# OPTIMIZING PALLAS REACTOR UTILISATION TO SUPPORT AN ECONOMICALLY VIABLE BUSINESS CASE

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## ABSTRACT

Stichting Voorbereiding Pallas-reactor (PALLAS) aims to realize a multi-purpose reactor to replace the current High Flux Reactor (HFR) in Petten, which has been in operation for over fifty years and is now approaching the end of its economic life. It is the goal of PALLAS to deliver a fully privately financed, owned, operated and utilised research reactor, with a safe, state-of-the-art and multi-purpose design enabling a world-leading position in the radio-isotope market and facilitating R&D in the field of nuclear technology.

PALLAS financing consists of two phases: a publicly funded phase of about five years followed by a privately funded phase. Phase one consists of preparing a design and obtaining the necessary licences. For this phase the government has granted a loan of 80 million euros. The first phase also involves attracting private resources to realize the construction and commissioning of the PALLAS reactor. This requires the development of a sound business case as a basis to eventually finance PALLAS based on private capital. The second phase involves the actual construction and commissioning of the PALLAS reactor. This paper summarises key elements of the PALLAS business case and financing project.

## 1. Introduction

The PALLAS organisation was part of NRG, a subsidiary institute of the Energy research Centre of the Netherlands (ECN), until the end of 2013. As of December 16, 2013 the activities of PALLAS have been incorporated in an independent foundation, the 'Stichting Voorbereiding Pallas-reactor', referred to as 'PALLAS' from this point forward. In 2012, the national government (Department of Economic Affairs) and the province of North Holland provided an investment of €40M each to lead PALLAS through its first phase, specifically to obtain a detailed design and a licence.

The PALLAS-reactor will be a pool-type reactor design based on proven technology (see Figure 1). The PALLAS-reactor will be optimized for production of medical and industrial isotopes and conducting nuclear technology research. The most important feature of PALLAS-reactor is its operational flexibility; the design of the core shall ensure that it can respond to changing markets. This paper focuses on the aspects of defining and optimizing the PALLAS-reactor utilisation to support the economically viable Business Case.

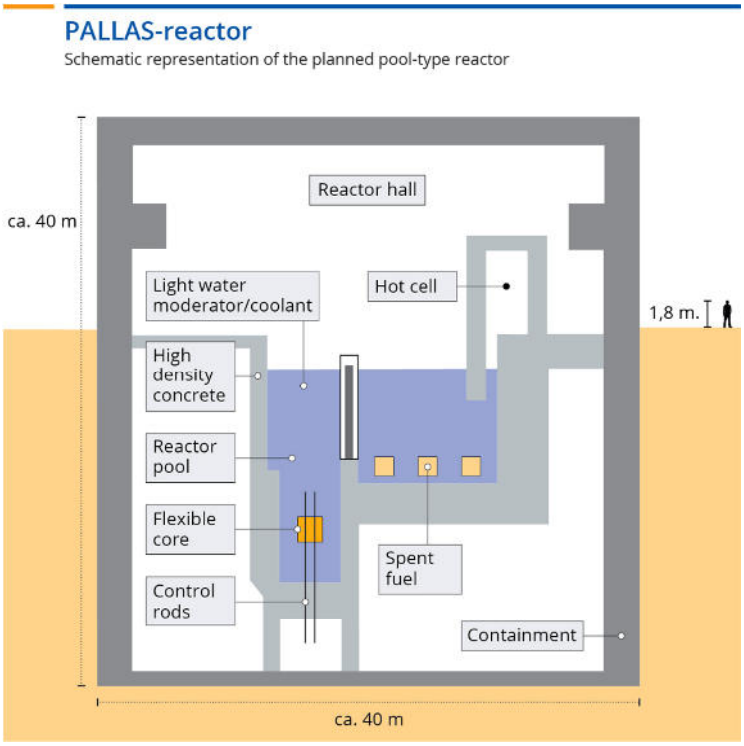



Fig 1: Schematic representation of the PALLAS-reactor

## 2. PALLAS at Onderzoekslocatie Petten

The PALLAS-reactor will be located near the village of Petten in the province of North Holland at the "Onderzoekslocatie Petten" (OLP) site (translated as "Research Site Petten"). Organisations such as NRG, Mallinckrodt, ECN, and the European Commission's Joint Research Centre - Institute for Energy and Transport (JRC-IET) all have operations at the OLP site. PALLAS will provide an integral asset for the continued success of these organisations by providing a replacement for the HFR. The design of the PALLAS-reactor shall seek to optimize interfaces with existing facilities and customers at OLP.

Fig 2: Onderzoekslocatie Petten (OLP) - PALLAS's future location

The existing facilities, experienced staff and organisations currently on the OLP site make it an ideal location for the PALLAS-reactor (Reference 1). The OLP site has the following interfacing nuclear facilities:

- High Flux Reactor (HFR) which will be replaced by the PALLAS-reactor;
- Hot Cell Laboratories (HCL)
- Molybdenum Production Facility (MPF);
- Decontamination and Waste Treatment Facility (DWT);
- Jaap Goedkoop Laboratory (JGL) for research into new radioisotopes;
- Waste Storage Facility (WSF);

The construction of the PALLAS-reactor by 2024 will ensure that medical isotope production and research activities can seamlessly transition to PALLAS-reactor and ensure business and research continuity for the organisations located in Petten.

PALLAS will support the Dutch Isotope Valley (DIVA) initiative and provide benefits to the Dutch medical isotope industry beyond the boundaries of the OLP site. NRG, URENCO and TU Delft have formed DIVA to ensure that The Netherlands continues to be a leader in the production of medical isotopes. PALLAS is preparing a vision on research to provide assurance that PALLAS will not only be a leader in the safe production of medical isotopes, but also contribute and benefit from the research and development of new medical isotopes and improving effective use of current isotopes.

## 3. PALLAS Organisation

PALLAS is organized into two primary teams, Design and Licensing (D&L) team and Business Case and Financing (BC&F) team. Each team is responsible for the respective projects and fulfilling the objectives:

- *D&L Objective* – to prepare a detailed design and obtain requisite licences;
- *BC&F Objective* – to prepare an economically viable Business Case and obtain financing.

The D&L- and BC&F-team are proceeding in parallel with significant interaction and communication between the teams. BC&F proposes the most economically viable quantity of radioisotopes / experiments (PALLAS's "products") and D&L evaluate the proposed "products" impact on design. The interaction between the teams is iterative and the process of interaction between the organisations is further described in Section 6 of this paper.

## 4.The PALLAS Business Case

The PALLAS Business Case is a fundamental deliverable of PALLAS with the primary function of attracting private investment in PALLAS. During the preparation of PALLAS-reactor Design Requirements, the Business Case is used to influence both design and product selection to maximise economic viability and optimise full lifecycle costs (design, construction, operation and decommissioning) of the reactor.

The PALLAS Business Case has continually evolved since PALLAS inception in early 2000's at NRG. Over the past five years, several major updates to the business case have been made in submission to key stakeholders (e.g., the Dutch government). As PALLAS originated as a project within the NRG organisation, the previous business cases were built

on the NRG product portfolio and therefore has a realistic market assessment based on performance and market projections at NRG. The formation of the independent entity of PALLAS allows for the BC&F team to independently verify previously made market and growth assumptions in the Business Case and expand PALLAS product offerings beyond those of the HFR. The last major revision was issued in May 2012. An update to the business case was made by PALLAS in June 2015.

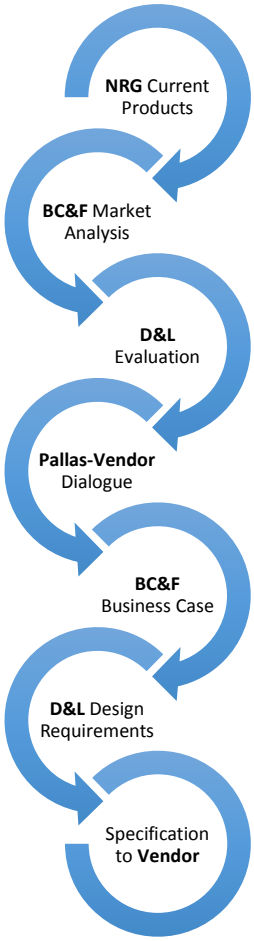
Throughout 2016, PALLAS has engaged in the Tender Phase for the selection of the reactor's designer under the European Union Procurement Directives. This process allowed PALLAS to have dialogues with the qualified Tenderers on a variety of topics prior to issuing an Invitation to Tender in January 2017. The dialogues were an opportunity for PALLAS to further validate and challenge the assumptions in the business case.

PALLAS issued an updated Business Case to stakeholders early 2017 that reflects:

- Current market analyses related to Mo-99 and other medical isotopes;
- A new "vision on research"; and,
- Updated cost estimates (e.g., CAPEX, OPEX, decommissioning) based on new assumed reactor specifications.

## 5. Financing PALLAS-reactor

The statutes of PALLAS state that PALLAS should be financed out of private sources (private financing) or 'open' public funding sources. To fulfill the financing objective PALLAS has prepared a financing strategy to approach the market of private investors, including both equity and debt financing. The mandate to seek private investment is consistent with a shift in utilisation of the current HFR in Petten from a subsidised public research use to commercial production. A privately financed reactor is also consistent with the principles of Full Cost Recovery for the production of Molybdenum by the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (Reference 1).




## 6. PALLAS reactor utilisation

Optimizing the economic viability of the PALLAS-reactor is achieved by: selecting products to maximise profitability; ensuring the proposed design has flexibility to meet changing market demand; and, minimising capital expenditures (CAPEX) and operating expenditures (OPEX). The PALLAS Business Case is based on revenues from four key complementary product areas:

- Irradiation of Mo-99 targets;
- Medical Isotopes;
- Industrial Isotopes;

- Irradiation and testing services for the nuclear energy sector.

Going forward, the product selection, number of positions and flux levels, production capacities as well as other operational parameters will be refined through an iterative process between business case and design teams.

## 7. Opportunities and Challenges

PALLAS is incorporating economic viability into the design process and capitalising on the existing infrastructure and assets on the OLP site. This design focus includes optimising interfacing onsite processes; such as the interfaces with the existing onsite Molybdenum Processing Facility (MPF) to maximising molybdenum output and minimising loss by virtue of decay. Located at Petten, PALLAS will have the option to also provide irradiated targets to other nearby processing facilities. PALLAS's location will provide good access to the North American and European isotope markets.

The business and design teams endeavor to maximise the flexibility of the isotopes and irradiation services offered to meet market demand, while minimising CAPEX and OPEX costs. The design of the PALLAS-reactor prioritizes the safe and reliable production of quality isotopes to meet customer demands.

PALLAS currently observes market challenges in achieving Full Cost Recovery pricing of Molybdenum and considers this to be a challenge to the PALLAS business case. Based on OECD NEA reports, the principles of Full Cost Recovery have been accepted by participating the governments of participating countries. PALLAS remains optimistic that Full Cost Recovery will be achieved before PALLAS enters the market in 2024.

## References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