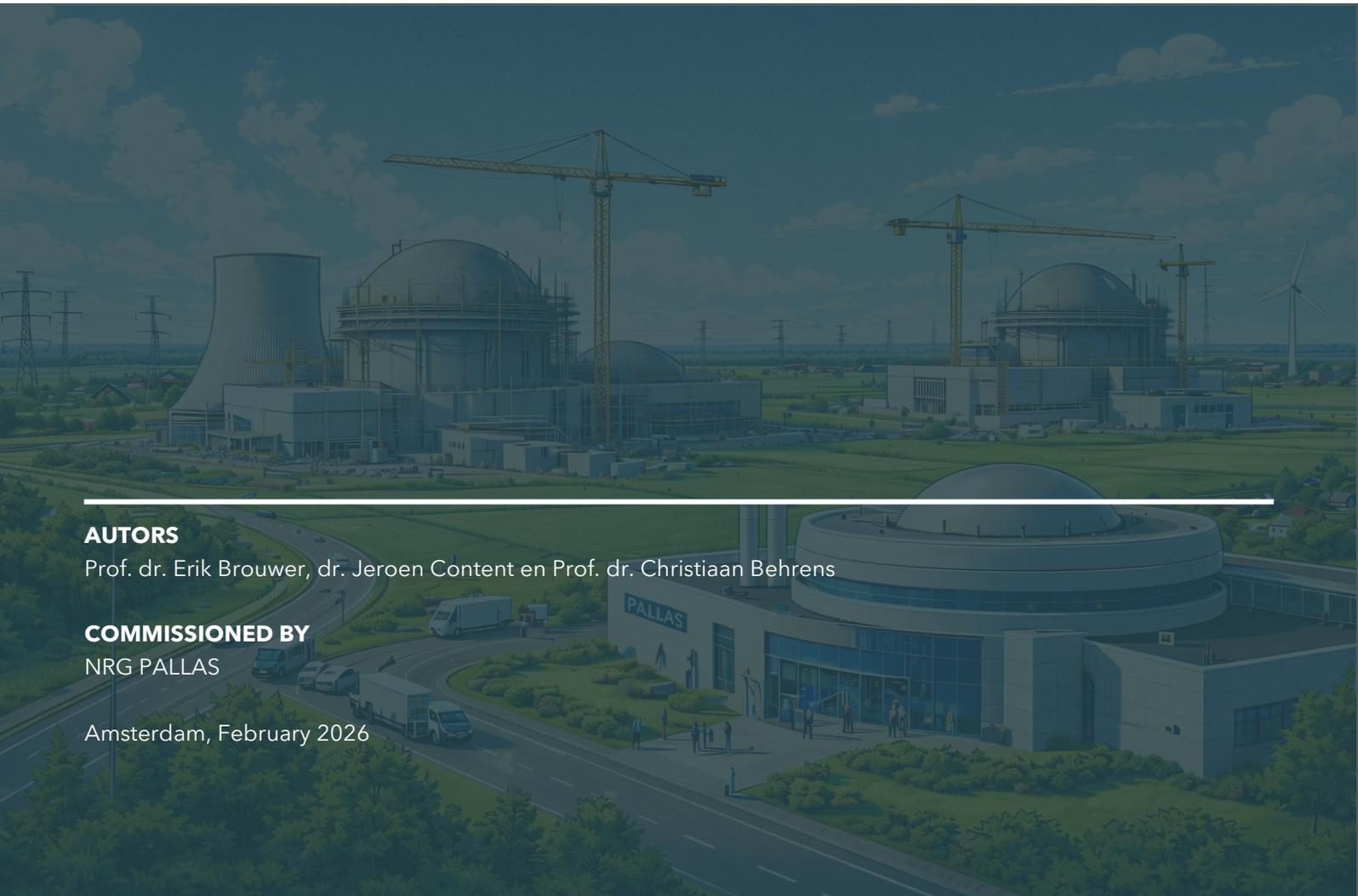# BUILDING ON EXPERIENCE

WHAT PALLAS CAN MEAN FOR THE FUTURE DUTCH NUCLEAR POWER PLANTS: A SOCIETAL BENEFIT ASSESSMENT

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AUTORS
Prof. dr. Erik Brouwer, dr. Jeroen Content en Prof. dr. Christiaan Behrens
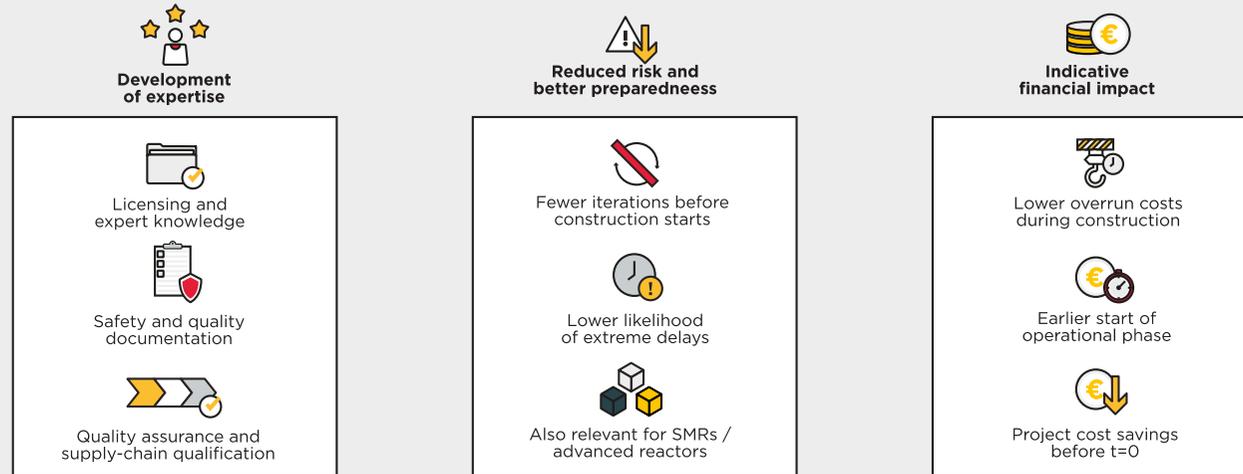
The societal value of PALLAS

Building on experience: a more predictable pre-construction phase and a lower likelihood of extreme delays in future nuclear energy projects.

The Dutch government is preparing for the construction of new nuclear power plants in a context in which such projects internationally often face delays and cost overruns, especially in the pre-construction phase. This study shows that the PALLAS programme, as the first large-scale nuclear project in the Netherlands since the 1970s, generates important learning effects in areas such as licensing, safety documentation, supply-chain qualification and cooperation with regulators. These learning effects increase predictability and reduce the risk of schedule overruns for future nuclear power plants. Even a limited time gain of 1 to 3 years can lead to substantial societal benefits, estimated at around €1 to €6 billion, mainly due to earlier operating revenues and lower financing costs. The effects presented are conservative and are expected to represent a lower bound of PALLAS's total societal value. The analysis is also based on the construction of two new nuclear reactors; if four new reactors are built, the societal benefits will increase further.
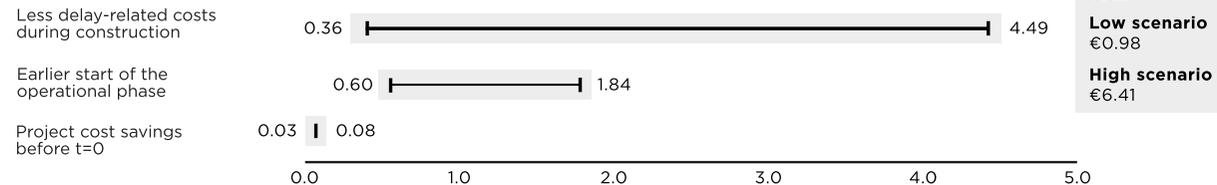
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What is the added value of PALLAS?

PALLAS MAINLY DELIVERS RISK REDUCTION: FEWER SURPRISES AND FEWER ITERATIONS

AND A LOWER LIKELIHOOD OF EXTREME DELAYS IN FUTURE NUCLEAR ENERGY PROJECTS

Development of expertise

- Licensing and expert knowledge
- Safety and quality documentation
- Quality assurance and supply-chain qualification

Reduced risk and better preparedneess

- Fewer iterations before construction starts
- Lower likelihood of extreme delays
- Also relevant for SMRs / advanced reactors

Indicative financial impact

- Lower overrun costs during construction
- Earlier start of operational phase
- Project cost savings before t=0

Spread of potential financial impact*

Less delay-related costs during construction	0.36 — 4.49
Earlier start of the operational phase	0.60 — 1.84
Project cost savings before t=0	0.03 — 0.08

Scale: 0.0 1.0 2.0 3.0 4.0 5.0
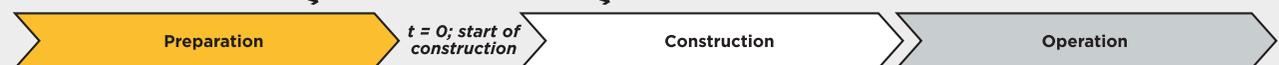
Total
Low scenario €0.98
High scenario €6.41

*Indicative; dependent on assumptions and the financing structure. Not all societal effects have been monetised.

Pallas reactor

Preparation → t = 0; start of construction → Construction → Operation

Learning-by-doing effect

Kerncentrale 1 + n

Preparation → t = 0; start of construction → Construction → Operation

Conclusion: The value of the learning effect is only fully realised if expertise embedded in people, processes and documentation remains available for subsequent projects.

Summary

The Netherlands faces the task of building new nuclear power plants. While such projects often experience delays when recent experience is lacking, PALLAS offers a unique opportunity to build on newly acquired nuclear expertise. This study demonstrates how this learning effect translates into societal value.

Background and research

The Dutch government is preparing for the construction of four new nuclear power plants. This development takes place within an international context in which large-scale nuclear construction projects often result in delays and cost overruns, particularly in the pre-construction phase (licensing, design, contracting, and planning). Against this background, this study examines the societal value that the PALLAS programme may offer for the construction of future Dutch nuclear power plants, and how this value can be realised.

The construction of the new PALLAS research reactor—intended for the production of medical isotopes and nuclear research—forms an interesting case study, as it is the first large-scale nuclear project in the Netherlands since the 1970s. Multiple studies indicate that experience with licensing procedures, safety and quality documentation, and supply-chain qualification are important explanatory factors for whether nuclear projects proceed according to plan. The hypothesis is that PALLAS generates such learning effects in the Netherlands. In line with this hypothesis, this study explores the societal value that the PALLAS programme may provide for future Dutch nuclear power plants, particularly through the channels of knowledge development, risk reduction, and potential acceleration of decision-making and project delivery.

Figuur S.1   Phasing of Nuclear New-Build and Position of the PALLAS Learning Effect
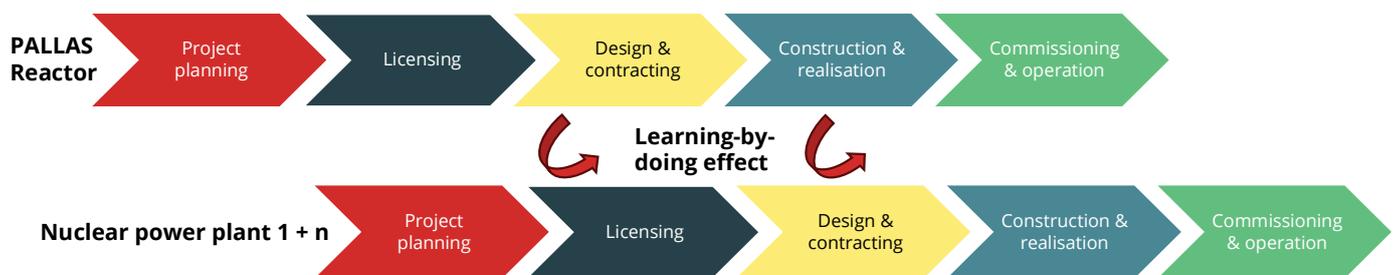
Bron: SEO Economisch Onderzoek (2026)

Figure S.1 illustrates the phases in the development trajectory of future nuclear power plants in which the PALLAS learning effect is most relevant. These primarily concern the licensing phase, design & contracting, and construction & realisation. As a result of these learning effects, nuclear plants can be commissioned earlier, leading to earlier revenues during both the commissioning and operational phases.

For this analysis, a Theory of Change was developed, interviews were conducted with stakeholders, and a scenario analysis was performed. In doing so, the assumed learning effects were distinguished between effects occurring before construction start and those occurring during the construction phase, and each of these effects was modelled separately in the scenario analysis. The scenario analysis includes a baseline scenario for the construction and operation of two nuclear power plants, incorporating assumptions regarding investment costs, construction time,

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lifetime, capacity factor, prices, and discounting. Explicit consideration was given to the real risk of delays. The baseline scenario assumes a longer effective construction period—that is, a delay. Subsequently, acceleration scenarios were modelled in which the plants enter operation one to three years earlier due to reduced delays during the construction phase as a result of prior learning effects (such as those from PALLAS), with one year of time savings serving as a conservative lower bound.

Economic Valuation of Impacts Across Three Mechanisms

Table S.1 provides an overview of potential financial benefits. The table distinguishes three separate benefit channels. The first two are linked to reduced delays during the construction phase and occur jointly, while the third channel relates to cost savings in the pre-construction phase (before $t=0$) and may stand independently. The amounts therefore indicate the order of magnitude of benefits per channel and do not represent an automatically cumulative scenario. The exact scale of the financial effects depends heavily on factors such as final initial investment costs, delay-related costs, electricity prices, and so on.

There is also significant uncertainty surrounding delays during the construction phase. Such delays are determined by many factors and are difficult to quantify ex ante. At the same time, the interviews conducted and existing studies indicate that a learning effect derived from PALLAS is very likely to result in a noticeable reduction in delays, with at least one year of time savings considered realistic (corresponding to the "Low" column in the table).

Tabel S.1   Potentiële maatschappelijke baten voor de bouw van twee nieuwe kerncentrales door PALLAS (in mld. euro)

Financial effects (in billion euros) *Number of years of reduced delay*	**Low** *1 year*	**Middle** *2 years*	**High** *3 years*
1. Reduced delay-related costs during construction *Range shows the financial benefits assuming 2.5–10% delay costs per year*	0.36 – 1.45	0.72 – 2.95	1.1 – 4.49
2. Earlier start of the operational phase *Low = 1 year less delay, …, High = 3 years less delay*	0.60	1.21	1.84
3. Cost savings before $t=0$ *Range shows the financial benefits for a 1-3 year earlier shift to t=0*	0.03 – 0.08	0.03 – 0.08	0.03 – 0.08
Indicative range of total benefits	**0.98 – 2.13**	**1.95 – 4.24**	**2.96 – 6.41**

Bron: SEO Economisch Onderzoek (2026)
Noot: The analysis is based on a scenario in which two new nuclear reactors are built. If four reactors were to be built, the financial benefits would be higher.

The scenario analysis shows that the financial benefits of reduced delays during the construction phase can increase rapidly when expressed in present-value terms. The total reduced delay-related costs depend strongly on how high these costs are relative to the initial investment (2.5 to 10 percent per year). With one year less delay, this results in a present value of between EUR 0.36 and 1.45 billion. In addition, there is the effect of an earlier start of the operational phase, which in present-value terms amounts to EUR 0.6 billion for one year less delay. With three years less delay in the construction phase, the total financial benefits in present-value terms range from EUR 2.94 to 6.33 billion.

On top of this come potential savings in the pre-construction phase (before construction starts). If the process can be completed more quickly, the costs of the project organisation and the costs for the regulator may decrease by several tens of millions of euros.

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Not all societal effects have been monetised within the scope of this study. For instance, climate benefits due to earlier CO_2 reduction may exist, but these have not been explicitly valued in the calculations. This suggests that the benefits presented are likely to underestimate the total societal value. Moreover, the assumptions applied in this study are intentionally conservative, meaning that the results should be interpreted more as a lower bound than an upper bound of the societal value of PALLAS.

Learning effects

In addition to these monetised effects, PALLAS creates value as a learning experience. The programme has rebuilt routines and practical expertise in the Netherlands concerning nuclear quality standards, documentation, supply-chain qualification, and the interaction between project developers and the regulator. This is not only about enabling faster performance on projects of this type, but above all about increasing predictability—with fewer surprises, fewer iterations, and a reduced likelihood of severe delays. Predictability is particularly important before construction starts, as much of the subsequent project duration and cost is effectively locked in during this phase. PALLAS also contributes to human capital and ecosystem strengthening, as a new generation of professionals gains experience and suppliers invest in nuclear expertise to meet nuclear quality standards.

At present, however, the learning effect of PALLAS has not yet reached its full potential. A substantial portion of the most relevant project experience is gained in the final phases of delivery, during commissioning and the initial period of operation. The full learning effect will materialise only once PALLAS is fully completed. Significant value has already been created during preparation, but the learning curve continues to grow, and the development of knowledge—and the associated financial benefits for future nuclear power plants—is still ongoing. In this regard, it is essential to actively retain and make transferable the knowledge and skills built up during PALLAS. If this knowledge is not actively preserved, expertise may dissipate and with it part of the societal value may be lost.

Summary of the main conclusions

- PALLAS primarily delivers risk reduction. Not necessarily faster construction, but a lower likelihood of redesigns, quality issues, and iterative processes with suppliers or the regulator, and therefore a reduced risk of delays.
- The literature shows that, based on experiences in other countries, uncertainty around project timelines and costs is substantial.
- Uncertainty around timelines and costs is high, but the OECD-NEA report *Unlocking Reductions in the Construction Costs of Nuclear* (2020) demonstrates that learning effects and standardisation can in practice lead to noticeable reductions in delay in subsequent projects. Interviews with experts and stakeholders across the sector also indicate that the PALLAS learning effect is highly likely to result in a significant reduction in delays in future nuclear projects, with one year of time savings considered a conservative lower bound. At the same time, by realising PALLAS, the Netherlands retains access to a unique experimental nuclear infrastructure which—consistent with the historical development of the HFR—can accommodate unforeseen applications, innovation, and knowledge development over the long term.
- With one to three years less delay during construction, the financial benefits amount to between EUR 1 and 6 billion. These benefits consist partly of reduced delay-related costs and partly of earlier revenues from earlier operation.
- Savings in the pre-construction phase (before construction start) are possible, as a more realistic and better-aligned process requires less effort from the project organisation and the regulator.
- The greatest qualitative value occurs before construction starts, because licensing, safety documentation, and coordination between parties can become more predictable and less iterative.

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- The learning effect in the Netherlands is still developing and will only be fully realised once PALLAS is completed (construction, commissioning, and early operational phase). It is crucial to minimise the time gap between the various phases of the PALLAS project and the project for the new nuclear power plants in order to maximise learning effects in each phase of the full nuclear project cycle.
- Retaining the knowledge and expertise gained is essential to secure future value. Without active safeguarding, transfer, and staff continuity towards upcoming nuclear projects, expertise may dissipate and the accumulated value may be lost.

Table of Contents

1   Introduction

The Dutch government intends to realise new nuclear power plants. International experience shows that nuclear projects are subject to structural delays and cost overruns, often even before construction begins. This study examines the role that PALLAS [1] can play—through learning effects—in the efficient realisation of new nuclear power plants.

1.1   Background

The Dutch government intends to give nuclear energy a greater role in the future energy system and plans to realise a total of four new nuclear power plants (Ministry of KGG, 2025a, 2025b). In 2022, preparations began for the construction of the first two plants. In this context, the government is currently commissioning various studies, including assessments of environmental and societal impacts and analyses of the costs and implications of potential site choices. The government is also engaging with local residents, businesses, and other organisations in and around the proposed areas.

These Dutch policy ambitions have become more common internationally in recent years, as the number of nuclear initiatives worldwide is increasing. However, new-build reactors often face considerable project durations and delays—particularly in First-of-a-Kind (FOAK) projects in countries that have not built a nuclear power plant for a long time (NEA/OECD, 2020). Experience with nuclear construction has eroded, while regulatory and non-nuclear requirements have risen significantly.

International literature shows that new-build reactors in recent decades have routinely been completed later than planned. The World Nuclear Industry Status Report (WNISR, 2024) indicates that average construction times worldwide range between 10 and 17 years, while many projects were initially budgeted for 6 to 8 years. The OECD Nuclear Energy Agency (OECD-NEA, 2020; 2022) shows that delays—particularly in Europe and the United States—are among the main drivers of cost overruns. International studies also confirm that delays occur both before and during the construction phase. Delays before construction start (during licensing, design, and planning) are often decisive for the ultimate project duration, as many choices are locked in during this phase and are difficult to correct later.

Concrete examples illustrate this pattern. The Finnish reactor Olkiluoto 3 was delivered more than 13 years later than planned. In France, Flamanville 3 has experienced over 10 years of delay. The United Kingdom shows similar trends with Hinkley Point C, with multiple years of delay due to design modifications, licensing timelines and quality assurance processes (IEA, 2020; IEEFA, 2017).

The societal consequences of such delays are substantial. Due to the capital-intensive nature of nuclear projects, interest during construction (IDC) costs can be very high. OECD-NEA (2020) shows that IDC can account for up to 30 percent of total project costs. KPMG (2021) and UK IEEFA (2017) confirm that one year of delay in European new-build reactors typically results in tens of millions of euros in additional financing costs.

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[1] Where this report refers to PALLAS, it specifically means the PALLAS reactor or the PALLAS programme.

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The Netherlands currently faces the task of realising two new Generation III reactors, and possibly two more at a later stage. The baseline scenario in this report assumes a planned construction period of ten years and a lifespan of sixty years, in line with internationally common ex-ante assumptions in policy and system studies (OECD-NEA, 2020; IEA, 2023; EC DG ENER, 2020). However, international experience shows that such planning assumptions are rarely met in practice. The baseline scenario therefore explicitly assumes an effective construction time of thirteen years, taking into account the structural risk of delays documented in the literature.

Het PALLAS-programma is relevant omdat het sinds de jaren '70 van de vorige eeuw het eerste grootschalige nucleaire bouwproject in Nederland is. Internationale literatuur wijst erop dat ervaring in vergunningverlening, documentatieprocessen en supply-chain-kwalificatie belangrijke verklarende factoren zijn voor projecten die wel op tijd worden opgeleverd (OECD-NEA 2022; IEA 2020). De hypothese is dat PALLAS zulke leereffecten deels al heeft gerealiseerd en deels nog steeds genereert. Daarmee vertegenwoordigt PALLAS niet alleen potentiële waarde via toekomstige tijdswinst en risicoreductie, maar ook een huidige waarde in de reeds opgebouwde kennis en kunde bij projectorganisaties, toeleveranciers, overheid en toezichthouder.

However, this knowledge base is not guaranteed to persist. Without mechanisms for safeguarding, transfer, or continuity between nuclear projects, there is a risk that expertise becomes fragmented or disappears. In that case, not only would knowledge be lost, but also a significant portion of the societal value that PALLAS has already created. This raises the question of what is necessary and reasonable to preserve this knowledge and expertise, given both the value accumulated within PALLAS and the risk that, without continued investment, knowledge and value may dissipate.

1.2 Research questions

The Dutch government intends to realise four new nuclear power plants. It is therefore important to gain timely insight into the factors that influence the lead time and feasibility of new-build projects.

International experience shows that delays may arise particularly in the phase before construction starts—during licensing, design choices, site selection, and the organisation of decision-making and public participation. Such delays are difficult to make up later and can have lasting consequences for both costs and planning. Against this background, the central research question of this study is: *what are the societal benefits of the PALLAS programme for the planned construction of two new nuclear power plants, in terms of time savings, cost avoidance, and risk reduction during construction?*

However, the societal value of the PALLAS programme goes beyond time savings, cost avoidance, and risk reduction in the construction of new nuclear power plants. With the realisation of the PALLAS reactor, the Netherlands will also retain nuclear infrastructure for decades to come—an infrastructure that enables research, knowledge development, and innovation. The current High Flux Reactor (HFR) in Petten has played an important role in shaping the Dutch nuclear knowledge landscape over the past sixty years.

For this reason, this study also addresses the following in-depth research questions:
- *What does PALLAS mean for the value of nuclear capacity in light of national climate and energy ambitions, including the development of SMRs and advanced reactors?*

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- *What additional benefits arise from knowledge development, human capital, and a strengthened nuclear supply chain in the Netherlands?*

This study explicitly focuses on the societal benefits of the PALLAS programme. The direct costs of PALLAS itself have already been incorporated into existing business cases and formed part of earlier decision-making processes. This study has a supplementary character and aims to provide insight into the additional societal value that PALLAS generates for future nuclear projects, on top of the investment already made. The analysis is therefore not an integrated societal cost-benefit analysis of PALLAS as a standalone project, but a targeted benefit analysis focusing on learning effects, risk reduction, and time savings for future nuclear new-build.

A further question of relevance concerns what is reasonably required to safeguard the knowledge and expertise developed through the PALLAS project, and what the risk is that—without further investment—this knowledge and expertise may dissipate. This question, however, falls outside the scope of this study. Nonetheless, the findings presented here provide some justification for potential efforts to retain this knowledge and expertise within the Netherlands, namely the societal benefits that would be lost if they were to disappear.

The main research question will be addressed primarily through the use of a model in which different scenarios are calculated. The two in-depth research questions will be answered mainly through qualitative research methods.

1.3   Guide to the report

Chapter 2 provides a concise description of the research approach and the methods used. Chapter 3 presents an overarching overview of the interview findings and identifies the qualitative benefits that emerge from them. Chapter 4 develops a baseline scenario, which is then compared with several alternative scenarios in order to determine the potential financial benefits of the PALLAS programme. Chapter 5 concludes the study.

2   Research approach

This chapter describes how the societal benefits of the PALLAS programme are assessed. Using a Theory of Change, we systematically collect information from literature, documents, and interviews. This input then serves as the basis for the scenario analysis.

2.1   Theory of Change

A *Theory of Change* (ToC) is a method used to clarify the relationship between inputs and their eventual impact. It provides a visual and detailed description of the steps through which change may occur, as well as the intermediate steps and assumptions required. A ToC is therefore a structured description of how and why an intervention is expected to work. This allows the underlying relationships to be analysed systematically and provides a basis for discussions on why and how the intended impact materialises.

A ToC consists of a series of cause-and-effect relationships that together form a chain of causal links. The various components of this chain are:
1.   **Inputs** are all the resources that are deployed—that is, what you put in.
2.   **Activities** are all actions carried out using the above inputs.
3.   **Outputs** consist of the direct results of the activities, such as products and/or services delivered.
4.   **Outcomes** describe the higher-level effects of the outputs (both positive and negative).
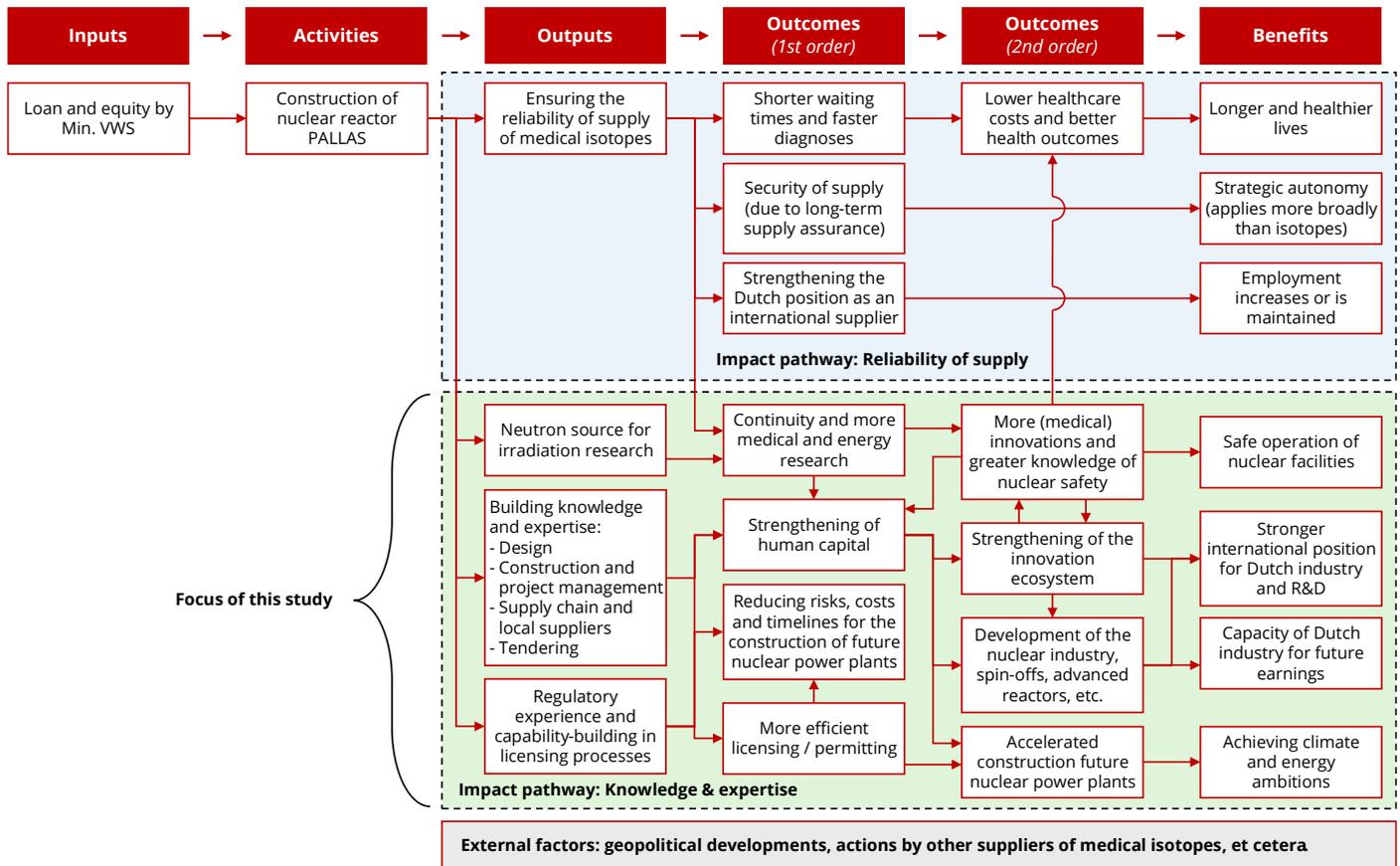5.   **Impacts** refer to the broader societal effects (both positive and negative).

We also explicitly identify the assumptions, preconditions, and potential external factors where these are decisive for how the chain manifests in practice.

Figure 2.1 presents the ToC of the PALLAS programme and shows, via which cause-and-effect relationships, the programme ultimately leads to specific societal benefits. This programme theory outlines how the public investment in PALLAS translates into societal benefits through two interconnected "impact pathways."

The input consists of a loan and equity provided by the Ministry of Health, Welfare and Sport (VWS). The ministry finances the PALLAS reactor partly through equity (capital injection) and partly through public loans. VWS is the 100-percent shareholder, and the financing includes, in addition to loans, a significant equity investment from the national budget. The core activity is therefore the realisation of a modern High-Flux Reactor to replace the ageing HFR. This aligns with the policy objective of VWS: ensuring the security of supply of medical isotopes, for which Petten currently covers a very large share of (European) demand.

From this core activity, two interconnected impact pathways extend in the figure. The first pathway (Security of Supply) describes how PALLAS leads to direct output in the form of stable production capacity for medical isotopes. The first-order effect is increased reliability in the availability of medical isotopes, enabling healthcare providers and patients to rely on continuity in diagnostics and treatment, and allowing the healthcare system to plan more effectively. In the longer term, this increased reliability translates into broader societal benefits, such as health gains (longer and healthier lives) and potentially lower healthcare costs due to earlier diagnostics and treatment.

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Figuur 2.1   Theory of Change PALLAS-programme

Inputs		Activities		Outputs		Outcomes (1st order)		Outcomes (2nd order)		Benefits

Impact pathway: Reliability of supply

- Loan and equity by Min. VWS → Construction of nuclear reactor PALLAS → Ensuring the reliability of supply of medical isotopes → Shorter waiting times and faster diagnoses → Lower healthcare costs and better health outcomes → Longer and healthier lives
- Security of supply (due to long-term supply assurance) → Strategic autonomy (applies more broadly than isotopes)
- Strengthening the Dutch position as an international supplier → Employment increases or is maintained

Focus of this study

Impact pathway: Knowledge & expertise

- Neutron source for irradiation research → Continuity and more medical and energy research → More (medical) innovations and greater knowledge of nuclear safety → Safe operation of nuclear facilities
- Building knowledge and expertise:
  - Design
  - Construction and project management
  - Supply chain and local suppliers
  - Tendering
→ Strengthening of human capital → Strengthening of the innovation ecosystem → Stronger international position for Dutch industry and R&D
- Reducing risks, costs and timelines for the construction of future nuclear power plants → Development of the nuclear industry, spin-offs, advanced reactors, etc. → Capacity of Dutch industry for future earnings
- Regulatory experience and capability-building in licensing processes → More efficient licensing / permitting → Accelerated construction future nuclear power plants → Achieving climate and energy ambitions

External factors: geopolitical developments, actions by other suppliers of medical isotopes, et cetera

Bron: SEO Economisch Onderzoek (2026)

The second impact pathway (Knowledge & Expertise) shows that PALLAS is not only a healthcare infrastructure project, but also an important learning environment and testing ground for the Netherlands' nuclear ambitions. Along this pathway, construction, licensing, supervision, procurement, project management and commissioning generate knowledge and experience that are scarce in the Netherlands—or were, until recently.

The first-order effects include: strengthening human capital (engineers, project managers, regulators); improved procedures; and fewer failure costs and delays in future nuclear projects. These effects translate into second-order outcomes such as accelerated development and reduced risks for new nuclear power plants and innovation (e.g. around SMRs/advanced reactors), ultimately resulting in benefits such as a stronger innovation ecosystem, increased economic value creation, and progress towards climate and energy ambitions.

This ToC forms the analytical framework for this study. The remainder of this research will focus on the second impact pathway of Knowledge & Expertise. Concretely, this means that we can systematically collect data through document and literature review and interviews. This, in turn, helps to explicitly incorporate assumptions and external factors into the scenario analysis and enables us to delineate what can be attributed to PALLAS and where uncertainty remains.

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2.2   Interviews

To complement the literature and document review with practical insights into how the Dutch nuclear value chain operates—and what role the PALLAS programme plays within it—a series of interviews was conducted with experts and representatives of organisations involved in the Dutch nuclear sector. Various organisations and individuals active in the nuclear value chain were approached, including regulators, ministries, suppliers, knowledge institutions, and international experts. Table 2.1 provides an overview.

Because these stakeholders speak from a wide range of perspectives—ranging from licensing to civil execution and international comparison—we are able to develop a clear picture of how PALLAS contributes in practice to knowledge development, risk management, and the functioning of the ecosystem. This also enables us to make assumptions, preconditions, and external factors explicit and to delineate more clearly what can and cannot be attributed to PALLAS. These insights are subsequently used in the scenario analysis.

The interviews were conducted using a semi-structured questionnaire, which made it possible to introduce structure into the data collection while still leaving sufficient room during the conversations to probe further based on respondents' answers.

Tabel 2.1   Interviewed people and organisations within this research

Organisation	People	Focus of the interview
Authority for Nuclear Safety and Radiation Protection (ANVS)	Marco Brugmans en Rick Bulk	Regulator: Licensing, supervision, safety
VDL KTI	Dorus van Leeuwen	Supplier, knowledge development
Urenco	Ad Louter	Knowledge position of the Netherlands, strategic autonomy, R&D
Ministry of Climate and Green Growth (KGG)	Martijn Schut	Governance, project preparation, procurement
Indepentent consultant	Rüdiger König	International nuclear expert, European construction experience, regulation, risk management
Électricité de France (EDF)	Sylvain Takenouti	International practical experience with nuclear new-build, with emphasis on learning effects and risk reduction
Allseas	Stephanie Heerema	Knowledge position of the Netherlands, spin-offs, R&D, innovation ecosystem

2.3   Scenario analysis

We use the scenario analysis to quantitatively demonstrate the societal value of (potential) acceleration or the avoidance of delays in the realisation of two new nuclear power plants. The analysis is not a prediction of a single most likely outcome, but rather a set of possible variants around a reference pathway (the baseline scenario), allowing us to illustrate the range and order of magnitude of the effects.

Methodologically, we work with one baseline scenario and several alternative scenarios in which only the timing of activities shifts. All other assumptions (prices, technology, policy, and operational conditions) are kept constant in order to isolate the pure effect of time. In each scenario, the operational cash flows are shifted over time: with earlier commissioning, revenues start sooner and capital is tied up for a shorter period (without generating returns in the meantime). In the analysis, we compare the baseline scenario with scenarios in which the commissioning of the nuclear power plants takes place one, two, or three years earlier.

3 Qualitative benefits of the PALLAS project

In addition to financial and quantitatively measurable effects, PALLAS generates benefits that manifest primarily as public value and strategic significance. This chapter outlines the main qualitative benefits of the PALLAS project.

3.1 A valuable learning experience

The interviews reveal a widely shared view that PALLAS has, in recent years, provided a unique learning experience for virtually all parties involved. For the first time since the construction of the Borssele Nuclear Power Plant, an entire nuclear project cycle has been completed in the Netherlands—from safety documentation and licensing to engineering, contracting, and actual construction. This cycle has enabled the sector to actively engage with modern nuclear quality standards, international audits, complex documentation requirements, and intensive interactions with the regulator. As a result, not only has technical knowledge been developed, but more importantly, the practical experience needed to continuously support future nuclear projects—experience that only fully develops when design and execution converge in practice. International experience shows that learning effects in nuclear projects are not limited to the preparatory phase but deepen during construction, when design decisions, quality assurance, and execution come together in real-world conditions.

In the Dutch context, PALLAS is therefore more than a construction project. It functions as a rare, practice-based learning case in which nearly all components of a modern nuclear development process are experienced. Respondents indicate that without PALLAS, this knowledge would now be almost entirely absent. The long period without new nuclear projects had caused routines, quality processes, and organisational reflexes to fade. PALLAS has re-established this infrastructure, enabling suppliers, the regulator, and government bodies to rely on people who have recently and demonstrably gained experience with complex nuclear procedures.

The learning takes place at multiple levels. For the regulator and relevant government bodies, it involves practical knowledge of licensing and supervision: understanding which information is required at which stage, the necessary level of detail, where the main assessment and implementation risks lie, and how supervision should be organised. Interviewees emphasise that going through the full chain—from preliminary consultations and dossier development to oversight of construction—provides knowledge that cannot be gained solely from codified documentation. Practical experience is essential.

On the market side, the learning concerns working within nuclear quality regimes, with strict requirements for documentation, traceability, and (information) security. As a result, parties now better understand which disciplines and capacities must be reserved for extended periods (for example, engineering and project management), and they develop more realistic expectations regarding timelines and iterations.

This learning experience has broader value than the benefit of having a state-of-the-art reactor for medical isotopes (the security-of-supply impact pathway in Figure 2.1). This collective learning process creates shared practical knowledge among government bodies, the regulator, and suppliers, allowing future nuclear projects to start with a more realistic understanding of roles, timelines, and bottlenecks. This reduces dependence on foreign expertise

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and provides a foundation for launching new nuclear initiatives in the Netherlands, including pathways related to SMRs and advanced reactors such as Thorizon.

3.2 Risk reduction as a key additional benefit

Although the interviewees are cautious about providing concrete estimates of the potential time savings that PALLAS could deliver, there is broad consensus that the programme can contribute to risk reduction. This risk reduction is less about building faster on average, and more about encountering fewer surprises and fewer delay scenarios. International experience confirms that the likelihood of exceptionally long delays is a key driver of costs and reputational damage in nuclear projects, and that recent project experience can reduce this risk. This expectation is supported by international literature, which shows that sequential nuclear projects exhibit learning effects that primarily translate into improved risk management and a reduced probability of extreme delays (OECD-NEA, 2020). In international new-build projects, uncertainty around the probability of major redesigns, delays due to quality issues, or prolonged coordination between applicant and regulator is a decisive source of cost overruns and reputational risk. The experience gained through PALLAS helps identify or prevent such outcomes earlier, because technical and organisational issues have already surfaced once in a Dutch context.

As a result, the likelihood of extreme delay scenarios has been reduced, because many uncertainties that would normally emerge only during the licensing or preparatory phase have already occurred once. This applies to technical issues as well as governance, role allocation, planning, quality assurance, and interaction with international suppliers.

A useful way to understand this is through the dispersion of risks. Instead of a single, fixed pathway with a fixed duration, a project in practice spans a range in which some steps proceed smoothly while others take longer. Interviewees indicate that PALLAS can narrow that range—not because every step suddenly fits within the shortest possible planning estimate, but because the likelihood of long delays decreases. The key point is not that a two-year phase becomes a one-year phase, but that the uncertainty margin around the timeline—for example ranging from about twelve months to several years—can shrink. This effect arises from a combination of factors such as: a better understanding of nuclear requirements among suppliers; greater routine in quality assurance and independent verification; and a clearer shared understanding of what constitutes sufficient quality in documentation and justification.

Economically, this is relevant because risk reduction can directly influence financing conditions and the cost of capital. Less uncertainty around planning and scope reduces the need for high risk premiums, for example. In this way, PALLAS not only contributes to potential time savings, but may also support a more favourable risk profile for future nuclear projects in the Netherlands.

3.3 Value is generated primarily before construction begins

An important insight from the interviews is that a substantial portion of the value of PALLAS becomes visible in the period before the actual construction of the new nuclear power plants. The preparation of licences, the structuring of preliminary consultations, the drafting of safety documentation, and the alignment of expectations between regulator and project developer all become much more predictable due to PALLAS. Because the ANVS and other involved organisations are now working with processes and quality frameworks that have been tested in practice, discussions and assessments are likely to be less iterative and therefore less time-consuming. PALLAS serves as a

concrete case through which both project developers and the regulator gain a clearer understanding of what is needed at each stage, enabling future projects to proceed with fewer uncertainties and fewer rounds of iteration.

This increase in predictability is not only relevant for large-scale new-build reactors. Interviewees indicate that PALLAS is also relevant for the development of nuclear applications such as SMRs and advanced reactors, particularly in light of challenges such as grid congestion and the limited availability of electricity and energy for industry. In this context, SMR concepts are mentioned that can supply both electricity and high-temperature heat, contributing to the decarbonisation of industrial processes. At the same time, respondents emphasise that recent Dutch practical experience with licensing and safety documentation—and the associated interaction with the regulator—is a crucial precondition for successfully initiating such trajectories.

For the regulator, the gains lie in being able to articulate expectations more clearly: which justifications are essential, which analyses are required, and how assessments can be organised in a way that ensures safety without unnecessary repetition. For project developers and project organisations, the value lies in building a knowledge base of working methods, quality plans, and organisational governance approaches that align with Dutch practice. This makes estimates and planning more realistic and allows capacity (personnel, advisors, inspection bodies) to be allocated earlier and more effectively.

On the market side as well, preparation has become more realistic. Suppliers have gained experience with nuclear certification, documentation requirements, and quality regimes. As a result, they can better assess what is feasible and which risks are realistic. Respondents indicate that this significantly improves the quality of cost estimates and planning. This reduces the likelihood of failed procurements, renegotiations, or unexpected failure mechanisms during execution. At the same time, respondents emphasise that the learning effect of PALLAS is not limited to the preparatory phase, but also emerges during construction, when design, quality assurance, and execution converge in practice and additional experience is gained that is relevant for future projects.

3.4 Strengthening of human capital & innovation ecosystem

As a result of PALLAS, a new generation of nuclear professionals has been trained. This includes engineers, safety experts, licensing specialists, quality managers and project leaders who have gained experience in an actual nuclear construction environment. Nearly all respondents identify this as a major benefit of PALLAS. The knowledge acquired is scarce and cannot be built up quickly through theory or codified knowledge; it requires hands-on experience. For a country aiming to expand its nuclear capacity, this form of human capital is a fundamental precondition for making progress.

The strengthening of human capital goes hand in hand with the strengthening of the nuclear supply chain. Suppliers involved in PALLAS have invested in, for example, nuclear quality standards, traceability, and the security of design and manufacturing information. As a result, PALLAS has helped reinforce the broader ecosystem. Several suppliers were able to enter the nuclear sector thanks to PALLAS or expand their existing capabilities. The regulator and government bodies have refined and better aligned their processes, creating greater clarity about expectations and assessments. Moreover, Dutch industry is now better prepared and includes a larger number of companies able to compete for nuclear projects, allowing contracts to be distributed across more suppliers—ultimately benefiting both price and quality.

International experience shows that skills in the nuclear supply chain deteriorate rapidly when they are not continuously applied in sequential projects, underscoring the importance of continuity in nuclear construction practice. At the same time, companies are cautious about making substantial investments in nuclear qualifications, processes and personnel when there is no structural pipeline of future projects. In this regard, the societal value of PALLAS arises particularly when the knowledge, skills and supply-chain experience built up are actually carried forward into subsequent nuclear projects.

However, retaining this knowledge is a concern. Because PALLAS is currently in the delivery phase and the number of project-specific positions will decrease over time, there is a risk that this expertise becomes fragmented or leaves the country. This highlights the importance of ensuring timely transition of personnel towards future nuclear projects. Without such continuity, part of the value created will be lost.

More broadly, this means that PALLAS creates value not only through individual learning experiences or temporary capacity building, but also by contributing to the preconditions required for preparing and delivering future nuclear projects in the Netherlands. By rebuilding routines, expertise and working practices around licensing, quality assurance and project preparation, follow-on projects can be initiated and assessed more effectively. This applies not only to large-scale nuclear power plants but also to other nuclear applications, such as SMRs and advanced reactors. In doing so, PALLAS contributes to a sustainable foundation for the Dutch nuclear ecosystem. The full value of this will only materialise if the knowledge and expertise developed are actually used in subsequent projects and not dispersed once PALLAS is completed.

4 Scenario analysis of time gains and risk reduction

Scenario analyses provide insight into the benefits of potential risk reduction and time savings. The scenario analyses show that with one to three years less delay during construction, the present-value financial benefits range from EUR 1 billion to EUR 6 billion.

4.1 Specification and parameters

The government intends to build a total of four new nuclear power plants. Preparations for the construction of the first two plants began in 2022. In 2024, the government decided that an additional two plants may be added. The House of Representatives and the Senate still need to take a final decision on this expansion. The baseline scenario therefore assumes two nuclear power plants.

For the scenarios, the key assumptions and parameters are established on the basis of (inter)national literature, including investment costs, construction time, lifetime and capacity factor. When developing and defining the baseline scenario, we used international reference values that are widely recognised in the literature. This includes inputs from the Market Consultation on Nuclear Energy (KPMG, 2021), the World Nuclear Industry Status Report 2024 (WNISR, 2024), the NEA Annual Reports (OECD-NEA, 2020; 2022), Berenschot (2020), and Veenstra et al. (2022). The established scenario parameters were then validated in discussions with relevant experts and, where necessary, adjusted based on these insights.

Table 4.1 provides an overview of the main scenario parameters used in the analysis. For the total investment required for the construction of two new nuclear power plants – including engineering, equipment, civil works, installations, project management and licensing – we apply a cost per megawatt. International reference values in the literature, based on estimates and ex-ante cost analyses of European new-build reactors, indicate an order of magnitude of approximately EUR 6.8 million per megawatt. Based on reactors with a capacity of 1,500 MW, this corresponds to a CAPEX of roughly EUR 10 billion per reactor. This lies at the optimistic end of the range found in the literature and aligns with assumptions that experts considered plausible during the interviews.

The construction time in the baseline scenario is set at ten years and functions as an ex-ante reference pathway, consistent with assumptions commonly used in international policy and system analyses of nuclear energy projects (OECD-NEA, 2020; Berenschot, 2020; Veenstra et al., 2022). International experience shows that delays are frequent (KPMG, 2021; WNISR, 2024; OECD-NEA, 2020); therefore, the baseline scenario assumes an effective construction time of 13 years. For each year of delay during the construction phase, total investment costs increase. In line with previous projects, we estimate annual delay-related cost increases at 5 to 10 percent of the initial investment costs.

The operational lifetime is set at sixty years, with an average capacity factor of 85 percent as a deliberately conservative assumption within the range used in international policy and system studies (OECD-NEA, 2020; IEA, 2023). The cost structure follows commonly used values in the literature and consists of a combination of fixed and variable operating costs, complemented by fuel and waste-processing costs.

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Assumptions regarding electricity prices are based on historical average market prices in the Netherlands and on TNO's future scenarios (Sijm et al., 2022). Electricity prices were relatively low prior to the 2021 pandemic and the start of the conflict in Ukraine in 2022. Since then, both the price level and volatility have increased markedly. For that reason, using a simple historical average is not an appropriate approach. Sijm et al. (2022) develop electricity-price scenarios that arrive at a price of EUR 73 per MWh, in line with the upward trend observed since 2022. This study follows that assumption.

All cash flows are discounted using a social discount rate of 2.8 percent, in line with the Dutch cost-benefit analysis guidelines and the recently adopted rate by the Discount Rate Working Group (2025).

Tabel 4.1   Scenario parameters form the input for the calculations

Scenario parameters	Baseline scenario	Scenario parameters (continued)	Baseline scenario
CAPEX (mln. EUR/MW)	6.8	Delay-related costs (% van CAPEX p/year)	2.5-10%
Fixed OPEX (EUR/MW/year)	90,000	Operational lifetime in years	60
Variable OPEX (EUR/MWh)	6.0	Capacity factor of the plant	85%
Fuel costs (EUR/MWh)	7.0	Number of reactors	2
Waste-management costs (EUR/MWh)	2.0	Electricity price in EUR/MWh	73
Net capacity in MW	1,500	Discount rate	2.8%
Construction time *(incl. 30% delay)*	10 years *(13 years)*	Decomissionig costs	15% of CAPEX

Bron: SEO Economisch Onderzoek (2026)

These parameters form the basis for the baseline scenario. The results build directly on them. In the calculations, we compare the baseline scenario with scenarios in which the commissioning of the nuclear power plants takes place one, two or three years earlier.

It is important to emphasise that this scenario analysis is primarily designed to make the effect of time (reduced delays and/or earlier commissioning) visible in financial terms, given a fixed set of assumptions regarding investment, operation and prices. This aligns with the objective of this chapter, namely to quantitatively demonstrate time savings, cost avoidance and risk reduction.

Not all societal effects of (faster) realisation of nuclear power plants can be monetised. Some effects are uncertain, difficult to attribute, or require additional assumptions (e.g. regarding displacement in the electricity system, marginal emission factors, or future policy and price developments) that fall outside the scope of this analysis. For this reason, this study does not include all potential societal benefits, but focuses only on those effects that are directly reflected in the project's cash flows.

A concrete example is the potential impact that earlier nuclear electricity generation may have on CO_2 emissions in the Netherlands as a result of a changing energy mix. If nuclear power plants become operational earlier, fossil-fuel generation may be displaced sooner—depending on market conditions and the energy mix—reducing emissions. These climate benefits do exist, but they are not explicitly valued in the monetisation presented here and are

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therefore not added to the results. This means that the monetised benefits presented are likely to underestimate the total societal benefits.

4.2 The baseline scenario

Table 4.2 shows that the baseline scenario is highly sensitive to the level of delay-related costs, to the extent that these determine whether the net present value is positive or negative. With delay costs of 2.5 percent per year (of the total initial investment), the net present value amounts to EUR 1,650 million; at 10 percent per year, it becomes EUR –1,740 million, i.e. a loss. In practice, however, it is unlikely that annual delay costs would amount to 10 percent or more, while 2.5 percent is probably a lower bound (KPMG, 2021). Because delay costs are expressed as a percentage of the total initial investment, an annual increase of 10 percent per extra construction year is improbable. A large share of CAPEX (e.g. civil works such as concrete and structural work, and major installations) is already committed or executed, meaning that delays do not typically add such a large amount on top of the total each year. A realistic value likely falls somewhere within this range.

On the cost side, CAPEX (around EUR 20 billion) is the dominant component, followed by fixed and variable OPEX (including fuel and waste management, together around EUR 12.5 billion). Fuel and waste costs contribute only a limited share to total costs. In contrast, total revenue over the full operational lifetime amounts to approximately EUR 33.8 billion. At the end of the lifetime, decommissioning costs amount to EUR 408 million.

Tabel 4.2   Net present value of the baseline scenario (in billion euros)

Present value in billion euros *Delay-related costs (% of CAPEX per year)*	**Baseline scenario** *(2.5%)*	**Baseline scenario** *(10%)*
CAPEX (incl. delay-related costs)	-19.22	-22.62
Fixed OPEX	-5.60	-5.60
Variable OPEX	-2.78	-2.78
Fuel costs	-3.24	-3.24
Waste-management costs	-0.93	-0.93
Revenue	33.84	33.84
Decommisioning costs	-0.41	-0.41
Net present value	**1.65**	**-1.74**

Bron: SEO Economisch Onderzoek (2026)

It is important to note that revenue and operational costs (fixed and variable OPEX) relate to the full 60-year operational lifetime and are therefore included as a series of annual cash flows, discounted back to the present. All cash flows are discounted at a rate of 2.8 percent.

The negative net present value at 10 percent is caused by the higher delay-related costs. At 2.5 percent, delay costs amount to more than EUR 500 million per year, while at 10 percent they amount to roughly EUR 2 billion per year. With three years of delay in the construction phase, as assumed in the baseline scenario, this results—after discounting—in a difference of roughly EUR 3.4 billion.

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Whether the baseline scenario breaks even and what its net present value is, is in itself of limited relevance for the scope of this study. This outcome is highly sensitive to assumptions and contextual parameters that may differ in future practice, such as investment costs, construction duration, capacity factor, financing conditions, and future electricity prices.

This applies to some extent also to the outcomes of the alternative scenarios. For that reason, this study does not focus on the absolute level of the net present value, but on the differences between the baseline scenario and the alternative (acceleration) scenarios. These differences are not completely insensitive to assumptions, but with a consistent set of parameters they do provide insight into the order of magnitude and direction of the effects of acceleration and risk reduction.

4.3   Acceleration scenarios

Now that the baseline scenario has been established as a reference point, we can calculate scenarios that deviate from this baseline on specific elements. The baseline scenario describes the core calculation for two new nuclear power plants, using a consistent set of assumptions on investment, operations and revenues. In the alternative scenarios, only the timing is adjusted, so that the effect of acceleration and risk reduction can be isolated as much as possible.

The full realisation trajectory of a nuclear power plant consists of two clearly distinguishable phases. The first phase concerns the period before the start of construction ($t=0$), during which licensing, design, contracting and organisational preparation take place. The second phase covers the construction period itself, from $t=0$ until commissioning. In the baseline scenario, the planned construction time is 10 years, with an additional delay of 3 years due to schedule overruns, resulting in an effective construction time of 13 years.

The PALLAS programme can lead to acceleration and risk reduction in both phases, albeit through different mechanisms. Based on the literature review and the interviews, we therefore distinguish two types of deviations from the baseline scenario that can plausibly be attributed to the PALLAS learning effect:
1. **Reduction of delays in the construction phase**
    Through better preparation, greater experience with nuclear quality standards and fewer surprises during construction, the likelihood of delays in the construction phase decreases. This results in earlier commissioning (by one year or more) compared with the baseline scenario, leading to lower delay-related costs and an earlier start of the operational phase.
2. **Costs savings from a shorter preparatory phase**
    The learning effect of PALLAS may lead to more efficient licensing procedures, dossier preparation and coordination, allowing construction to begin one or several years earlier. This effect does not primarily translate into time savings during the construction phase, but rather into lower preparatory costs, due to a shorter period of involvement for the project organisation and the regulator.

These two mechanisms are elaborated separately in the following paragraphs, so that the impact of each channel can be assessed individually. In Chapter 5 (Conclusion), we add together the separate effects.

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4.3.1 Reduced delays in the construction project

Due to the learning effect generated by PALLAS, it is expected that the uncertainties surrounding the construction of future nuclear power plants will be reduced. PALLAS serves as a first-of-a-kind (FOAK) trajectory through which parties gain experience with licensing, design decisions, contracting, project governance and quality assurance. This accumulated knowledge and these routines can be reused in subsequent construction projects, allowing uncertainties to be identified earlier and managed more effectively. In this scenario, we therefore assume not so much a fundamentally different project, but rather a project with fewer surprises and fewer disruptions that could lead to delays.

Concretely, this means that the likelihood of (extreme) delays during construction decreases. Instead of assuming a single realised construction duration, we work with a range of possible outcomes—from significant delay to no delay during the construction phase. If PALLAS leads to better preparation and execution in the construction of future plants, the main effect will be a reduced probability of exceptionally large delays. Such extreme overruns would occur less frequently. The spread around the realised construction time narrows, increasing predictability and improving the ability to plan the construction process.

However, it remains difficult to pinpoint the exact amount of time saved in terms of years. The ultimate construction duration also depends on factors such as market conditions, supply-chain dynamics, decision-making processes and unforeseen technical issues. For this reason, we work with multiple acceleration scenarios (one, two or three years earlier commissioning) rather than relying on a single point estimate. This approach illustrates the financial impact that a reduced likelihood of delays can have.

In the calculations, we compare the baseline scenario with scenarios in which the commissioning of the nuclear power plants takes place one, two or three years earlier. This has two important financial consequences:
1.   Due to fewer delays during the construction phase, total investment costs decrease, as delays in the construction phase generate additional costs.
2.   The operational cash flows shift in time. Because the operational phase starts earlier, revenues begin sooner and the period during which capital is tied up without generating returns becomes shorter.

Table 4.3 shows how the outcomes change when the commissioning of the nuclear power plants takes place one, two or three years earlier due to reduced delays in the construction phase. In this calculation, $t=0$ refers to the start of construction. The duration of the construction phase from the investment at $t=0$ decreases from 13 years (operational in $t=13$) to 12 years ($t=12$), 11 years ($t=11$) and 10 years ($t=10$). In each variant, the *initial* investment costs (CAPEX) remain the same—approximately EUR 20.4 billion—but discounted. *Total* investment costs vary across the scenarios because scenarios with 1–3 years of construction delay incur additional delay-related costs.

In the baseline scenario, the construction delay amounts to 30 percent, whereas in the acceleration scenarios it is 20, 10 or 0 percent, corresponding to a construction period shortened by one, two or three years. As a result, the present value of the CAPEX (initial investment costs + any delay-related costs), as well as all operational items—both revenues and operating expenses (OPEX) and other operational costs—become larger in present-value terms.

Overall, the net present value improves from EUR −1.74 billion to EUR 1.65 billion in the baseline scenario to EUR 0.31–2.60 billion, EUR 2.41–3.58 billion and EUR 4.58 billion in acceleration scenarios 1, 2 and 3, respectively. In the scenario where the construction phase is shortened by three years—meaning there is no longer any construction delay—there is no range in total investment costs, as no additional delay-related costs exist.

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The difference between the scenarios can be explained by the timing and discounting effect. In each acceleration scenario, the operational cash flows (both revenues and costs) shift earlier in time, which means they are discounted less heavily and therefore weigh more in the present value. This can be seen in Table 4.3: not only do revenues increase in present-value terms, but so do variable costs such as variable OPEX, fuel and waste. Decommissioning costs also move slightly closer in time and therefore increase marginally in present value. The net effect is positive because the additional present-value revenue from earlier operation outweighs the additional present-value operational costs.

Tabel 4.3   Construction scenarios with reduced delays bring future revenues forward (in billion euros)

	Baseline scenario	1 year less delay	2 years less delay	3 years less delay
Construction time from t = 0 *Operational in t = …*	13 years *t = 13*	12 years *t = 12*	11 years *t = 11*	10 years *t = 10*
CAPEX (incl. delay-related costs)	-19.22 tot -22.62	-18.86 -tot -21.15	-18.48 tot -19.64	-18.09
Fixed OPEX	-5.60	-5.76	-5.92	-6.09
Variable OPEX	-2.78	-2.86	-2.94	-3.02
Fuel costs	-3.24	-3.34	-3.43	-3.52
Waste-management costs	-0.93	-0.95	-0.98	-1.01
Revenue	33.84	34.78	35.76	36.76
Decomissioning costs	-0.41	-0.42	-0.43	-0.44
Net present value	**-1.74 to -1.65**	**0.31 to 2.60**	**2.41 to 3.58**	**4.58**

Bron: SEO Economisch Onderzoek (2026)

A second explanatory factor arises from the lower delay-related costs in the scenarios with one to three years less delay in the construction phase. Delay costs are estimated at 2.5–10 percent of the initial investment costs for each year the construction phase overruns. This amounts to approximately EUR 0.5–2 billion per year. The potential delay-related costs are combined with the initial investment costs in Table 4.3, together forming the total CAPEX (excluding decommissioning costs). With three years less delay, there is no longer any construction overrun, and therefore no delay-related costs. For that reason, there is no range of total investment costs (CAPEX) in that scenario, as CAPEX consists solely of the initial investment costs.

Table 4.4 summarises the effects by providing an overview of the delta (Δ) in discounted revenues, total investment costs (CAPEX including decommissioning costs), and the net discounted outcome for each of the acceleration scenarios compared with the baseline scenario.

It shows that acceleration leads to higher (discounted) revenues. With one year less delay, revenues increase by EUR 0.95 billion; with two years by EUR 1.92 billion; and with three years by EUR 2.92 billion. Total investment costs also decrease with a shorter construction period. Depending on the delay-related costs (2.5 or 10 percent), the reduction ranges between EUR 0.36 and 1.45 billion for a one-year acceleration. For an acceleration of two or three years, this increases to EUR 0.73–2.95 billion or EUR 1.11–4.49 billion, respectively.

Tabel 4.4   Deltas of the acceleration scenarios compared with the baseline scenario (in billion euros)

	Revenue	Δ vs baseline scenario	CAPEX	Δ vs baseline scenario	Result = Revenue – CAPEX - OPEX	Δ vs baseline scenario
0 **Baseline scenario** *13 years construction time*	33.84		19.63 - 23.03		-1.74 - 1.65	
1 **1 year less delay** *12 years construction time*	34.78	**0.95**	19.28 - 21.57	**0.36 - 1.45**	0.31 - 2.6	**0.95 - 2.05**
2 **2 years less delay** *11 years construction time*	35.76	**1.92**	18.91 - 20.07	**0.73 - 2.95**	2.41 - 3.58	**1.93 - 4.16**
3 **3 years less delay** *10 years construction time*	36.76	**2.92**	18.54	**1.11 - 4.49**	4.58	**2.94 - 6.33**

Bron: SEO Economisch Onderzoek (2026)

Table 4.5 provides a breakdown of the deltas between the different acceleration scenarios. It separates the total delta into two components. The first component is attributable to lower investment costs resulting from reduced delays during the construction phase and the associated delay-related costs that would otherwise be incurred. The second component relates to the earlier start of the operational phase, which brings future revenues forward.

The table shows that, depending on the level of delay-related costs (2.5 or 10 percent per year), the largest contributor to the total delta is either the lower total investment costs (when delay-related costs are high) or the earlier revenues (when delay-related costs are low). Because the operational phase begins earlier, the discounted revenues are higher.

The table also shows that the financial benefits of reducing delays by one year are greater when the reduction is from three years to two years than when it is from two years to one year, or from one year to no delay at all. In other words, the present-value benefit of accelerating by one year is larger when the initial delay is greater.
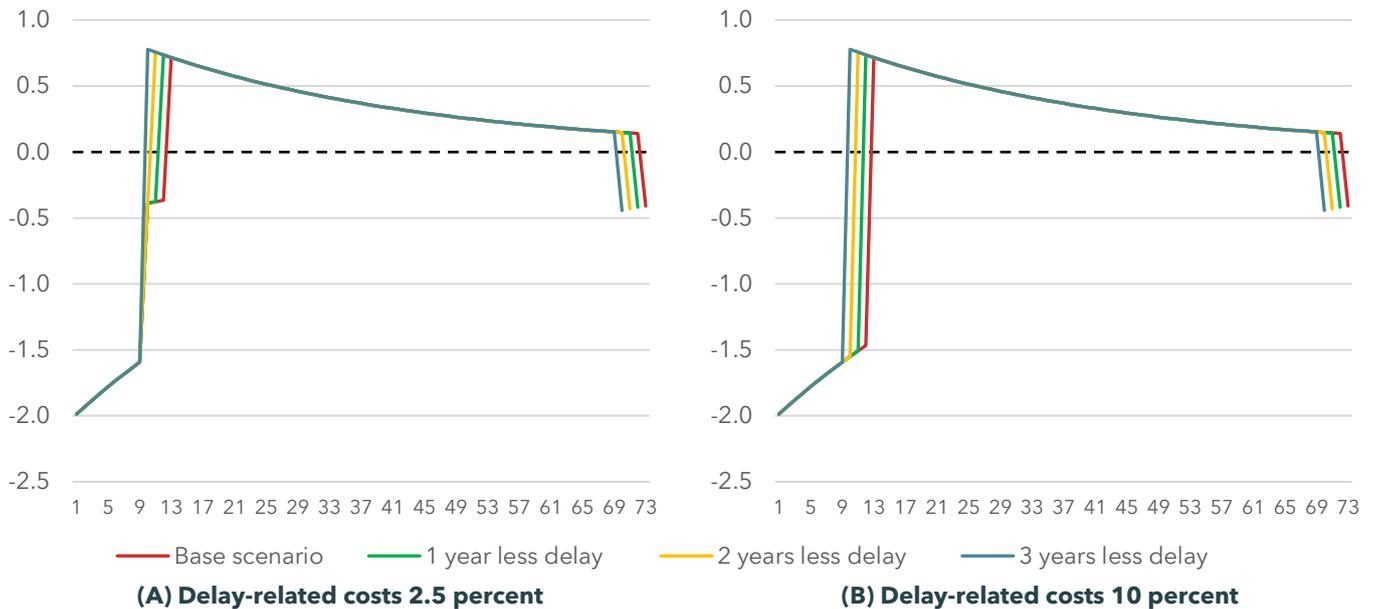
Tabel 4.5   Breakdown of deltas for different acceleration scenarios (in billion euros)

	Total delta (CAPEX and operation)	Delta investment costs (Delay-related costs 2,5-10%)	Delta discounted revenue (Earlier start of operations)
1 year less delay *12 years construction time*	0.95 - 2.05	0.36 - 1.45	0.60
2 years less delay *11 years construction time*	0.98 - 2.11	0.37 - 1.50	0.61
3 years less delay *10 years construction time*	1.01 - 2.17	0.38 - 1.54	0.63

Bron: SEO Economisch Onderzoek (2026)

Figures 4.2 and 4.3 show the development of cash flows and the cumulative result over time. The figures start at t=1, the first year of construction. Figure 4.1 presents the annual (discounted) cash flows as revenues minus OPEX over the entire lifetime of the plants. During the construction phase, revenues are negative, after which a positive cash flow begins at commissioning (in the baseline scenario this starts later than in the acceleration variants). The first operational years have the highest present value, after which the annual discounted revenues gradually decline due to discounting. At the end of the period, a negative cash flow becomes visible due to decommissioning costs (approximately EUR 400 million in present-value terms).
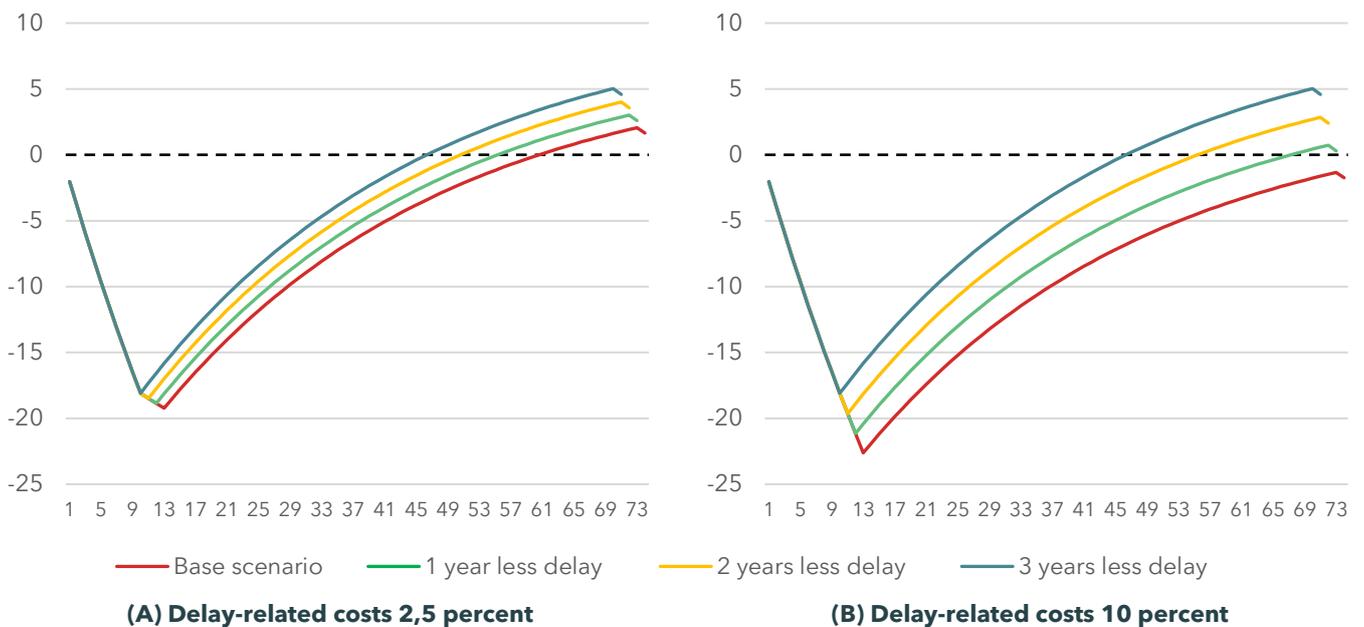
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Figuur 4.1 Annual operations for different scenarios (in billion euros)

(A) Delay-related costs 2.5 percent **(B) Delay-related costs 10 percent**

Bron: SEO Economisch Onderzoek (2026)

Figure 4.2 shows the cumulative discounted cash flow. This figure also starts at t=1, but the cumulative result additionally takes into account the initial investment and any delay-related costs incurred during the construction phase. From the start of the operational phase onward, the cumulative result increases due to annual revenues. With less delay during the construction phase, this increase occurs earlier and the break-even point is reached sooner; as a result, the final outcome is also higher.

Figuur 4.2 Cumulative result per year for different scenarios (in billion euros)

(A) Delay-related costs 2,5 percent **(B) Delay-related costs 10 percent**

Bron: SEO Economisch Onderzoek (2026)

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4.3.2 Cost savings from a shorter preparatory phase

An earlier start of construction – in other words, bringing forward $t=0$ – affects, among other things, the costs incurred before that point. This effect differs from reduced delays during the construction phase, because the greatest potential time savings may occur before $t=0$. At the same time, this is also the most difficult phase to quantify. What exactly does an earlier start mean in practice, and how much time savings are realistically achievable? The overall project duration is determined by a chain of preparatory steps, in which multiple parties depend on each other's information, decisions and assessments.

The PALLAS programme is expected to generate knowledge and practical experience that is relevant for the phase before $t=0$. This includes establishing a project organisation, organising quality assurance, compiling licensing dossiers, and structuring interactions with the regulator. Through this learning experience, the preparatory phase becomes more efficient. Parties gain a clearer understanding of which information is needed, which justifications are required, and which process steps must be completed and in what sequence.

An important mechanism here is improved alignment between the regulator and the applicant. The regulator can specify more clearly what it needs to see, the required level of detail, and where the main assessment risks lie. The applicant better understands what must be provided and how it should be structured. As a result, fewer iterations, additional rounds of questions, and revisions are needed, and misunderstandings can be avoided earlier. This translates not only into time savings, but also into capacity savings, such as reduced effort from the project organisation (advisory work, engineering, dossier management) and reduced assessment and coordination effort for the regulator.

Table 4.6 elaborates the cost savings before $t=0$ that may arise due to reduced delays during the construction phase. To illustrate the order of magnitude, PALLAS is used as an example of a project organisation for the construction of a nuclear power plant. In the execution phase, PALLAS has a project organisation of approximately 150 people. This is a relatively compact organisation; project organisations for the construction of large-scale nuclear power plants, such as the future Dutch reactors, are expected to be significantly larger. The assumptions used here are therefore deliberately conservative and result in an underestimation of the potential cost savings.

Tabel 4.6   Cost savings before $t=0$ (the start of construction) resulting from an earlier construction start

Start of construction (T=0)	Project organisation	Regulator	Total
1-year earlier start	15.4 million	10.3 million	25.5 million
2-year earlier start	31.3 million	20.8 million	52.1 million
3-year earlier start	47.6 million	31.7 million	79.3 million

Bron: SEO Economisch Onderzoek (2026)

The capacity of the regulator has grown significantly in recent years. For the coming period, a size of approximately 200–300 staff members is mentioned. In our indicative calculation, however, we do not use the full size of this capacity; instead, we assume that 50 percent of it is relevant for the type of activities for which time can be saved in the preparatory phase (before $t=0$). In addition, we assume an average employer cost of EUR 100,000 per employee, both for the project organisation and for the regulator.

This results in a rough indication of the cost savings that may occur before $t=0$, which is likely an underestimate given that we only consider personnel costs from two organisations. Table 4.6 shows that the potential savings range from

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approximately EUR 25 million when the process before *t=0* is completed one year faster, to approximately EUR 79 million when this process is completed three years faster. The table presents the present value of these financial benefits using a discount rate of 2.8 percent.

5   Conclusion

The Netherlands is preparing for a new phase in nuclear energy. International experience shows that delays are costly and commonly occur in nuclear projects in countries with little or no recent experience in this field. This study demonstrates the value that the learning effect of the PALLAS programme can generate through knowledge development, risk reduction and time savings.

The Dutch government is preparing for the construction of four new nuclear power plants. These preparations are taking place in a context in which recent international experience shows that nuclear projects frequently face delays and cost overruns, particularly in countries with little or no recent experience with such projects. Delays often arise specifically in the pre-construction phase – during licensing, design, contracting and planning – and these are difficult to make up later in the project.

The construction of the new PALLAS research reactor, intended for the production of medical isotopes and nuclear research, provides an interesting case study, as it is the first large-scale nuclear project in the Netherlands since the 1970s. The literature shows that experience in licensing procedures, documentation processes and supply-chain qualification are important explanatory factors for whether nuclear projects proceed according to plan. The hypothesis is that PALLAS has generated such learning effects in the Netherlands.

The results show that, in present-value terms, the effect of acceleration can increase rapidly. The analysis is based on a baseline scenario with a realistic effective construction period, explicitly accounting for structural delays. Earlier operation means that revenues become available sooner. In addition, part of the costs shifts forward in time, and the period during which capital is tied up without generating returns becomes shorter. As a result, the outcomes in the acceleration scenarios improve substantially compared with the baseline scenario. The net present value of the baseline scenario is, in itself, less informative because it is strongly dependent on parameters that may differ in practice, such as electricity prices, investment costs, construction pace, capacity factor and future market conditions. For this reason, the differences between the baseline scenario and alternative scenarios are the most informative.

Table 5.1 summarises the potential financial benefits. These consist of three channels: (1) benefits from lower delay-related costs during the construction phase (ranging from EUR 0.4 to 4.5 billion for one to three years less delay), 2) earlier revenues due to an accelerated start of the operational phase (ranging from EUR 0.6 to 1.8 billion), and 3) modest but positive savings in the preparatory phase before $t=0$ (ranging from EUR 25 to 80 million).

The three channels in Table 5.1 represent two distinct mechanisms. The first two result from reduced delays during the construction phase and occur simultaneously. The third concerns cost savings in the preparatory phase (before $t=0$) and can occur independently. The amounts presented therefore indicate the order of magnitude of benefits per channel and should not be interpreted as one automatically cumulative scenario.

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Tabel 5.1   Potential financial benefits for the construction of two new nuclear power plants enabled by PALLAS
(in billion euros)

Financial effects (in billion euros) *Number of years of reduced delay*	Low *1 year*	Middle *2 years*	High *3 years*
1. Reduced delay-related costs during construction *Range shows the financial benefits assuming 2.5–10% delay costs per year*	0.36 – 1.45	0.72 – 2.95	1.1 – 4.49
2. Earlier start of the operational phase *Low = 1 year less delay, …, High = 3 years less delay*	0.60	1.21	1.84
3. Cost savings before _t=0_ *Range shows the financial benefits for a 1–3 year earlier shift to t=0*	0.03 – 0.08	0.03 – 0.08	0.03 – 0.08
Indicative range of total benefits	**0.98 – 2.13**	**1.95 – 4.24**	**2.96 – 6.41**

Bron: SEO Economisch Onderzoek (2026)

Noot: The analysis is based on a scenario in which two new nuclear reactors are built. If four reactors were to be built, the financial benefits would be higher.

The exact magnitude of the financial effects depends strongly on the assumptions used in this study, such as initial investment costs, delay-related costs, electricity prices and the discount rate. The uncertainty surrounding the effect of reduced construction delays is also substantial. Delays are influenced by many factors and are difficult to quantify ex ante. International literature shows that learning effects in sequential nuclear projects can translate into reduced delays and a lower likelihood of extreme overruns. The interviews indicate that PALLAS may support a similar learning effect in the Netherlands, with one year of time savings considered a conservative lower bound within the analysed range (corresponding to the "Low" column in the table). Additionally, not all societal effects have been monetised. For example, climate benefits due to earlier CO_2 reductions may materialise, but these have not been explicitly valued in the calculations.

Beyond these financial effects, PALLAS primarily creates value as a learning experience: better understanding of licensing processes, quality assurance, documentation requirements, supply-chain qualification and collaboration between parties. The key effect is not only faster execution, but above all greater predictability, with fewer surprises, fewer iterations and a lower likelihood of extreme delays. This is particularly relevant in the Netherlands, where recent experience with modern nuclear new-build projects is limited. At the same time, the knowledge built up is not guaranteed to persist. Without targeted investment in preservation, transfer and continuity, expertise may erode, reducing the potential benefits of these learning effects.

Importantly, the assumed learning effect has not yet fully materialised, since part of the relevant knowledge and routine is accumulated specifically in the final stages of delivery, commissioning and the early operational period. The full learning effect will only materialise once PALLAS is fully completed. If the project were to be stopped now or significantly delayed, the learning curve would remain incomplete and the eventual knowledge build-up – and associated financial benefits – would be smaller. Therefore, it is essential to actively retain and make transferable the knowledge and expertise developed during PALLAS. The value of the learning effect can only be realised if the expertise embedded in people, processes and documentation remains available for future projects. In other words, if the knowledge is not retained, the societal value associated with it is lost.

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