REALISING THE PALLAS-REACTOR, STATUS UPDATE OF THE PROJECT

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ABSTRACT

PALLAS (Stichting Voorbereiding Pallas-reactor) aims to realise a safe 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 and operated reactor focussing on a world leading position in the (medical) radio-isotopes market and facilitating R&D in the field of nuclear technology.
The project is now close to selecting a contractor for the design and realisation of the nuclear island. The last year, Pallas has gone through an extensive period of dialogues with the preselected Contractors to develop the user requirements and to fine tune the contracting strategy. In parallel, significant preparation works in the licensing area have been done.
With the upcoming selection of the designer of the nuclear island the project will step from development towards realisation. Engineering will step from setting requirements towards designing an installation. Licensing will step from preparing supporting documents towards obtaining the permits. These step changes have a large impact on the project organisation, asking for different controls and structures, and requiring the project team members to take different roles and responsibilities.

1. Introduction

1.1 PALLAS

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 the required licences.

1.2 Two phases

The PALLAS reactor project consists of two phases. The first phase comprise procurement, design, licensing and shaping the necessary nuclear organisation. The second phase is privately financed and comprises detailed design, construction and commissioning of the reactor until commercial operation. Once successfully commissioned, the PALLAS reactor will be ramped up to full production.

1.3 Two project teams

PALLAS is organised into two primary project teams: the Design and Licensing team (further called PALLAS reactor project) and Business Case and Financing (BC&F) team, see figure 1 below. Each team is responsible for the respective projects and fulfilling the objectives:

- *PALLAS reactor project objective* – to prepare a detailed design and obtain requisite licenses;
- *PALLAS BC&F Objective* – to prepare an economically viable Business Case and obtain financing.

The reactor project and BC&F-team in close cooperation define the capabilities of the PALLAS reactor in terms of production capacities of various radioisotopes and capabilities for research.

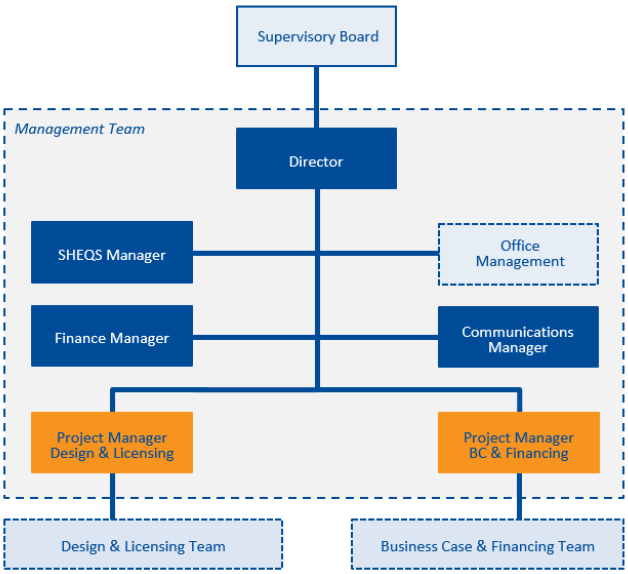

Fig 1: PALLAS teams

1.4 The PALLAS-reactor

The PALLAS-reactor will be a pool-type reactor design based on proven technology. The PALLAS-reactor will be optimised for production of medical and industrial isotopes with the possibility to conducting nuclear technology research. The main design characteristics of the PALLAS-reactor are given in Table 1.

No.	Parameter	Description
1	Reactor type	Light water moderated, open pool type reactor
2	Reactor Power (MW_{th})	As low as possible < 30 MW_{th} (expected)
3	Thermal Flux (n/cm ^{2}/s)	• Low flux zone - 1.0 X 10^{14} • Moderate flux zone- 2.0 X 10^{14} • High flux zone - 3.0 X 10^{14}
4	Reactor Fuel	• Low-enriched Uranium Silicide-Aluminium dispersion • Fuel burn-up more than 55%.
6	Reactor availability	>300 Full Power Days

Table 1: PALLAS Technical Overview

1.4 Location of the PALLAS-reactor

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"), see figure 2 below. Several nuclear 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 optimise 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. 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 will ensure that medical isotope production and research activities can seamlessly transfer to the PALLAS-reactor and ensure business and research continuity for the organisations located in Petten.

1.5 PALLAS in the Dutch nuclear infrastructure

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.

2. Why PALLAS?

All ingredients described above provide the ideal setting for realising the first new nuclear reactor in the Netherlands for many decades. But next to that, there are two prominent reasons why the PALLAS reactor will be realised.

Because PALLAS will provide unique solutions for life saving nuclear medicine and for research.

The Netherlands are the largest producer of radio-isotopes worldwide. HFR in Petten is producing about 70% of the European demand or 30% of the world demand to Molybdenum-99. Mo99 is the most commonly used radio-isotope for medical purposes worldwide in SPECT scans for heart and cancer diagnosis. Next to Mo99 there is a strong development in the use of radio-isotopes for therapeutic applications like Ir-192 and Lu-177. PALLAS will build on the strong position of the HFR to provide solutions to the nuclear healthcare worldwide.

PALLAS will built on the unique position of HFR in the Dutch Nuclear knowledge infrastructure and will be the landmark of the European Energy and Health Campus providing services to a wide variety of customers in the area of nuclear medicine development.

Because PALLAS will deliver a state-of-the-art, safe commercial production facility for nuclear isotopes.

PALLAS will realise a reactor with state-of-the art production facilities and logistic infrastructure. A reactor with a focus on commercial operation with a high amount of full power days, reliable operation and optimized logistics. A reactor that is designed and built around a philosophy of flexible production of radio isotopes for medical and industrial applications. A reactor that is adaptable to fulfil future needs in the area of medical, material and fuel research. And above all a reactor that is safe for the people that maintain and operate it and that is safe for the people that live in the neighbourhood.

3. PALLAS reactor project status

Engineering

PALLAS wants achieve four main goals during the design phase:

- To realise the preferred functionalities selected to drive value for PALLAS by implementing and managing the design drivers within the design,
- To manage the ‘value’ of PALLAS within the project lifecycle by means of value engineering (what is currently important to PALLAS),
- To enable the increase of ‘value’ during the PALLAS-reactor lifecycle by means of design for adaptability (enable what is important in the future),
- To manage the cost of the preferred functionalities through design-to-cost methods.

PALLAS will follow an integrated approach of the selected design drivers, value engineering and design-to-cost during the PALLAS-reactor project life cycle, see figure 3 below.

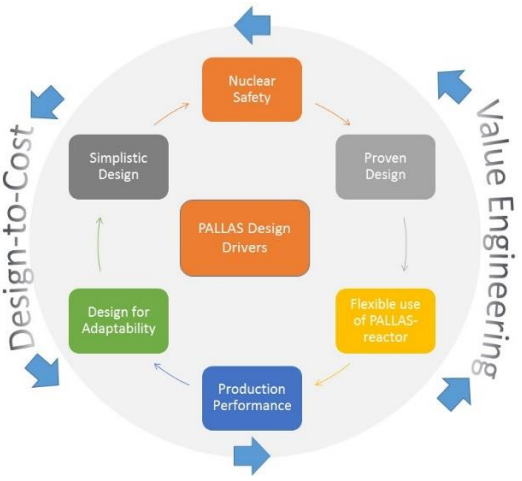

Fig 3: Integrated Approach to Design Drivers, Value Engineering and Design-to-Cost

Licensing
The PALLAS reactor requires both nuclear and conventional licenses. The conventional licenses are mainly driven by the update of the zoning plan supported by the Strategic Environmental Assessment (SEA) and the environmental and nature licenses supported by the Environmental Assessment Report (EAR). Currently the SEA has been issued to the authorities and the update of the zoning plan is expected to be published later this year. Next to the conventional licenses two nuclear licences are required:

1. Nuclear energy act licence for Construction, including cold commissioning;
2. Nuclear energy act licence for Operation, including hot/nuclear commissioning.

The Dutch nuclear authority, the ANVS, has implemented the following regulatory framework for the nuclear licences:

1. Dutch Safety Requirements
2. Organisation of the (SAR) Review Process
3. Technical Review Plan

These documents are based on the latest international standards, best practices and experience. PALLAS recognises the complexity of the licensing process and strives for an early involvement of and a close interaction with the ANVS. In this respect, PALLAS has engaged with the ANVS by organising regular meetings in the pre-licensing phase, being the period prior to the submittal of the first application for the Nuclear energy act. During the pre-licensing phase PALLAS is formally not yet under regulatory control.
One of the main steps PALLAS has taken to ensure early regulatory involvement in the design and safety concepts and methodologies of PALLAS is to add an informal step to the Dutch licensing process being the Conceptual Safety Document or “CSD”. The main objective of the CSD is to inform and give the regulator an early insight into the processes and methodologies of PALLAS and its contractors towards safety and design to ensure the development of a safe and licensable reactor. The CSD will provide information on the preconceptual design of the reactor and on those (design) topics which are fundamental for PALLAS safety and licensing approach such as the design process and control activities or the safety concepts and principles. It will provide the Regulator a profound insight into key design features, processes and methodologies used in the design and the safety demonstration of the PALLAS-reactor.

Procurement
PALLAS is currently in the process of contracting a designer of the nuclear island (DNI). In this respect PALLAS is following an EU Negotiated Procedure as part of the Tender Phase, PALLAS engaged in approximately one year of dialogues with the pre-qualified candidates. The dialogue process included various technical, project and contractual discussions with candidates and visits to facilities designed, constructed and commissioned by the candidates. The site visits were mainly done to learn from the experiences of the current owners. Information gained during this period was used to direct and enhance the development of the PALLAS invitation to tender (ITT) package.
The first phase of the contract with the DNI will be based on a EPCM contract. Under this contract the DNI provides design services to PALLAS to execute conceptual and basic design. In this phase also all required licensing documents will be prepared. The EPCM contract includes an option to convert to an EPC contract, which is essentially a lump-sum turnkey project with fixed price, guaranteed performances and commercial operation date for the construction and commissioning. It is anticipated that conversion to EPC will take place once the irrevocable licence to construct is obtained and private financing of the project is secured.

4. PALLAS reactor project organisation

In the second half of 2017, PALLAS will sign a contract with the DNI. With the signing of this contract the project will step from development to execution. The engineering stream will step from setting requirements towards supervising and reviewing the design of the reactor while in parallel transforming to capable organisation to become the design authority of the reactor.

Based on the design the conceptual safety document and PSAR will be prepared and application of the nuclear construction license can be started. So, the licensing stream will step from preparing supporting documents towards obtaining licenses. See figure 4 below for the PALLAS reactor project organisation.
The project management office (PMO) will step from general support to preparing procedures and work instructions for a proper implementation of project controls like progress management, cost management, document management, risk management, change management, reporting, etc.
HSE and Security support functions are currently implemented to support the design and prepare for safe and secure construction and commissioning. Also the Quality Control support function is installed to ensure a risk based approach towards the proper functioning of vital components and systems.
Construction, Commissioning and Operational support streams are set-up to support the constructability and operability of the design and start with preparation of site and laydown area.
Finally management of contracting and procurement is implemented to manage all contract related aspects and to maintain the design baseline including cost, schedule and performance over the design stages of the project. This project baseline forms the basis for a conversion to an EPC contract.

Project execution will be done based on Work Packages that are defined in accordance with the project WBS. Work package owners are responsible for:

- Managing WP team and resources, organise WP meetings
- Managing technical content and quality of WP
- Managing interfaces with other WP's
- Managing risks inside WP's
- Monitor progress and budget, with support from the project management office

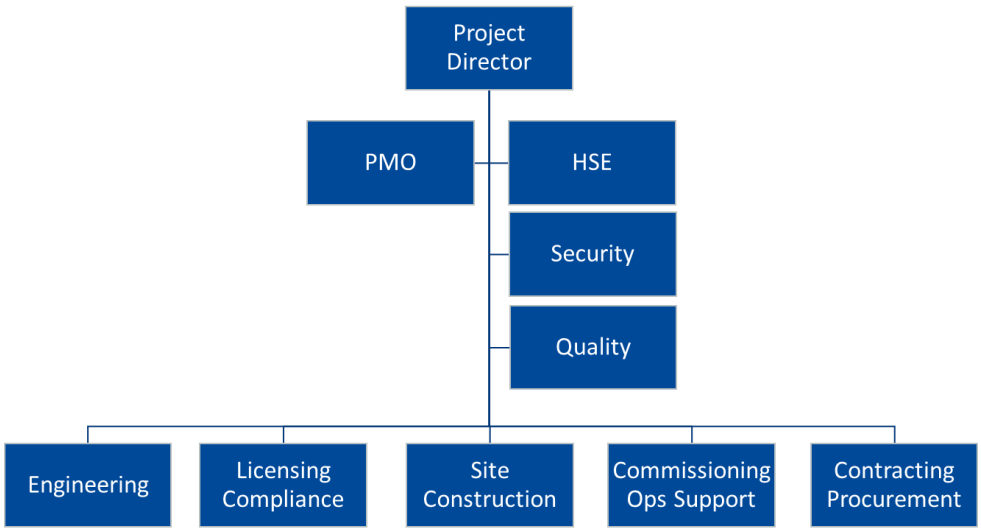

Fig 5: PALLAS project organisation

5. Conclusion

PALLAS is in the process of selecting a DNI and shaping the PALLAS organisation to realise a state-of-the-art, safe and commercial production facility for radioisotopes that will provide unique solutions for life saving nuclear medicine and for research.
With the right team & the right organisation, with the right contractors & the right cooperation with the right licensing approach & the right relation with the regulator, with support from investors, government, medical society, industry and the public PALLAS will succeed.