



Approved,

**Robert Tudorache**  
**Chairman of the Board of Directors**

## **Implementation Strategy of "Cernavoda NPP Tritium Removal Facility" Investment Project, in virtue of the Feasibility Study rev.11.**

### **1. General aspects /competence**

Pursuant to the provisions of art. 13 paragraph 2 letter h) in the updated Articles of Incorporation of SNN, the Ordinary General Meeting of the Shareholders "*approves the strategy and the development policies of the Company*".

Via the medium and long-term benefits, Cernavoda NPP Tritium Removal Facility (CTRF) is a priority project of Nuclearelectrica S.A. National Company ("SNN"), being an organic part of the development strategy of the company, the implementation thereof significantly supporting the control of the costs related to the decommissioning and the maximization of the economic efficiency. The synergies that it creates from the perspective of the implementation of Cernavoda NPP Unit 1 Revamping Project represent a strong additional argument in support of the Project.

At the same time, it should be emphasized that, in terms of the estimated costs of the project, the General Meeting of the Shareholders is competent to approve, within the development of the project, any legal commitment/act involving important obligations of the company on investment projects with a value exceeding 50 million Euro, in compliance with the provisions of art. 13 paragraph 4 and Annex no. 1 to the Articles of Incorporation of the Company.

Therefore, the competence to approve the Implementation Strategy of the Investment Project "Cernavoda NPP Tritium Removal Facility" in virtue of the Feasibility Study rev.11. (the "Strategy") rests with the Ordinary General Meeting of the Shareholders.

### **2. Presentation of the Project of the Tritium Removal Facility at Cernavoda NPP**

#### **2.1. Introduction**

This Strategy refers to the Investment Project "Cernavoda NPP Tritium Removal Facility", a strategic project for SNN.

Cernavoda NPP Tritium Removal Facility Plant, a project related to the CANDU technology, concerns the management of the tritium that is formed in heavy water as a result of the operational process. Thus, this investment project will have a beneficial impact on the development of the current operational activities, on the short-, medium- and long-term management of radioactive

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waste, on the specific measures and radioprotection programs and implicitly on the budgets to be allocated for the proper administration and the solving of all the aforementioned.

In order to choose the optimal tritium removal technology, the National Institute for Research and Development in Cryogenic and Isotopic Technologies ("ICSI Ramnicu Valcea") developed in 2006 a Prefeasibility Study wherein the technologies existing at that date were compared, the chosen technology being the **LPCE - CD (Liquid Phase Catalytic Exchange - Cryogenic Distillation)** type because:

- The solution does not pose problems in the licensing process, as it currently has an external experience - the tritium removal facility in Wolsung, South Korea;
- Other technological solutions analyzed pose great practical problems as well as very high operating costs, which is why they have not been implemented anywhere in the world on an industrial scale;
- There is availability for potential contractors for equipment and services at all the construction stages of the tritium removal facility.

### **2.2. *Impact of the tritium removal facility on the revamping project***

Analyzing the revamping operational experience at Point Lepreau (which implemented revamping without prior tritium removal) and Wolsong 1 (revamping after tritium removal), it is ascertained that, at Point Lepreau, during the revamping, the use of such technology would have had visible effects in the specific radioprotection programs.

Reduction of the tritium inventory in the moderator and in the primary circuit will reduce the cost of providing the radioprotection of the personnel involved in the revamping activities of Unit 1. Considering the aforementioned, it is estimated that, by reducing the tritium concentration and improving the access conditions, a reduction of the shutdown time by about 40-50 days will be obtained, with a direct impact on the economy of the revamping project.

### **2.3. *Objectives expected to be achieved by the implementation of Cernavoda NPP Tritium Removal Facility Investment Project. Benefits resulting from the construction of the tritium removal facility***

The objectives envisaged by the implementation of this Strategy on the tritium removal facility Investment Project are the following:

- Reduction of the decommissioning-related expenses;
- Reduction of the operational costs by significantly reducing the need for radiation protection materials;
- Reduction of the waste management costs resulting from the normal operation of the units;
- Reduction of the duration of planned stops;
- Reduction of the downtime for revamping;
- Reduction of the waste management costs resulting from revamping;
- Reduction of the revamping costs by significantly reducing the need for the necessary radiation protection equipment during the shutdown for revamping;
- Support for revamping;
- Revenues from tritium sale;
- Revenue from the sale of heavy water after tritium removal;

These objectives are transposed both in the technological plan (safe operation) and in the economic plan (expenditure cuts, additional revenues) and will be detailed in the technical and economic analyses that we will present in this Strategy.

In terms of benefits, we mention the following:

- Optimization of the application of the ALARA principle "As Low As Reasonably Achievable", i.e. the principle of radioprotection optimization, in the sense of ensuring that all exposures, including the potential ones, within the performed practice, are kept to the lowest possible reasonable level, taking into account the economic and social factors. This principle is a legal requirement, according to the provisions of art. 16 of NSR-01- "Fundamental Radiological

Safety Rules".

- Simplification of the access to radioactive areas and reduction of the duration of maintenance /repair work, including reduction of the duration of the revamping project;
- Provides the opportunity to capitalize tritium and the tritium-free heavy water;
- Reduction of the costs related to the storage tanks for tritiated heavy water upon revamping;
- Reduction of the extra costs for the management of the tritiated heavy water upon decommissioning.

#### **2.4. Project Implementation**

The implementation of the project is based on the conclusion of an EPC (Engineering Procurement Construction) contract with an economic operator or an association with experience in achieving such objectives, selected in virtue of a competitive procedure according to the legal provisions. This economic operator will be in charge of drawing up the construction -assembly details, procurement of the necessary equipment, performance of the works, commissioning and training of the personnel, until the trial operation of the facility.

At the same time, considering, on the one hand, the scope and specificity of the technologies used in the project and, on the other hand, the limited resources and insufficient expertise available within SNN / Cernavoda NPP, the CTRF implementation strategy aims at providing resources and the expertise required by Owner's Engineering, contracting with an organization that possesses the necessary knowledge and experience on the tritium removal technology. This organization will be able to provide the necessary support to the beneficiary both in the relations with the involved authorities (in order to obtain the necessary authorizations, agreements and approvals), and to initiate and carry out the EPC contracting procedure. The supply of these engineering support services is to be carried out in two phases: in the first phase, the contractor will provide consultancy for the necessary activities, preparing for the conclusion of the EPC contract; in the second stage, after the signing and until the end of the trial period and demonstration of the guaranteed technical performances, the Owner's Engineer will provide the supervision and technical consultancy on site, necessary to confirm the full compliance with the designed concept and technology and a permanent confirmation of the expected quality level for the works being performed by the EPC contractor.

The Owner's Engineer will also provide the coordination, technical supervision and acceptance of the construction details and possible project amendments elaborated by the EPC contractor.

### **3. FEASIBILITY STUDY - REV. 11**

Considering that the previous revision (revision no. 10) of the SF was drafted in June 2016 (endorsed by the CTES Notice 16 /September 19<sup>th</sup>, 2016), in order to have a correct assessment of the investment cost corresponding to the applicable legislative amendments stipulated in the Government Resolution no. 907/2016 on the structure and content of the feasibility study for investment projects, legislative act having come into force on February 28<sup>th</sup>, 2017, a new revision of SF for Cernavoda NPP tritium removal facility has been elaborated. We specify that the Government Resolution no. 907/2016 refers to the elaboration stages and the framework content of the technical and economic documentation for the accomplishment of the new investment objectives/projects in the field of constructions, the intervention works on the existing constructions and other investment works the expenditure whereof is fully or partly financed from public funds, respectively from the budgets stipulated in art. 1 paragraph 2 of Law no. 500/2002 on public finances and in art. 1 paragraph 2 of Law no. 273/2006 on local public finances. Although Cernavoda NPP tritium removal facility Investment Project is not financed from public funds but from the own funds of SNN and, therefore, this legislative act is not mandatory for SNN, however, considering the extent of the investment and the fact that there are no other express legal provisions covering the documentation to be drawn up in the case of an investment project of a public

enterprise, this legislative act was used as the reference basis for the elaboration of the SF.

### **3.1. Investment cost and financing sources**

The total cost of the investment according to the General Estimate of “Cernavoda NPP Tritium Removal Facility” is of RON 895,247,882, respectively EUR 190,478,273 (at a rate of 4.7 RON /EUR), out of which the construction-assembly (C + M) represents RON 145,531,444, respectively EUR 30,946,137.

The financing of the investment shall be provided from the funds of S.N Nuclearelectrica S.A. (50%) as well as, if considered appropriate, from attracted funds (50%). The financing structure of this analysis is estimated, the concrete financing method being established upon the project initiation, following an opportunity analysis based on the financial resources existing upon the accomplishment of the investment.

We mention that the total expenses incurred so far with the undergone design phases and the obtained permits and licenses amount to 63.23 million RON.

### **3.2. Analysis of the technical-economic options**

In compliance with the provisions of the Government Resolution no. 907/2016, two options were considered within the cost-benefit analysis:

- 1. Operation of U1 and U2 with CTRF and U1/U2 revamping (when CTRF becomes operational in 2026)*
- 2. Operation U1 and U2 without the creation of the tritium removal facility and with U1/U2 revamping*

By maintaining the current situation (variant 2), there will be no changes in the current configuration of the units, but the benefits of the tritium removal facility, explained above, both for the revamping of the units and for the decommissioning thereof are major.

Summarizing, the following are identified for this solution (variant 2):

- major difficulties and costs during the decommissioning of the units, for the management of the tritiated heavy water; the related costs for the treatment and storage of the tritiated heavy water at the end of the life of the units in the decommissioning process are estimated at **EUR 275,107,770 /unit, i.e. EUR 550,215,540** for the plant;
- increase of the radioprotection expenses;
- increase of the expenses on radioactive waste, transport included;
- difficult and longer lasting maintenance;
- During the unit revamping process, it is necessary to achieve the temporary storage of the extracted heavy water by implementing a system of 4 nuclear grade vessels. The estimated costs for heavy water storage from the SPTC and moderator systems have been estimated to be estimated to EUR 20,000,000 (RON 94,000,000).

#### **3.2.1. Financial analysis**

In order to determine the feasibility of the project, the elements specific to the financial analysis were defined and the revenues and the operational costs generated by the tritium removal facility have been quantified. Thus, for the calculation of the financial indicators, a real discount rate of 3% was used, namely a nominal discount rate of 5.58%. The time span for the calculation of the financial and economic indicators is of 50 years.

The financial indicators primarily considered in the financial analysis are represented by VNAF<sup>1</sup> (net updated financial value of the investment), respectively RIRF<sup>2</sup> (internal rate of return) of the

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<sup>1</sup> The updated net financial value of the VNAF investment (net present value - NPV), representing the difference between the sum of all the financially quantified revenues that the project produces over the analyzed period, updated on the current date and the sum of all the costs that the objective implies over the analyzed period

<sup>2</sup> The internal rate of return is also an indicator used in the economic analysis of projects, highlighting the overall, nominal profitability of the project; IRR is the discount rate at which the sum of all current, updated

investment.

Therefore, taking into account the future revenues/savings from CTRF operation, respectively the expenses generated by the maintenance and operation of the facility, by the application of the update technique, the resulting financial indicators recommend the accomplishment of the project. The **VNAF** value is of **RON 828,697,088**, which indicates that the project is feasible, i.e. it indicates an increase in the assets of the company by the implementation of the project. The **RIRF** value resulting from the cost benefit analysis is of **11.58%**, which highlights a good return on funds, exceeding the value of the discount rate taken into account.

### 3.2.2. Sensitivity analysis

The study also presents the risks that need to be considered in relation to the accomplishment of the project, the potential impact thereof, as well as the envisaged countermeasures.

The assumptions considered in the risk sensitivity analysis were taken into account and considered working assumptions:

- Operating revenue reduction by 4%
- Increase of the operating expenses by 10%
- Increase of the investment value by 5%

The project presents moderate sensitivity for all assumptions. In all cases, VNAF is positive, indicating that the project is a feasible one. The highest vulnerability is recorded in the 4% reduction of the revenues, the assumption where VNAF has the lowest positive value, and RIRF a 0.4376% reduction.

Crt. No.	Specification	VNAF (RON)	RIRF (%)
1.	Basic Scenario	828,697,088	11.58
2.	Assumption of revenue reduction by 4%	756,512,382	11.1424
3.	Assumption of increase of the operating expenses by 10%	804,379,375	11.4530
4.	Assumption of increase of the investment value by 5%	793,615,914	11.1357

Regardless of the impact of the sensitivity analysis and the risks on the financial and economic indicators taken into account, the project has a major positive impact on the economic indicators within the company, in the sense of the removal of expenses amounting to EUR 550 million, related to the treatment and geological storage of the tritiated heavy water.

### 3.2.3. Investment Risk Analysis

The study comprises an analysis of labor force-related risks, technological risks and a sensitivity analysis of the risk of exceeding the planned term of the project implementation.

#### A. Labor force risks:

Despite the current trend, it is considered that, over the period of implementation of the tritium removal facility, the works for the extension of the life of U1 will start, as well as the possibility of starting the works at Units 3-4, which could have a positive impact on the number of available specialists from inside and outside the SNN) and the workers.

At the same time, by involving a strong and experienced organization in virtue of the EPC contract and the attractive salaries that the general contractor and the subcontractors thereof will pay, the shortness of labor force will be removed.

In the case of initiation of the revamping projects too, i.e. the start of works at U3-U4, a high risk is represented by the number of personnel within CNCAN, the Ministry of the Environment, which is limited and will work on all these projects. This possible risk can be mitigated by the use of the O

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financial flows of revenue type equals the amount of all updated cost-type financial flows

& E (Owner's Engineer) resources in the elaboration of the licensing documentation at a higher quality level.

#### **B. Technology implementation risks**

The study indicates that any deviations from the specified technical performances will be corrected in the project implementation stage, and the related additional expenses will be covered from the various and unforeseen expenses chapter of the estimate.

#### **C. Project delay with impact on the revamping of Unit 1**

Due to delays in EPC contracting, in obtaining the authorizations, the impossibility of the providers to deliver the equipment and materials at the stipulated deadlines, delays in the completion of the construction-assembly works, delays in commissioning, the CTRF project may not provide the support necessary for the tritium removal from the heavy water before the revamping of U1 of Cernavoda NPP.

In this case, RIRF has a decrease of 2.77%, but it remains above the discount rate used in the financial analysis, and VNAF remains positive RON 514,815,129.

On the other hand, even in the case of delayed operation of CTRF, there will still be a partial tritium removal from the moderator until the initiation of the U1 revamping activities, which can be accepted, given the relatively low impact on the slight increase of the doses.

#### **D. Risk from the sale of low quantities of tritium in reference to the estimation**

Three components were also taken into account within the study as revenues from tritium sale: tritium sale to industrial users, tritium sale to ITER (International Thermonuclear Experimental Reactor - Cadarache, France) (estimated to be the most important tritium purchaser on the market) and tritium sale to other fusion projects.

There is a possibility for ITER not buy tritium from Romania or to buy in small quantities, as a consequence of the fact that Korea, as participant in ITER and the owner of a tritium inventory stored as a result of the WTRF operation, will provide this tritium as contribution to the financing of ITER operation. Likewise, another pessimistic variant is the possibility for the ITER project to be delayed in such a way as to decide the interruption thereof.

In this case, the risk assessed in the case of the sale of 50 gr /year does not have a significant impact on the project. Thus, VNAF remains strongly positive RON 637,589,680, and RIRF indicates a 1.25% decrease, as compared to the baseline scenario.

**Feasibility Study - Code 79-38500-SF-001, Rev. 11 related to the Investment Project entitled "Cernavoda NPP Tritium Removal Facility" has been approved by CTES SNN (CTES notice no. 12/July 12<sup>th</sup>, 2018).**

#### **4. Proposals submitted to the approval**

In reference to the aforementioned, considering the provisions of art. 13 paragraph 2 letter h) in the updated Articles of Incorporation of SNN, subject to the approval of the Ordinary General Meeting of the Shareholders, this document representing the

*Implementation Strategy of "Cernavoda NPP Tritium Removal Facility" in virtue of the Feasibility Study rev.11.*

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