such as costs for grid connection – are still excluded in the metric.

Once refurbished, nuclear plants operate, according to nuclear operator representatives, with low fuel and operating costs. This means they typically bid into electricity markets at low marginal cost compared with other baseload sources of electricity and are dispatched whenever available. Hence, maintaining nuclear power in the energy mix is expected to have a price decreasing effect, in turn increasing industrial competitiveness and favoring new investments and job creation in both Sweden and Finland.

The stated economic attractiveness of LTEs is also recognized by market operators. As an example, in 2021, the French TSO Réseau de Transport d'Électricité (RTE) – majority owned by French nuclear operator EDF – published the Energy Pathways to 2050 on possible pathways for the French electricity system to 2050.

One of the conclusions was that the scenarios that call for phasing out nuclear by 2050 were significantly more expensive than other options, as summarized in quote below:[14]

> ”
>
> In the short or medium term (2030–2035), any decisions about shutting down nuclear reactors would be political.
>
> **- RTE, France**

14 https://assets.rte-france.com/analyse-et-donnees/2023-07/Energy%20pathways%202050_Key%20results.pdf

Support for climate and other environmental benefits: The IEA, the UN (via IPCC) and The World Bank all recognize the role of nuclear power – being a low-emission technology – in reaching climate goals. [15] [16] [17] Furthermore, the EU Taxonomy classifies nuclear-related activities such as new-build and LTE to be environmentally sustainable under a set of defined conditions[18].

The US states of Illinois, New York, and New Jersey provide examples of how the low climate impact rationale has been translated into market mechanisms for existing nuclear power through Zero Emission Credits (ZECs). Motivated by reaching state climate targets, this market scheme gives nuclear operators a low-emission certificate for its generated electricity, which electricity buyers need to buy in order to be compliant. The scheme implies electricity buyers to pay a premium price for low-emitting generation sources, significantly improving revenue streams of nuclear power.

Aside from maintaining a low-emitting power generation source, LTE also delivers environmental benefits by avoiding material use, land take and emissions associated with building new power plants, and the additional grid infrastructure required to connect them.

It can be noted, however, that compared to other generation technologies, nuclear power generates radioactive waste. With current conventional methods, this waste needs to be stored underground for 100,000 years to protect the environment from hazardous radiation. Historic nuclear reactor accidents showcase the consequences of potential errors. The Swedish Society for Nature Conservation (Naturskyddsföreningen) states that, after 2040, Sweden ought to have solely renewable electricity production.[19]

Energy security: The energy crisis and price volatility of 2022-2023 reinforced the value of stable baseload generation. In the recent IEA report, The Path to a New Era for Nuclear Energy, several country representatives view nuclear power as insurance against fuel market fluctuations and geopolitical risks.[20] As an example, the European energy crisis in 2022-2023 contributed to the Belgian government abandoning its previous nuclear phase-out policy, allowing the reactors Doel 4 and Tihange 3 to operate beyond the scheduled decommissioning dates in 2025. In April 2026, the Belgian government stated that they had entered negotiations with Engie to acquire its Belgian nuclear assets, in a move to help secure the country's energy supplies.[21]

As of June 2026, the Strait of Hormuz has been effectively closed for energy shipping for three months. EY experienced professionals expect the resulting fossil fuel price increases to further reaffirm the case of energy security, sovereignty and lower reliance of fossil fuel.

15 https://iea.blob.core.windows.net/assets/b6a6fc8c-c62e-411d-a15c-bf211ccc06f3/ThePathtoaNewEraforNuclearEnergy.pdf
16 https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-3/
17 https://documents.worldbank.org/en/publication/documents-reports
18 https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698935/EPRS_BRI(2022)698935_EN.pdf
19 https://www.naturskyddsforeningen.se/artiklar/vanliga-fragor-om-karnkraft/
20 https://iea.blob.core.windows.net/assets/b6a6fc8c-c62e-411d-a15c-bf211ccc06f3/ThePathtoaNewEraforNuclearEnergy.pdf
21 https://www.reuters.com/business/energy/belgium-government-plans-buy-engies-nuclear-assets-country-2026-04-30/

Job creation and industrial benefits: Major refurbishment programs have been seen to generate thousands of local jobs, support the domestic supply chain and maintain skilled technical capabilities.[22] The refurbishment program in Darlington, Ontario, Canada, is an example where the owner-operator Ontario Power Generation (OPG) highlights in its project communication the number of jobs created (14,200 per year), its contribution to GDP (equivalent to ~66b US$) as well as how much of its expenditure are spent within Ontario (96%) – shaping the narrative of the refurbishment program as a publicly owned utility.[23]

Status for nuclear lifetime extensions

To the right is an overview of different markets where LTEs of nuclear power have been decided recently, together with the project status and the structures present in those markets.[24]

Note that the overview is done for North American and selected European markets, where the relationship between owner-operator companies and the public sector is transparent and allows for comparison to Swedish and Finnish market conditions.

22 https://www.oecd-nea.org/jcms/pl_114405/status-report-on-long-term-operation-of-nuclear-power-plants-beyond-60-years?details=true
23 https://www.opg.com/documents/2025-06-17-cac-minutes-appendix-3-pdf/
24 https://world-nuclear.org/images/articles/World-Nuclear-Outlook-Report_dfed5656.pdf

Country	Operating reactors	LTE status for fleet	Examples of supportive market mechanisms for LTE business cases
United States	94	Majority of reactors are licensed to 60 years, and selected units are progressing toward 80 years. Interviewed professionals expect most reactors to have their lifetime extended to 80 years of operation.	Regulated cost of service markets; state-level Zero Emission Credits (ZECs)
France	57	An LTE assessment program is rolled out over the entire fleet, investigating operation beyond 60 years.	Agreed price level with the state for existing nuclear power; CfDs (explained in section 2.4) under discussion
Canada	18	Large-scale refurbishment programs are underway in Ontario, home to 17 of the 18 operating reactors.	Regulated provincial markets; lifetime revenue contracts with the transmission system operator
United Kingdom[25]	9	Operation of the eight advanced gas reactors has been extended several times. Future extension possibilities are however limited for these reactors. For the PWR, Sizewell B, the owner EDF UK is working to agree a commercial model for an LTE of 20 years to 2055.	The UK government intends to proceed with "the proposed amendment to support existing nuclear power stations to become eligible for CfD support for lifetime-extension activities"
Czech Republic	6	Announced intention to pursue 80-year operation. LTE for the two reactors at Temelín is under assessment.	No dedicated LTE support mechanism
Hungary[26]	4	The Hungarian parliament has approved plans of LTE for the four operating reactors in Paks to 70 years.	No dedicated LTE support mechanism
Belgium	2	Two reactors have been decided to be lifetime extended, securing approximately 50 years of total operation. The government has announced plans for additional extensions to more than 60 years.	State-operator joint venture; two-way CfD; state take-over of back-end responsibility
Bulgaria[27 28]	2	Two reactors received lifetime extensions, securing 60 years of total operation to 2047 and 2051.	Part of generated electricity sold at regulated prices, almost half of generated electricity sold through bilateral contracts
Romania[29 30]	2	LTE pursued for existing units to 2060, increasing the total lifetime of the first reactor to 64 years.	Direct grant, state-backed loan guarantees and 30-year two-way CfD under investigation by the European Commission
Sweden	6	LTE options beyond 60 years, are under consideration.	No dedicated LTE support mechanism
Finland	5	LTE options beyond 60 years, are under consideration.	No dedicated LTE support mechanism

Figure 5: Overview of markets where LTE of nuclear power has been decided recently, including project status and selected market conditions

25 https://www.gov.uk/government/consultations/financial-support-for-nuclear-lifetime-extensions
26 https://world-nuclear.org/information-library/country-profiles/countries-g-n/hungary
27 https://www.neimagazine.com/analysis/kozloduys-reactor-protection-upgrade/
28 https://www.kznpp.org/upload/35235/Kozloduy_NPP_AR_2023_en.pdf?inline=1
29 https://world-nuclear.org/images/articles/World-Nuclear-Outlook-Report_dfed5656.pdf
30 https://claytonsegura.com/commission-opens-formal-investigation-into-romanian-state-aid-for-cernavoda-nuclear-reactor/

Market and regulatory conditions supporting lifetime extensions

Electricity markets are often described as either regulated or deregulated, although in practice most markets combine elements of both models.

In regulated or semi-regulated markets, electricity prices or revenues are influenced by regulatory oversight, long-term arrangements and direct state involvement, providing stability for capital-intensive generation assets. Within regulated market frameworks, an infrastructure operator is permitted to recover approved investment and operating costs, plus a regulated return, through charges set by a regulator.

In contrast, in deregulated electricity markets, such as the ones seen in EU countries, prices are set through short-term (mostly day-ahead) marginal pricing. This occurs through an auction mechanism where plant operators place sales bids on their electricity, in Sweden and Finland this is through the market platform Nord Pool. The lowest bidders – being first in the so-called "merit order" – satisfying electricity demand get called upon. Without targeted support mechanisms, capital-intensive assets in these markets, such as nuclear power, are exposed to energy market revenues with limited long-term price visibility.

In some countries, governments also provide targeted support mechanisms to manage the capital costs associated with LTEs. For example, the UK, Belgian, and Romanian governments have used, or are assessing, combinations of state aid measures and regulated revenue frameworks for existing nuclear facilities, which are operating in unregulated electricity market structures. [31] [32] [33]

One of the main support schemes used for nuclear power is contracts for difference CfDs, a long-term contract designed to stabilize revenues for electricity generators, see Figure 6. Under a two-way CfD, a strike price is set: If market prices fall below this level, the generator receives a top-up payment; if prices rise above it, the generator pays back the difference. The EU's electricity market design explicitly accommodates two-way CfDs as a support mechanism for low-emitting electricity generation, including nuclear power.[34]

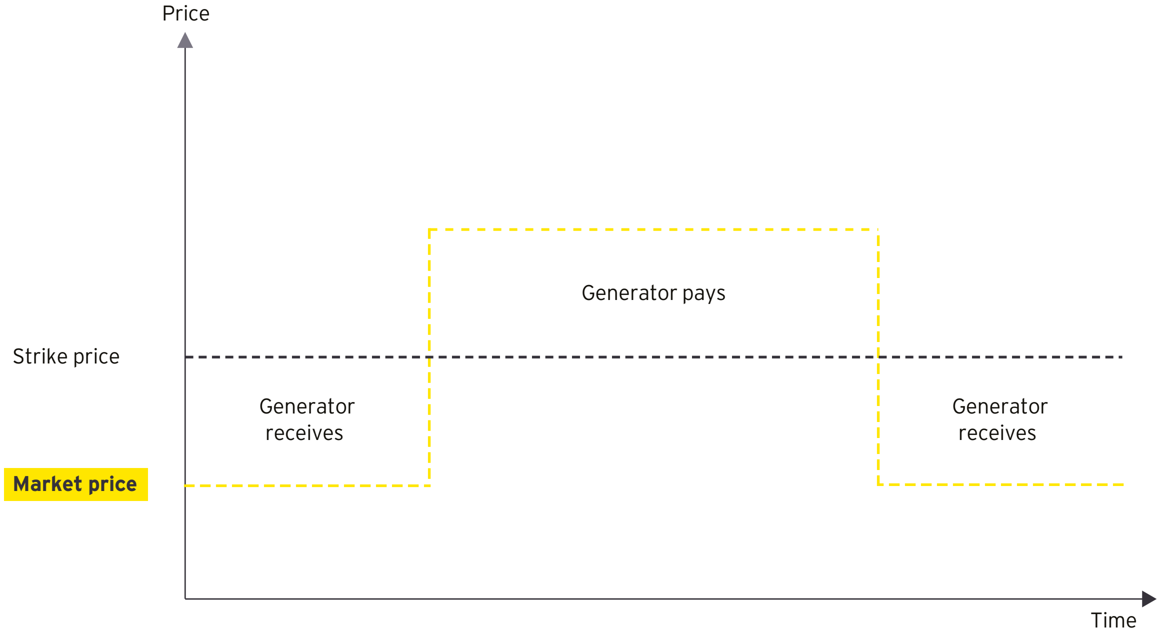

Figure 6: Positive and negative payouts in a two-way CfD.
Note that the figure is schematic, power prices vary with a new pricing set every 15-minute interval.

31 https://www.gov.uk/government/news/government-to-unlock-advanced-nuclear-to-grow-economy
32 https://competition-cases.ec.europa.eu/cases/SA.106107?from=latest-updates&caseInstrument=SA&dateHighlight=2025-12-16
33 https://www.transelectrica.ro/documents/10179/17691688/CfD-Government-Decision-318_2024.pdf/b93ab692-bcdb-4629-8d01-a3ccfc85c7a9
34 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52025XC06701

Case studies from nuclear lifetime extension decisions

Photo: TVO

To showcase different approaches to LTE investment decisions under current market and policy conditions, this report presents case studies from Belgium, Canada, France and US. Nuclear operators in these countries have different market prerequisites and allow for a comparison between LTE decisions across varying conditions. This breadth supports the identification of features and drivers that are relevant across different settings while also highlighting characteristics that are specific to the Swedish and Finnish energy markets.

Each case study was conducted through interviews with representatives from the respective markets. Several interviews were conducted with leading actors from Belgium, Canada, Czech Republic, France and US. The interviews focused on market design, key drivers and public rationales for LTEs, and lessons relevant for LTE investment decisions in Sweden and Finland. A more detailed description of the methodology and list of interviews is found in the Appendix.

Summary

Country	Market setup	Stated key drivers for LTE	Selected statements from the interviews
Belgium	Deregulated, with state intervention for LTE through revenue support and co-financing	Security of supply, rising demand	LTE was driven by the government, where the agreement with the operator was based on a state-operator joint venture, a CfD scheme, and state take-over of back-end responsibility. LTE costs increased due to the short timeline.
Canada (New Brunswick and Ontario)	Regulated	Rising demand, security of supply and economic benefits	Provincial and federal support and lifetime revenue contracts support large-scale, refurbishment programs which are on time and within budget. Coordinated and sequenced LTEs across units and sites are also seen as a success factor.
France	Deregulated, with agreed pricing with the state for existing nuclear	Cost efficiency and security of supply	10-year energy planning between nuclear operator and state is seen as more important than a potential revenue-supporting mechanism. Rising renewable capacity – both domestic and imported – generates price volatility and uncertainty.
US (different market conditions per state)	Mixed: regulated (~60% of plants) and deregulated	Rising demand and decarbonization	LTE is seen as more attractive in regulated markets. Bilateral power contracts with hyperscalers are seen to drive LTE investments. Targeted low-emission remuneration strengthens the LTE investments in certain deregulated markets.

Figure 7: Summary table of takeaways from markets selected for case studies

Belgium

Policy and regulatory framework

Belgium's approach to LTEs has been shaped by its shifting political landscape. Until 2022, the country was committed to a nuclear phase-out by 2025. Following the 2022 energy crisis, the government reversed course and negotiated the Phoenix Agreement with Engie and its Belgian nuclear owner subsidiary, Electrabel, securing an additional 10 years of operation for its reactors Doel 4 and Tihange 3. In 2025, the newly formed governmental coalition signalled a further change in direction, announcing plans to operate the two reactors to 2045 or even longer, potentially prolonging other units and expressing interest in new-build reactors.

The decision to pursue LTE was ultimately a state-driven strategic choice, articulated by the European Commission decision document as: "The Belgian government decided that nuclear power should be part of Belgium's energy mix for the next 10 years"[35]. Before the crisis, Engie and Electrabel had adopted a strategy of making no further investments in nuclear power in Belgium. The strategic direction was due to the Belgian nuclear phase-out law, as well as a combination of heavy taxation on profits and continuously increasing requirements on setting aside assets (€11 billion accumulated at the time of the agreement) to cover the liability for nuclear waste management. These conditions led Engie to operate reactors at a cumulative loss, Engie shared.

The government's urgent need for security of supply, which led to new conditions through the Phoenix Agreement, made Engie revise the previously set strategy. The negotiated outcome included, among other aspects a 50/50 state-Engie joint venture for the LTE investment; a two-way CfD scheme toward the newly formed joint venture and a shift of long-term waste liabilities to the Belgian state in exchange for a lump-sum payment of €15 billion, the liability for decommissioning (separately provisioned at €9 billion) remaining with Electrabel and being guaranteed by Engie. The agreement was approved by the European Commission with reference to observed "market failures" as:

> There are a number of market failures arising from mainly (i) an uncertain energy market and investment climate, (ii) uncertain costs related to the management and disposal of spent fuel and nuclear waste and (iii) exposure to political decisions, which prevent the nuclear operator from obtaining revenue certainty so that the lifetime extension of the LTO [long-term operation] units is profitable.
>
> **– European Commission**[36]

Market conditions and revenue potential

As in all EU countries, Belgian power prices fluctuate according to a deregulated electricity market structure. The financial architecture of the Phoenix Agreement was designed to mitigate the price risk that this market structure creates for Electrabel and Engie. A two-way CfD was set to provide price stability for the venture, with a preliminary strike price set to target a return on capital of around 6–8% for the joint venture. The return is, however, linked to plant availability, meaning Engie's exposure to operational performance remains.

Opportunities to increase performance during the LTE were limited according to interviewees. As the technical studies had to be completed in only 18 months, Electrabel pursued a technical approach with minimal design changes and no major upgrades (which are otherwise common in LTE refurbishments). The priority was to maintain reliable winter operation during the LTE project – supported by sequencing the refurbishment. In addition, the relatively short extension period of 10 years reduced the potential payback for performance-improving investments, according to interviewees.

Power system context and energy mix

The 2022 energy crisis demonstrated to Belgium, according to the interviewees, the vulnerability of relying heavily on gas and electricity imports, leading the government to reassess nuclear as a pillar of security of supply. The decision document from the European Commission stated that Belgium also saw LTE as a way to secure baseload capacity in response to the country's growing electrification requirements.

Interviewees framed Belgium as an example of the high cost of abrupt political reversals. Once the government urgently needed LTE, refurbishment costs were higher than comparable projects and the opportunities for performance improvements were limited.

Broader reflections from interviewees underline that only the state can hold the long-term strategic perspective required for nuclear investment, given the political, regulatory and financial risks involved. Stable, long-term energy strategy – as opposed to shifting political stances over different mandate periods – is seen as essential for the future role of nuclear power in Belgium.

> Only the state can have the strategic view that is needed upon nuclear investments. For private parties, the exposure to different [political and regulatory] risks are simply too big.
>
> **– Interviewee**

35 https://competition-cases.ec.europa.eu/cases/SA.106107?from=latest-updates&caseInstrument=SA&dateHighlight=2025-12-16
36 https://competition-cases.ec.europa.eu/cases/SA.106107?from=latest-updates&caseInstrument=SA&dateHighlight=2025-12-16

Canada

Policy and regulatory framework

Canada's LTE environment is shaped by provincial market structures that differ across the country. Ontario – home to 17 of Canada's 18 operating nuclear reactors[37] – operates under a regulated framework where, according to interviewees, nuclear power is viewed as a foundation for clean, reliable electricity supply. Furthermore, the nuclear sector is, according to interviewees, receiving a high degree of support and attention from the provincial government. This has helped both nuclear operators OPG and Bruce Power to pursue large-scale, long-term refurbishment programs with strong provincial backing. These programs, being finished ahead of schedule and within the predefined budgets, have been highlighted as success stories by several interviewees. Decisions to extend reactor lifetimes were, according to one Canadian interviewee, motivated partly by reliability needs and partly by socioeconomic considerations, including job creation and regional economic development.

> The Ontario provincial government recognized the importance of securing reliable energy and supported decisions for LTE at the government and privately owned utilities.
>
> **Demilade Fayemiwo, Director in Policy, Canadian Nuclear Association**

While new-build projects may receive CAPEX support, LTEs primarily benefit from Canada's Clean Energy Investment Tax Credit and rely on non-public funding.

Market conditions and revenue potential

In Ontario, both OPG and Bruce Power operate under long-term arrangements with the Independent Electricity System Operator, providing stable revenue streams.

The LTE narrative in Canada heavily emphasizes domestic job creation and supply chain development. Canada has a strong supply chain for its domestic reactor technology, though some components still rely on foreign suppliers. Overall, LTEs are seen as economically attractive investments that maintain industrial capabilities ahead of potential new-build deployments.

> The key is to keep the supply chain engaged. Supply chain liability [problems not within the nuclear operators control but stemming from its supply chain of products and services] leads to delays and overspending. LTEs can be used to maintain the supply chain ahead of new-builds. The Nordics could learn from Canada on this aspect, adding supply chain activation, as well as societal economic benefits, among communicated rationales for LTEs.
>
> **Demilade Fayemiwo, Director in Policy, Canadian Nuclear Association**

Furthermore, interviewees noted that coordinated and sequenced LTEs across units and sites have improved cost-efficiency, supported continuous access to critical supply chain capabilities and reduced execution risks.

Power system context and energy mix

Interviewees underline that nuclear power plays a central role in Ontario's electricity system, providing stable, low-emitting baseload generation. They say that provincial support, combined with an experienced and coordinated workforce, has contributed to the success of major LTE projects.

From a broader system perspective, interviewees state that LTEs are seen as a cost-effective way to increase the value of existing assets, maintain supply chain readiness for future reactor deployments, and facilitate long-term system reliability in a decarbonizing electricity mix.

Photo: By Kevin M Klerks from Inverhuron, Canada - Nuclear Plant, CC BY 2.0, see link

37 https://world-nuclear.org/images/articles/World-Nuclear-Outlook-Report_dfed5656.pdf

France

Market design and regulatory framework

France's nuclear sector, comprising 57 reactors, all owned and operated by the state-owned utility EDF, has undergone a strategic shift in recent years. The Pluriannual Energy Programme had planned to decommission up to 14 reactors. Now, according to interviewees, the French government, transmission grid operator RTE[38] and EDF regard LTE as the most cost-effective means of meeting future electricity demand, with plans to expand the fleet by six new reactors and a futher eight being considered. Interviewees, therefore, expect the share of nuclear power in the French electricity system to remain above 50% over time.

EDF's LTE strategy is centered around the Grand Carénage, a multi-year modernization program investing around €5 billion annually to upgrade safety, extend asset life and meet new regulatory requirements. An EY experienced professional states that state-backed CfDs are planned for newly built units and have also been preliminarily proposed for lifetime-extended units. At present, there is no decision taken to include LTEs in the CfD scheme.

However, a French interviewee commented that a potential CfD scheme would not be as important as state-level energy planning:

> Using CfDs to de-risk nuclear investment might be coming back for debate in France. But France could avoid it [for LTEs] since it is a cheap way of producing electricity and hence should be profitable without long-lasting overcapacity. What is key here is good energy planning at the state level, especially regarding the next ten years.
>
> **Francois Dassa, Director Long Term Planning, DPNT, EDF**

Market conditions and revenue potential

According to interviewees, historically, EDF's revenue potential was constrained by a mechanism that required EDF to sell a share of its nuclear output to competing suppliers at regulated prices. Under this framework, the regulated price limited EDF's ability to fully recover costs, say interviewees. Under a revised framework, active since January 2026, EDF now sells electricity at market prices in line with EU market design, with an agreed average price level of €70/MWh set in agreement with the French state. [39]

Due to the high share of nuclear in the French energy mix, nuclear produces more electricity than baseload power demand and is hence required to follow the load – varying power output with consumer demand. In Sweden and Finland, nuclear power can to a higher degree provide maximum power output as it is hydro power, instead of nuclear power, that is steered to follow fluctuating demand. According to interviewees, the short-term absence of demand growth combined with steady development of renewables leads to overcapacity and to increasing needs of variations of power from the reactors. The varying operation results in higher thermo-mechanical demands on certain components, which can lead to outages.

Longer term, an EY experienced professional shared, supply-demand forecasts are uncertain not only due to the forecasted output from intermittent renewables, but also due to the uncertainty over when the electrification trend will outgrow the decrease in electricity demand from energy efficiency measures.

> In the coming years, even if France stopped to invest in new renewables, its market would still import volatility, negative prices from its neighbors. As long as they continue to invest massively in new generation means without a parallel increase in demand, this will create tensions.
>
> **Francois Dassa, Director Long Term Planning, DPNT, EDF**

Power system context and energy mix

Nuclear power remains the backbone of the French electricity system, accounting for around 70% of annual generation. Due to the absence of variable electricity generation sources, French nuclear power output follows the electricity system demand to a higher degree than, for example, Swedish and Finnish nuclear power plants. Several interviewees highlight this as a reason for lower average plant availability (62.5%, 2022–24) compared to other markets (global average of 82.3% over the same period).[40] Lower availability requires a higher price level per kWh to reach profitability on the LTE investment.

Overall, the alignment of economic efficiency, system reliability and national strategic objectives has led to governmental support for long-term nuclear operation in France. Nevertheless, interviewees point to EDF remaining exposed to operational and system-level challenges, including price pressures arising from built-out subsidized renewable generation in neighboring countries.

38 https://www.rte-france.com/en/media/10390
39 https://www.sfen.org/rgn/le-nucleaire-a-70-e-mwh-cinq-questions-pour-tout-comprendre/
40 https://pris.iaea.org/PRIS/WorldStatistics/ThreeYrsEnergyAvailabilityFactor.aspx

The US

Policy and regulatory framework

The US nuclear fleet operates under a mixed policy and regulatory landscape. The Nuclear Energy Institute (NEI) states that close to 60% of nuclear power plants function within regulated markets, where nuclear assets are generally integrated into larger utility portfolios.[41] Within this framework, US interviewees describe LTEs as generally economically rational, largely independent of short-term commodity price fluctuations.

In contrast, nuclear plants exposed to competitive wholesale markets face price fluctuations, which implies higher risk. Interviewees shared how this risk materialized during 2012–18, where low electricity demand combined with low prices for natural gas decreased electricity prices. This resulted in the early retirement of 13 nuclear units across the country – eight of them primarily for economic reasons according to NEI representatives. In response, several state governments introduced targeted policy support mechanisms, most notably Zero Emission Credits (ZECs) in states such as New York, Illinois and New Jersey. These support mechanisms are still present today.

> There are 94 reactors [in the US]; 95% have already received licenses to go to 60 years and probably most will go to 80 years or longer.
>
> **Garry Young, Technical Executive LTO and Aging Management Strategy, EPRI**

Market conditions and revenue potential

Rising electricity demand and higher fossil fuel prices have improved market conditions for non-fossil generation. At the same time, growing corporate demand for baseload, low-emitting electricity has strengthened the competitive position of nuclear power. One interviewee commented that, together, these factors have reinforced the business case for continued operation, with many operators now targeting 80 or even 100 years of operation.

In particular, the emergence of hyperscalers and data center operators – satisfying the surging demand of AI-driven computing – has increased demand for stable electricity supply. By entering into power supply agreements with these buyers, operators can secure long-term price certainty and, in some cases, obtain premiums for low-emitting electricity. This market trend further strengthens incentives for LTEs.

> There will be additional LTEs, which we otherwise wouldn't have seen because of these data centers.
>
> **Matt Crozat, Executive Director for Strategy and Policy Development, NEI**

The higher average availability of nuclear power plants in the US – 93.2% over the period 2022–24 – further strengthens the business case for operators[42]. US nuclear-owner-operator Constellation Energy, which operates several plants with above-average availability, notes that consistently high availability improves its negotiating position when entering bilateral power supply agreements with electricity consumers.

Power system context and energy mix

From a system perspective, nuclear power is seen to continuously play a critical role as a source of stable, low-emitting generation within the electricity system of the US. With many states being reliant on fossil electricity production – more than half of the electricity production in the US is fossil – LTE of nuclear plants contributes to emission reduction objectives. See Figure 8.[43]

41 https://www.nei.org/resources/statistics/nuclear-plants-in-cos-regulation-merchant-markets
42 https://pris.iaea.org/PRIS/WorldStatistics/ThreeYrsEnergyAvailabilityFactor.aspx

43 https://www.energyinst.org/statistical-review

Trends identified across case studies

Trend 1

Governments' involvement supports nuclear lifetime extensions in several countries

LTEs in several countries depend on state involvement to support investment decisions relying on targeted mechanisms – such as direct investment aid and price intervention in the case of Belgium, and emission-based support in the case of New York, Illinois and New Jersey. However, there are notable exceptions. As highlighted by one interviewee, LTEs in the Czech Republic are proceeding without dedicated state support, indicating that public intervention is not a prerequisite in all contexts. One should note that Czech electricity prices are generally higher in comparison with other countries, for example France, Sweden and Finland. See Figure 9.[44]

> We don't need to discuss additional involvement of the government since the LTO of Dukovany [and Temelin] program is NPV positive [with a positive Net Present Value, indicating profitability]. Sure, it has some risks, on the CAPEX side and regarding the CO2 prices [affecting power prices in the market] … but state involvement is not needed, at least for now.
>
> **David Hajman, Strategy Director, CEZ Group**

44 https://www.entsoe.eu/data/transparency-platform/

Trend 2

Energy security and climate targets strengthen the case for nuclear lifetime extensions

Energy security and climate targets have been mentioned as strategic rationales for LTEs. After recent years' increases in fossil fuel prices, especially for natural gas in Europe, LTEs are viewed as a way to secure predictable, baseload electricity supply at relatively low system cost, while simultaneously contributing to decarbonization objectives. As a result, several countries – such as France and Belgium – have been reassessing previous phase-out decisions and extending the role of existing nuclear assets in the energy systems.

Trend 3

Uncertain electricity supply and demand forecasts increase business case risks

Uncertain long-term supply and demand forecasts have been mentioned to increase the complexity of LTE investment decisions. EDF is an example of an operator where intermittent generation affects price formation and operating patterns for nuclear units, and where uncertainty over the timing and scale of future demand growth complicates long-term revenue projections.

Trend 4

Industrial benefits matter politically

Large-scale refurbishment programs are communicated to have substantial industrial and regional benefits. Projects such as the Darlington refurbishment in Canada have communicated the generated employment and contribution to GDP. These socioeconomic effects beyond energy-system considerations, have been stated as politically important for LTE decisions.

In terms of supplier selection, EDF representatives shared that it is trying to maintain the French supply chain "as much as possible". This is to increase the resilience in its operation.

Trend 5

Policy uncertainty impacts investment sentiment

Inconsistent long-term policies weaken the certainty under which the LTE investment decisions are taken, exemplified by Engie and its Phoenix Agreement in Belgium. Furthermore, EDF mentioned long-term energy planning from the state as more important for its decision-making than revenue-supporting mechanisms. Nuclear owners' perception of the long-term political risk in the market can therefore be seen to affect the LTE investment decisions.

Trend 6

Power demand from data centers strengthens the case for nuclear lifetime extensions

In the US, the rapid expansion of data centers has led to rising demand for highly reliable, low-emitting electricity, which aligns well with nuclear power's operating profile. Interviewees note that nuclear operators increasingly enter long-term PPAs with hyperscalers, providing revenue stability that materially improves the business case for nuclear lifetime extensions. This growing demand from data centers has been described as supporting additional LTEs that might otherwise not have been economically viable under wholesale market conditions alone.

Comparison of market conditions between Sweden and Finland and case study markets

Photo: OKG

As the case studies show, market show, conditions vary across each individual market. Consequently, multiple comparative perspectives can be applied when assessing Sweden and Finland. The following chapter will focus on comparing two specific market characteristics: regulatory support and revenue potential.

In contrast to several of the observed case studies, Sweden and Finland operate within deregulated electricity markets. Furthermore, revenue-supporting mechanisms, or other targeted interventions, for LTEs are currently absent.

Deregulated markets in Sweden and Finland, with comparably limited state intervention

Sweden and Finland operate within largely deregulated, energy-only electricity markets although both have a history of specific mechanisms to support new production capacity on the market (electricity certificates for renewables and a proposed support for new nuclear). This stands in contrast to the markets in which the majority of the US operators and all Canadian operators are situated. In these regulated markets, nuclear power operates frameworks that allow cost recovery and provide investment-grade revenue stability.

Some of the recent European LTE decisions – most notably in Belgium, but also in UK and Romania – are based on explicit state intervention. In these markets, governments are proposing long-term price arrangements that reduce revenue uncertainty for nuclear owners.

Revenue-supporting mechanisms, or other targeted interventions, for LTEs are currently absent in Sweden and Finland. As a result, LTE decisions face higher economic uncertainty than in countries with state financial support. On the other hand, a history of specific support mechanisms for building new production capacity has, among Swedish nuclear operator representatives, been noted as creating market uncertainties for LTE decisions.

Lower electricity prices in Sweden and Finland, with limited potential for low-emission premiums

In unregulated electricity markets, the feasibility of LTE business cases depends primarily on the value of dispatched electricity. With regards to the income per generated kWh, Sweden and Finland differ from many markets where LTEs have recently been decided upon.

As illustrated in Figure 9, 36-month average wholesale electricity prices in Sweden and Finland are lower than in observed markets across Europe. In North America, revenue conditions for nuclear power are typically stronger, either through regulated cost recovery or through supplemental mechanisms such as emission-based support schemes in competitive markets. These mechanisms increase revenue and the revenue stability for the LTE business cases, according to EY analysis.

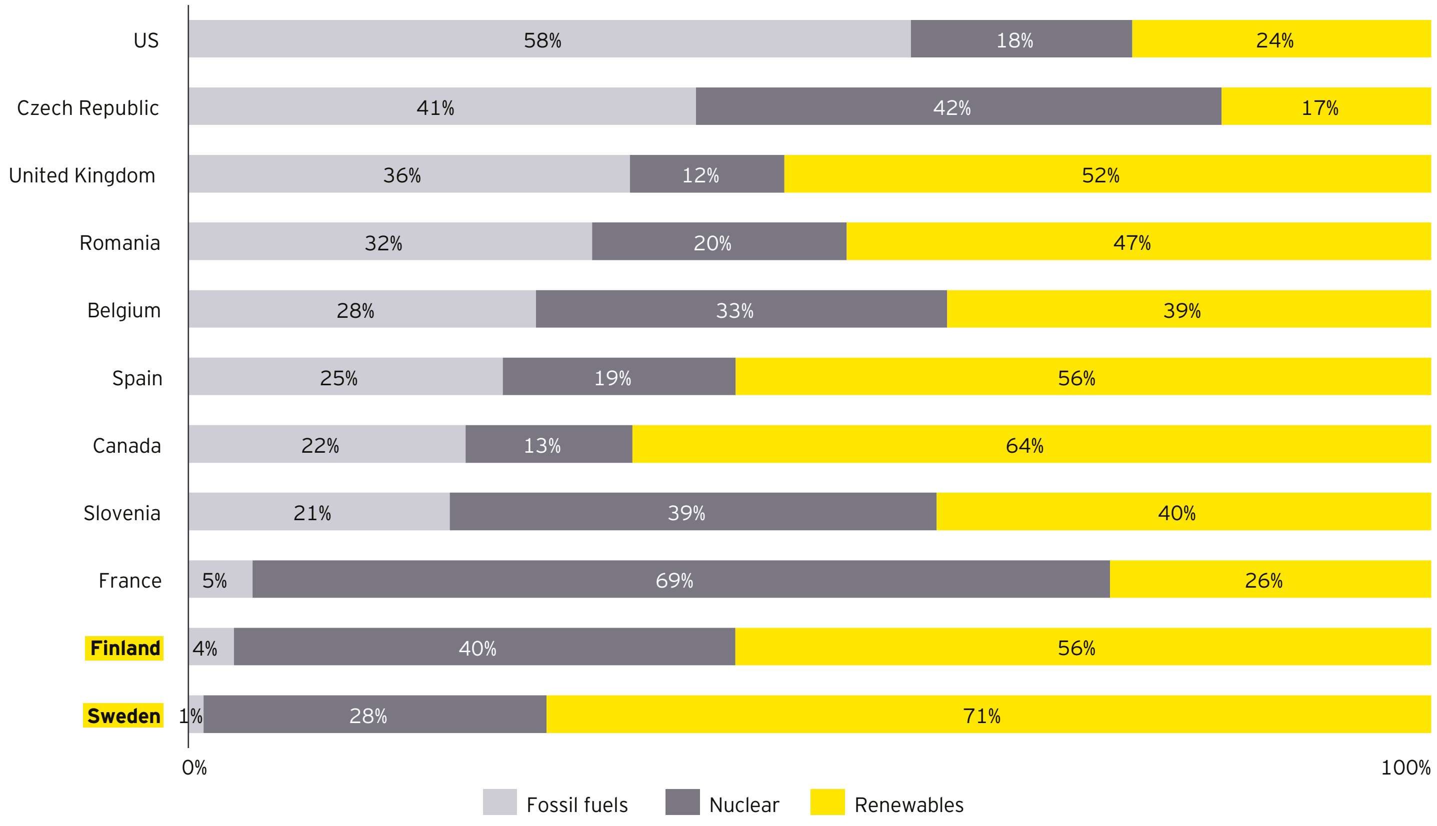

Figure 8: Electricity generation per generation source

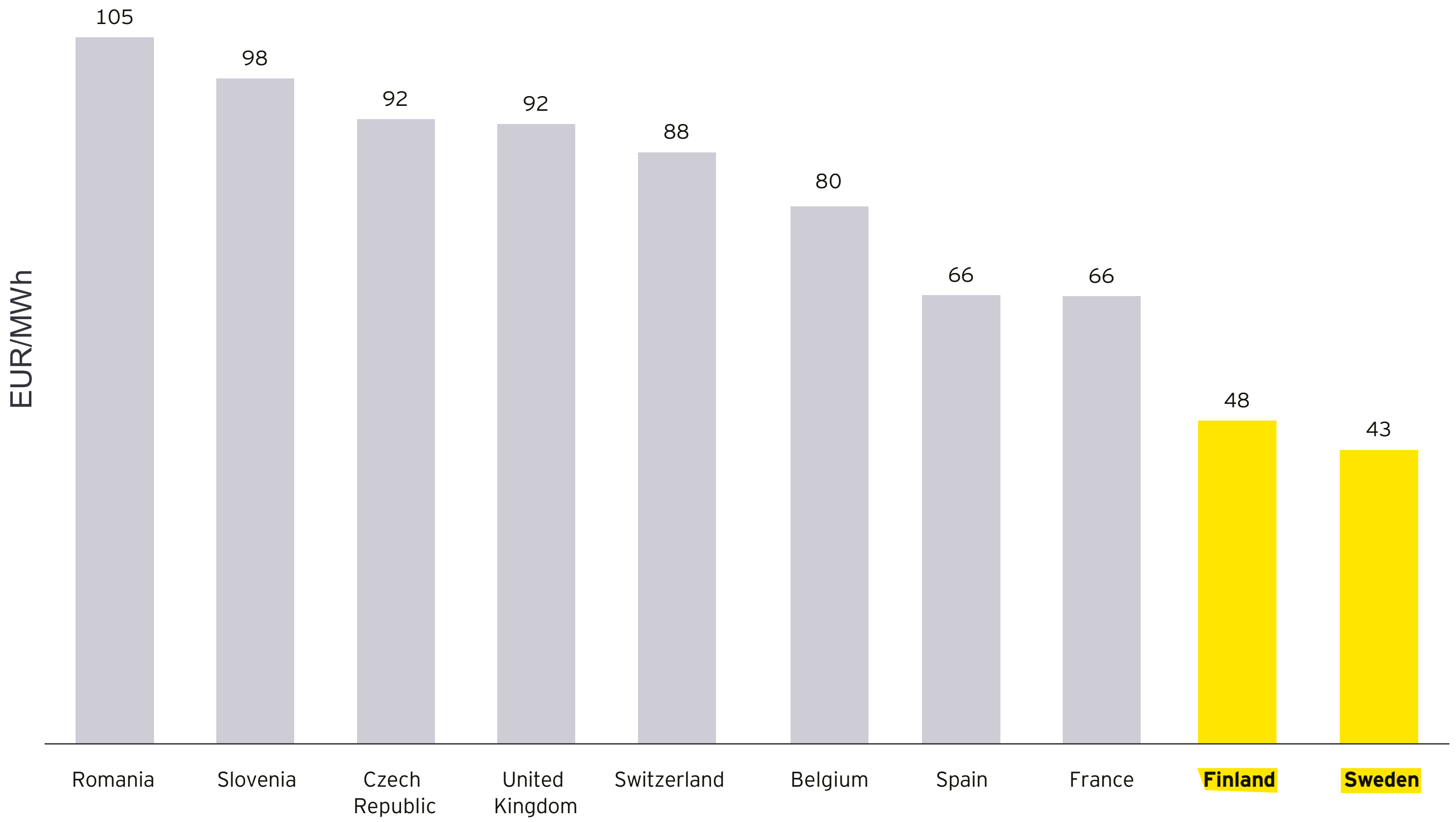

Figure 9: EU prices based on rolling 36 months data (May 2023 to April 2026) from the ENTSO E Transparency Platform

The Swedish and Finnish power system context further constrains revenue potential. Compared to observed countries where LTEs are taking place, Sweden and Finland have a lower share of fossil fuels in the electricity mix, meaning nuclear power competes on a deregulated market with other low-emitting generation rather than displacing fossil-based supply. As a result, in these markets, nuclear plants will capture limited additional revenue from any potential carbon pricing – such as the European emission rights trading system or carbon taxes – or dedicated policy support for low-emitting electricity.

Conclusions and implications for Swedish and Finnish decision-makers

Photo: OKG

Price volatility and shifting political stances risk leading to uncertain investment conditions for energy generators. LTEs are stated to bridge the gap between the forecasted surge in power demand, increase energy security, and support national economic growth and the national nuclear power supply chain.

Nuclear lifetime extensions are cost-efficient for owners and society, but investment risks are present

Interviewees and multiple market reports and system studies describe LTE as a competitive option for maintaining capacity and bridging the gap to the forecasted surge in demand. The generation gaps of 122 TWh and 155 TWh by 2045, in Sweden and Finland, respectively, would increase to 175 TWh and 180 TWh if reactor lifetimes are not extended.

If LTEs do not take place, the resulting capacity gap would need to be addressed through investments in new generation capacity. New-build generation would entail higher system costs, materialized through a need for subsidies or additional flexible energy assets that are ultimately borne by electricity consumers. Alternatively, insufficient replacement capacity could lead to tighter supply-demand balances, higher price volatility and higher electricity prices. Under both scenarios, electricity costs for consumers in Sweden and Finland would increase, either directly through supported investments or indirectly through market prices. Higher electricity costs would, in turn, hit private consumers, weaken industrial competitiveness and limit job creation in both countries.

LTE investment decisions are made on a multi-decade revenue forecast, taking on power supply and demand development expectations into account. These forecasts are noted as uncertain in deregulated markets due to the high forecasted increases in electricity demand. In contrast, countries operating in regulated or other forms of markets with preset prices (Belgium, Canada, US) can secure long-term stable revenues, independent of supply-demand balances, and therefore have more predictable LTE investment pathways.

The challenges are not unique to nuclear power. Price volatility and weak long-term price signals affect all power generation investments. However, capital-intensive technologies with long operating lifetimes are disproportionately affected, as viability depends on stable revenues over several decades.

Multiple societal rationales can be seen for the public to engage in lifetime extensions

From the perspective of other markets, where LTEs have been decided upon, there are multiple rationales that nuclear operators and associations use to engage the public on LTE. These rationales have even been used to motivate revenue-supporting mechanisms, as seen in Belgium.

From the interviews and reports examined as part of the study, LTEs are stated to:

- Bridge the gap between forecasted surge in power demand and establishing of low-emitting generation.
- Increase resilience and national energy security.
- Support national economic growth, i.e., creating qualified jobs.
- Support low power prices, increasing industrial competitiveness.
- Support the national supply chain and developing competencies within the nuclear sector – indirectly supporting other potential nuclear projects.

Decision-makers can learn from other markets in their efforts to develop prerequisites for nuclear lifetime extensions

The case studies featured in this report provide learning opportunities for actors in the nuclear value chain. Through coordinating and sequencing LTE programs across units and sites, interviewees have outlined the potential to improve cost efficiency, facilitate access to critical capabilities and reduce execution risks. In addition, nuclear operators can continue to strengthen collaboration on the consumer side. Strengthening collaboration with end-users that value stable, low-emitting electricity – particularly where data center operators have been mentioned – can unlock new commercial arrangements and drive LTE investments.

Representatives from other markets state that LTE decisions benefit from stable and predictable policy frameworks. Long-term political alignment and explicit guidance on what role lifetime extended nuclear power plays within the future electricity system are said to reduce investment risk and support timely investment decisions. Policymakers therefore play a role in LTE investment decisions.

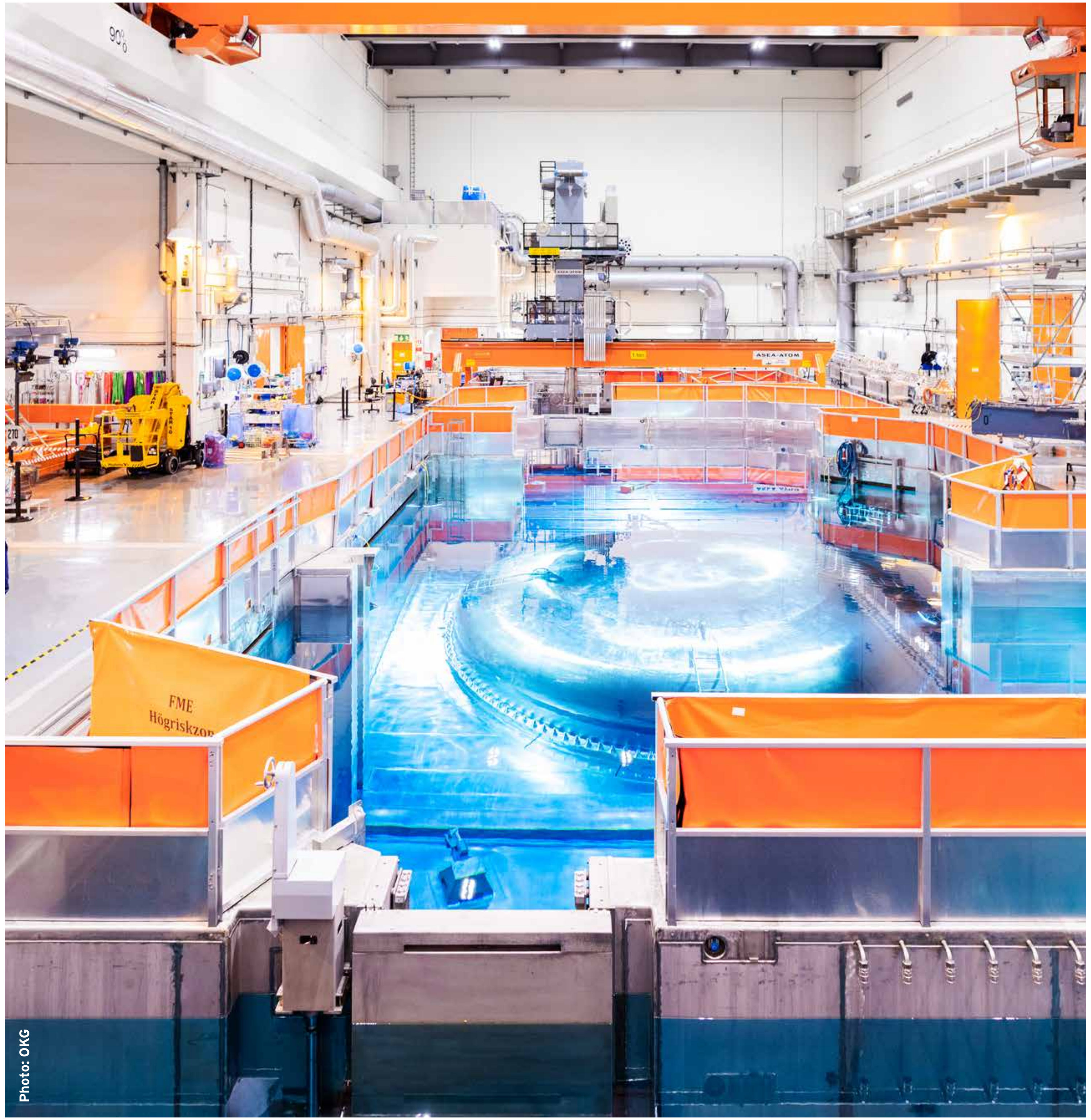

Photo: OKG

Appendix

Photo: Fortum

Sammanfattning

Elbehovet i Sverige och Finland bedöms öka under de kommande decennierna till följd av elektrifiering av industri, transporter och nya elintensiva verksamheter såsom vätgasproduktion samt datacenter. Detta förväntas leda till ett behov om ytterligare produktionskapacitet på 122 TWh respektive 155 TWh i Sverige och Finland till 2045 – upp från dagens 140 TWh respektive 83 TWh. Samtidigt närmar sig majoriteten av den befintliga kärnkraftsflottan slutet av sin nuvarande drifttid inom 10–20 år. Om kärnkraftsreaktorernas livslängd inte förlängs, ökar produktionsgapet till 175 TWh respektive 180 TWh år 2045.

Utöver sitt bidrag i form av årlig elproduktion anses kärnkraften tillföra ytterligare värden till elsystemet genom egenskaper såsom planerbarhet och hög tillgänglighet. Dessa egenskaper anses i sin tur bidra till att minska variationer i elpriser, stärka leveranssäkerheten och möjliggöra ett effektivt utnyttjande av elnätet.

Om inte reaktorerna drifttidsförlängs skulle det uppkomna kapacitetsgapet behöva hanteras genom investeringar i nybyggd produktion. Nybyggd produktion skulle innebära högre systemkostnader. Högre kostnader skulle slå på enskilda konsumenter, försämra industrins konkurrenskraft och begränsa sysselsättningstillväxten i båda länderna.

Denna rapport har tagits fram gemensamt av Energiforsk och EY och beskriver hur beslut om drifttidsförlängning av kärnkraft har fattats i andra länder. Studien bygger på intervjuer med ägare, myndighetsrepresentanter och branschaktörer i olika marknader. Rapporten fokuserar på de inledande stegen i beslutsprocessen för drifttidsförlängning, med särskilt fokus på affärslogik och finansieringsförutsättningar.

I rapporten beskrivs fallstudier från andra investeringsbeslut om drifttidsförlängningar i de utvalda länderna Belgien, Frankrike, Kanada och USA. Fallstudierna visar på att drifttidsförlängningar har beslutats utifrån förutsägbara intäktsramar, politiska signaler om kärnkraftens roll i energisystemet och/eller riskdelning mellan stat och ägare. I flera fall har argument kring klimat, kostnadseffektivitet, samhällsekonomi och försörjningstrygghet använts för att motivera olika typer av offentligt engagemang. Samtidigt lyfter vissa intervjuer på att osäkerhet kring framtida elpriser, efterfrågeutveckling och politisk inriktning kan fördröja eller försvåra investeringsbeslut, särskilt i avreglerade elmarknader.

Sverige och Finland har avreglerade elmarknader, lägre intäktspotential för fossilfri energiproduktion samt saknar särskilda stödmekanismer för drifttidsförlängning. Utifrån dessa aspekter fattas investeringsbeslut i Sverige och Finland under större ekonomisk osäkerhet än i de länder som valdes ut för fallstudier.

Rapporten syftar till att bidra med internationella perspektiv för svenska och finska beslutsfattare — inklusive politiker, offentliga myndigheter, systemoperatörer och ägare — i arbetet med att förstå vilka marknadsförutsättningar för drifttidsförlängningar som ska råda i Sverige och Finland.

Tiivistelmä

Sähkön kysynnän odotetaan kasvavan merkittävästi tulevina vuosikymmeninä Ruotsissa ja Suomessa teollisuuden ja liikenteen sähköistymisen sekä uusien sähköintensiivisten toimialojen, kuten vetytuotannon ja datakeskusten, kasvun seurauksena. Kasvun myötä sähkön lisätuotannon tarpeen arvioidaan vuoteen 2045 mennessä olevan 122 TWh Ruotsissa ja 155 TWh Suomessa nykyisen 140 TWh:n ja 83 TWh:n tuotannon lisäksi. Samanaikaisesti suurin osa nykyisistä ydinvoimaloista saavuttaa sallitun käyttöikänsä seuraavien 10–20 vuoden aikana. Mikäli käyttöikiä ei jatketa, syntyvä tuotantovaje kasvaisi vuoteen 2045 mennessä arviolta 175 TWh:iin Ruotsissa ja 180 TWh:iin Suomessa.

Ydinvoima tuottaa sähköntuotannon lisäksi lisäarvoa sähköjärjestelmälle, koska se on ennustettavaa ja hyvin saatavilla olevaa perusvoimaa. Näiden ominaisuuksien ajatellaan vähentävän sähkön hinnan vaihtelua, vahvistavan toimitusvarmuutta sekä edistävän sähköverkon tehokkaampaa hyödyntämistä.

Jos reaktoreiden käyttöikiä ei jatketa, syntyvä kapasiteettivaje olisi katettava investoinneilla uuteen kapasiteettiin. Uuden ydinvoiman rakentaminen kasvattaisi järjestelmäkustannuksia, jotka viime kädessä kantaisivat sähkön kuluttajat. Korkeammat kustannukset vaikuttaisivat yksittäisiin kuluttajiin, heikentäisivät teollisuuden kilpailukykyä ja rajoittaisivat työllisyyden kasvua molemmissa maissa.

Tämä raportti on Energiforskin ja EY:n yhdessä laatima, ja se kuvaa, miten päätöksiä ydinvoimaloiden käyttöiän jatkamisesta on tehty muissa maissa. Tutkimus perustuu haastatteluihin omistajien, viranomaisten ja toimialajärjestöjen kanssa useilla markkinoilla. Raportti keskittyy käyttöiän jatkamista koskevan päätöksentekoprosessin alkuvaiheisiin painottaen erityisesti käyttöiän jatkamisen liiketoimintalogiikkaa ja rahoitusedellytyksiä.

Raportti sisältää case studyjä käyttöiän jatkamiseen liittyvistä investointipäätöksistä Belgiassa, Ranskassa, Kanadassa ja Yhdysvalloissa. Case studyt osoittavat, että käyttöiän jatkamisesta on päätetty ennustettavien kannattavuusnäkymien, ydinvoiman roolia energiajärjestelmässä koskevien poliittisten signaalien ja/tai valtion ja omistajien välisten riskinjakojärjestelyjen perusteella. Useissa tapauksissa ilmastotavoitteisiin, kustannustehokkuuteen, yhteiskuntataloudellisiin hyötyihin ja toimitusvarmuuteen liittyviä perusteluja on käytetty erilaisten julkisen omistuksen ja tukimuotojen oikeuttamiseksi. Samalla osa haastatelluista korostaa, että epävarmuus tulevista sähkön hinnoista, kysynnän kehityksestä ja politiikkalinjauksista voi viivästyttää tai vaikeuttaa investointipäätöksiä, erityisesti vapailla sähkömarkkinoilla.

Ruotsalaiset ja suomalaiset ydinvoimaoperaattorit toimivat vapailla sähkömarkkinoilla, niillä on pienempi tulospotentiaali fossiilivapaalle sähköntuotannolle, eikä niillä ole käyttöiän jatkamiseen kohdennettuja tukimekanismeja. Tämän seurauksena investointipäätökset Ruotsissa ja Suomessa tehdään suuremman taloudellisen epävarmuuden vallitessa kuin case studyissä tutkituissa maissa.

Raportin tarkoituksena on tuoda kansainvälisiä näkökulmia ruotsalaisten ja suomalaisten päätöksentekijöiden – mukaan lukien poliittisten päättäjien, viranomaisten, järjestelmäoperaattoreiden ja omistajien – käyttöön heidän pyrkiessään luomaan edellytyksiä ydinvoimaloiden käyttöiän jatkamiselle.


Photo: Fortum

Method

Market trends can be understood through case studies from countries where decisions on LTEs have been taken recently. These case studies provide learning opportunities for Swedish and Finnish decision-makers as they assess similar decisions — but they ought to be seen in the light of the underlying market prerequisites in each specific market. The case studies are structured across three areas: (i) policy and regulatory framework, (ii) market design and revenue potential, and (iii) power system context and energy mix.

Category	What it covers	Question answered
1. Policy and regulatory framework	Government stance on nuclear and the formal rules supporting or constraining LTE	How stable and durable is political support for nuclear across electoral cycles and governing coalitions?
2. Market conditions and revenue potential	How nuclear plants earn revenue and manage risk	Under what conditions can LTE investments recover costs over extended operating lifetimes?
3. Power system context and energy mix	Role of nuclear power in the electricity system	What role does existing nuclear capacity play in facilitating system adequacy, security of supply and decarbonization?

Photo: Vattenfall

Definitions

Term	Explanation
Availability	The proportion of time a power plant is technically capable of producing electricity.
Baseload generation	Electricity generation that can operate continuously and reliably over long periods, providing a stable foundation for the power system.
BWR (boiling water reactor)	A type of nuclear reactor where water is heated in the reactor until it boils, and the steam produced is used directly to generate electricity.
CfD (contract for difference)	A long-term revenue stabilization contract under which a generator receives a top-up payment when market prices fall below a predefined strike price and pays back revenues when market prices exceed it.
Day-ahead market	An electricity market where power is traded for physical delivery the following day. Market participants submit bids and offers for each 15 minutes of the next day, and prices per geography are set for supply to meet demand. In the Nordic region, the day-ahead market is operated through Nord Pool and forms the primary price reference for electricity trading.
Deregulated (liberalized) electricity market	A market structure where electricity is traded at short-term marginal pricing exposing generators to price volatility and market risk.
Dispatch	The process by which electricity generation units are instructed or scheduled to produce electricity to meet demand at a given point in time, based on market bids, system constraints and security of supply requirements. Dispatchable generation technologies are technologies which allow for scheduling of their electricity generation at a given point in time.
Energy-only market	An electricity market design where generators are remunerated solely through the sale of electricity, without separate capacity payments or guaranteed revenues.
FID (Final Investment Decision)	The formal decision by a project owner or investor to commit to a large capital investment, based on an assessment of, e.g., the business case, risks, financing conditions, regulatory approvals and project readiness.
GWe (gigawatt electrical)	A unit of power capacity equal to one billion watts of electrical output. GWe is commonly used to express the net electricity-generating capacity of power plants, particularly for nuclear generation, and distinguishes electrical output from thermal power (GWth).
Load following	The operational practice of adjusting power output to match variations in electricity demand, increasingly relevant for nuclear plants in systems with high shares of variable renewable generation.
LTE (lifetime extension)	The process of refurbishing and re-licensing an existing nuclear power plant to safely operate beyond its original design life, commonly extending operation from 40 years to 60, 80, or longer.

Term	Explanation
LTO (long-term operation)	A term often used interchangeably with LTE, referring specifically to continued operation of a nuclear power plant beyond its originally licensed lifetime, subject to regulatory approval.
Owner-operator	The entity that both owns and operates a nuclear power plant, responsible for investment decisions, operations and regulatory compliance.
PPA (power purchase agreement)	A long-term bilateral contract between an electricity producer and a buyer specifying price, volume and duration of electricity supply.
PWR (pressurized water reactor)	A common type of nuclear reactor where hot, pressurized water carries heat from the reactor to make electricity, without the water boiling.
RAB (Regulated Asset Base)	A regulatory framework allowing an infrastructure operator to recover approved investment and operating costs, plus a regulated return, through charges set by a regulator; commonly applied to long-lived, capital-intensive infrastructure.
Regulated electricity market	A market structure where electricity prices or generator revenues are determined or strongly influenced by regulatory oversight, cost recovery mechanisms and long-term arrangements.
Security of supply	The ability of an electricity system to reliably meet demand at all times, considering generation adequacy, fuel availability and system resilience.
State aid	Public financial support granted by a state to companies, subject to EU State aid rules, often used to support capital-intensive or strategic infrastructure projects such as nuclear lifetime extensions.
Strike price	The predefined electricity price in a CfD against which market prices are compared to determine top-up payments or pay-backs.
TSO (Transmission System Operator)	The entity responsible for operating and developing the high-voltage electricity transmission network. The TSO facilitates the continuous balance between electricity supply and demand, system stability and security of supply, and facilitates cross-border electricity trade. Examples include Svenska kraftnät in Sweden and Fingrid in Finland.
Two-way CfD	A CfD design where payments flow both to and from the generator depending on market prices relative to the strike price, limiting both downside risk and excess returns.
ZEC (Zero Emission Credit)	A policy instrument used in some US states that provides additional remuneration to low-emitting electricity generation, including nuclear power, based on environmental attributes rather than energy output alone.

List of interviews

Name	Role	Company	Country
René Lauwers, Francois Graux	Fleet Program Manager LTO, Secretary General	Engie	Belgium
Demilade Fayemiwo	Director, Policy	Canadian Nuclear Association	Canada
Clint Thomas	Director of Government and Stakeholder Relation	Bruce Power	Canada
Candice Johnston	Director Corporate Affairs		
David Hajman	Head of Strategy	CEZ	Czech Republic
Janne Mokka	VP co-owned Nuclear	Fortum	Finland
Riku Huttunen	Director General of the Energy Department	Ministry of Economic Affairs and Employment	Finland
Francois Dassa, Helene Chao	Director Long Term Planning, DPNT	EDF	France
Johan Svenningsson	Country Chairman	Uniper	Sweden
Stefan Kvarfordt	Experienced professional, energy and climate policy	Confederation of Swedish Enterprise	Sweden
Jesper Marklund	Senior Manager, Strategic Partnerships, New Nuclear	Fortum	Sweden
Fredrik Norlund	Administrative official, Nuclear Power	Ministry of Climate and Enterprise	Sweden
Magnus Blümer	Head of Division for Energy		
Carl Berglöf	National Nuclear Coordinator	Government offices of Sweden	Sweden
Garry Young	Technical Executive, LTO and Aging Management Strategy	EPRI	USA
Monica Hurley	Senior Technical Leader – Power Uprate and LTO		
John Kotek	Senior Vice President in policy and public affairs	Nuclear Energy Institute (NEI)	USA
Matt Crozat	Executive Director for Strategy and Policy Development		
Darryl T Sagel	VP and Treasurer	Ameren	USA
Baris Sarikaya	Principal Engineer	Constellation Energy	USA
Issam Taleb	Experienced nuclear professional	EY Advisory	France
Julien Saigault	Experienced nuclear financing professional	EY Advisory	France

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