2017 International Nuclear Atlantic Conference - INAC 2017
Belo Horizonte, MG, Brazil, October 22-27, 2017
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR – ABEN

Agência Brasileira do ISBN
ISBN 978-85-99141-07-6
9 788599 141076

TECHNICAL AND ECONOMIC FEASIBILITY STUDY FOR THE REACTIVATION OF THE INTEGRAL TEST FACILITY OF IPEN/CNEN NUCLEAR ENGINEERING CENTER

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ABSTRACT

The Integral Test Facility of Nuclear Engineering Center (CEN/IPEN/CNEN-SP), known as "Loop 70", is a semi-industrial thermal-hydraulic test facility and can operate as a BWR (Boiling Water Reactor) or a PWR (Pressurizing Water Reactor) mode. Designed and built in the 1980's, it is currently disabled. The experimental circuits ("test loop") are facilities that reproduce the thermohydraulic and fluiddynamic conditions that occur inside a reactor and are used to simulate the practical reality which it is not possible to be obtained through mathematical models. In this context, this research project aims the development of a Business Plan to analyze the technical and economic feasibility related to the reactivation of the facility. This methodology (adapted to the government sector) is a decision-making tool that will offer a wide perspective of the project, set the guidelines and actions that will define the future of the facility and provide a general rule to make investments on it. This paper presents the historic aspects to better understand the Loop 70's current situation. It also presents information about similar facilities around the world, services that can be offered (thermal-hydraulics parameters measurements, equipment qualification and transient analysis due accident situations), results of the strategic analysis (SWOT) performed, specific goals for each critical success or failure factor of the facility, financial aspects related to the reactivation and an overview of the facility's perspectives.

1. INTRODUCTION

The Integral Test Facility of Nuclear Engineering Center[1] (CEN/IPEN/CNEN-SP), also known as "Loop 70", it is a semi-industrial facility of thermohydraulic tests and it was conceived in the 1980's. However, nowadays it is disabled.

The experimental circuits ("test loop") are facilities that reproduce the thermohydraulic and fluiddynamic conditions that occur inside a reactor through a circuit in which the fuel elements are replaced by electric resistance. Those facilities are used to simulate the practical reality which it is not possible to be obtained through mathematical models. In the case of the present installation, the main technical characteristics are described on the following Table 1 [1].

Table 1: CEA's Technical Characteristics

Description	Unit	Rate
Duty fluid	[-]	Demineralized water
Design pressure	[kgf/cm^2]	80

Maximum operating pressure	[kgf/cm^2]	70
Design temperature	[ºC]	300
Maximum operating temperature in the exit of tests section	[ºC]	285
Maximum operating temperature in the main pump entrance	[ºC]	256
Manometric high of the main pump	[mca]	90
Flow in the exit of the main pump	[m^3/h]	72
Maximum capacity in the test section	[kW]	1.600
Pressurizer power	[kW]	30
Pre-heater power	[kW]	200
Daeration power	[kW]	30
Maximum length in the test section	[mm]	3.600
Installed power	[kVA]	2.800

The main goal of this paper was to elaborate a business plan in order to analyze the technical and economic feasibility related to the reactivation of the CEA. This reactivation would provide not only the research and technology development for the nuclear sector, but also the technological and laboratory services resulting in financial return for the facility maintenance e partnerships to develop projects and upgrade the laboratory infrastructure.

The Business Plan [2] methodology works as a script that has as a goal to provide a wide view of the enterprise and to allow the definition of strategies in order to achieve the final objective. Furthermore, by this methodology it is possible to gather a large range of information and to analyze them in a pragmatic way. Bearing in mind that this is a used tool, mainly, in the private enterprises, the adjustment of its structure to the reality of a public institution was one of the challenges of the present paper.

1. STUDY OF THE ENTERPRISE

To introduce the elaboration of the business plan, the reactivation of the Integral Test Facility of Nuclear Engineering Center (CEN/IPEN/CNEN-SP)[1] was defined as an enterprise in order to study its feasibility. Subsequently, the relevant elements related to the reactivation were analyzed to reduce part of the risks and doubts and to obtain in detail the history of the tests installation, the scenario on which it is located, and through a strategic analysis the critical elements for the study to be successful were defined.

2.1. Historical Aspects

Between mid-1960 and the beginning of the 1970's, the nuclear market presented a noticeable expansion.

The installation's concept was developed by Dr. Henry J. Fenech (UCSB – University of California in Santa Barbara) and by Dr. Marcokzy (EIR - *Institute* for Reactor Research in

[1] Circuito Experimental a Água do Centro de Engenharia Nuclear

Wuerenlingen, Switzerland). The conception, basic project and mounting were carried by IPEN[2], with the ambition to use the maximum possible national technology. [3]

Loop 70 presented as basic pressure parameters 70 bar, power of 1200 kW and flow of 20 kg/s. It was built to perform drainage experiments and to determine the correlation of critical heat exchange in specific conditions and flow simulations.

The circuit mounting was held in 1977 and 1982, and in 1982 the first tests were accomplished. Initially, the following experiments were arranged [4]:

- Cleaning (*flushing*);
- Calibration of valves, relays and instruments;
- Electrical system and instrumental grid tests;
- Hydrostatic test;
- Secondary operation;
- Pressurizer test: 5; 15; 40; 70 bar;
- Main and primary pump;
- Main heater;

The 1982 tests presented a thermal balance with pronounced deviations. In 1983, COPESP (current CTMPS) initiated Loop 150 projects, superior capacity installation and concepts under IPEN's responsibility. Hence, many of the projects and experiments were no longer held in Loop 70.

Moreover, a number of problems that made the use of the facility difficult were noticed, such as: energy intensive peak hours, the need of non-stop operations associated to the operators work and high operation cost, as well as the need for regular maintenance and specialized staff.

2.2. Scenario

In the beginning of the 1970's, the necessity to offer reliable methodologies appeared in order to provide realistic estimations in accident situations. In this context, in the last forty years a number of tests facilities were used in the development and comprehension of transients in nuclear plants around the world [5].

Therefore, there were 50 test facilities analyzed in many countries, being United States, France, Germany, Switzerland, Japan and South Coreia the main ones [6]. It was then necessary to analyze those which would offer similar services as those proposed by CEA and those which had relevant information in order to provide a comparison among them. Following there are examples of important facilities around the world.

Table 2: Tests facilities around the world [6].

Facility	Country	Status
BETHSY	France	Disabled
LOBI	Italy	Closed

[2] Instituto de Pesquisas Energéticas e Nucleares

LOFT	United States	Disabled
APEX	United States	Operating
ATLAS	South Coreia	Operating
CDTN	Brazil	Operating
KATHY	Germany	Operating
PANDA	Switzerland	Operating
PKL	Germany	Operating

2.3. Strategic Analysis

To perform the enterprise strategic analysis it was used a resource named SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats). This analysis is a tool that allows the evaluation of internal and external factors related to the enterprise in order to collect factors that can influence it positively or negatively [7].

In its development, the SWOT Analysis was divided in two environments: the internal and the external.

The internal environment gathers the factors that influence the business and about which the entrepreneurs may wield direct influence. These factors must be separated in strength and weakness and present internal characteristics that work in favor or against the enterprise development, respectively. They might also be subdivided in organizational aspects, marketing aspects, financial aspects, personal aspects and production aspects, with the purpose to segment the analysis and maximize the score to be obtained along it.

The external environment contemplates the factors that influence the business and about those the entrepreneurs cannot wield direct influence. Organized in opportunities and threats, they show what can influence the enterprise positively and negatively. It may be done a classification by the operational environment, considering international, supplier, staff, competitor and customer components. It is also essential to analyze the general environment, subdivided in economic, social, political, legal and technological components. As in the previous case, such segmentation has as an objective to maximize the score in the analysis.

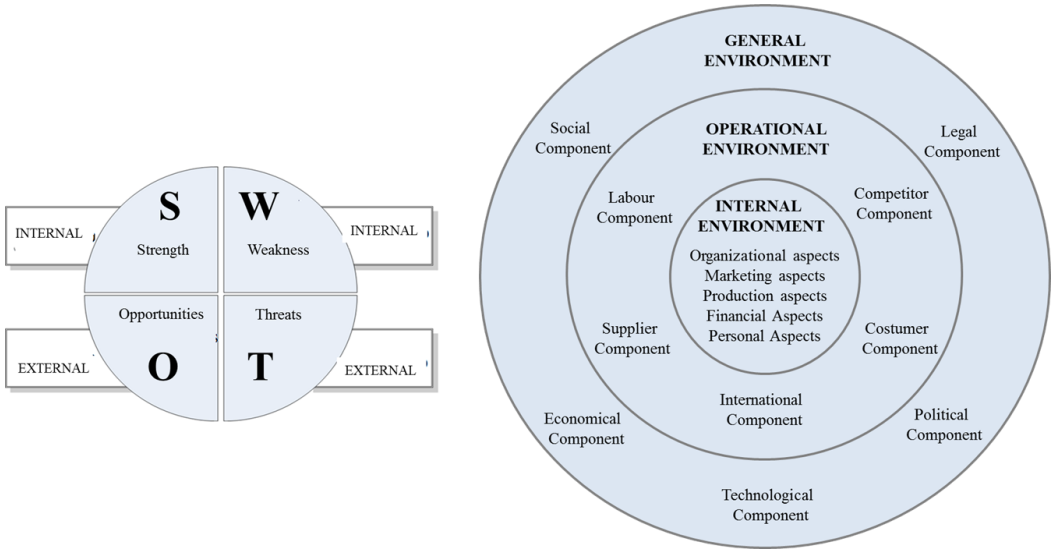

Figure 1: Analysis Structure SWOT.

Along the analysis there were 68 relevant points identified that influenced directly the enterprise from the confrontation of strength with opportunities and from weakness with threats and so the critical factor for success was determined.

Thus, it was possible to detect the situations which represent major or minor risks to the enterprise. These factors are listed below in Table 3.

Table 3: Enterprise's Critical Factors

Factors for Success	Factors of Risk
Interest of large companies in order to generate income for development and maintenance	Limited electric supply
Development of papers and research by students and researchers	Excessive internal bureaucracy
Pre-existence of trained workforce	Lack of clear regulation (internal) about contracting
Pre-existence of structure and equipment	Funding of initial resources
Low competition in the country	Non-stop operation/ non-conventional work schedule (human resources)

2.4. Goals

The points which influenced the enterprise supported the goals definition to be accomplished in order to enable the reactivation of the facility CEA and they are presented below in Table 4.

Table 4: Goals

Goal
Formation of Project group (mechanical, electric and I&C)
Interested students collection in the electric and marketing project
Research on hiring
Research on workers in non-conventional work schedule
Marketing Project realization
Definition of supply electric structure

2. SERVICE STUDY

Following the enterprise's study, the factors related to the services which will be offered in this new business were analyzed. The services that would take place after the reactivation of CEA were defined from the analysis of history and data from other facilities.

3.1. Definition

The services were organized in three main groups:

- Thermohydraulic parameters measurement: enables the acquisition of thermohydraulic parameters before the project and the building of equipment.
- Equipment test: enables the performance analysis and characterization of existing equipment in the market allowing its qualification for the operation as a nuclear class item.
- Transient analysis due to accidents: enables the dynamic performance analysis and the safety of systems in face of a variety of failures and operational transients.

3.2. Necessary resources

In this topic the needed resources for the development of the enterprise were defined. These resources may be divided in human and physical resources and are listed below.

3.2.1. Human resources

Tablea 5: Human Resources

Qtd.	Qualification	Description	Profile	Situation
1	Mechanical Technician	Permanent Maintenance	Field experience	Hiring

1	Eletrothecnic Techinician	Permanent Maintenance	Field experience in operation	Hiring
1	Mechanical Engineer/ Chemist	Facility supervision	Field experience in operation	Hiring
8	Techinician: Mechanical / Eletrotechnical	Facility operation	Field experience	Hiring

Along the strategic analysis two problems related to the staffing operating to the reactivation were found: a large number of internal professionals are close to the retirement process and the overload of task of those who have no time to be dedicated to this project. Consequently, the hiring listed in the above table would be a way to solve the problem.

However, it was also verified in the analysis that there are difficulties in the official hiring by IPEN, what can interfere in the working retention. Besides, there is the need of adjustment in the work schedule as the circuit operation is non-stop and it requires people working in unconventional hours. These are the important points to be solved by the institution before the decision to be made.

3.2.2. Physical resources

The Experimental Circuit is composed basically by a main circuit where it is the test section, the supply, purification, daeration and heat removal water system. There are still the electric supply system, instrumentation, control and security.

Although it contains a huge part of the structure as it is the old facility, many of the necessary components for its operation became outdated. Thus, in relation to the needed physical space for the operation of the facility, it is already available.

All the necessary changes must be analyzed and discussed by the project group responsible for the reactivation and, afterwards a list of all resources and specific components that should me obtained be made.

Meanwhile, it is visible the necessity of a modernization in the instrumentation and controlling systems and the definition of a supply electric structure of the system. An analysis should be held in the existing pipes and valves to ensure its physical integrity.

All those items will impact in the financial area of the Loop 70 reactivation Project.

3. MARKET SURVEY

By the definition of the enterprise’s purpose and the services to be offered, an analysis of the market in which the business will be located is needed.

The business success is related to the market evolution in which it will be executed, however, it is not possible to have influence over this evolution but only to be adapted to it.
This way, it is crucial the monitoring of the following markets:

- Consuming market
- Competitor market
- Supplier Market

3.1. Consuming market

Based on the definition of products and services offered, the reactivation arises as mandatory to answer to a public demanding for test installation services. There are big companies in national and international market which demonstrated interest in circuits and test plant.

In CEA case, the customers, that it is to say those who will buy the services and who are the target public, service customers. These would be the public and private companies, national and international, which are interested in the research development and which are willing for partnerships, moreover students and academy researchers who have the intention to work with Loop 70.

It is possible to divide the Market in three main groups:

- National companies
- International companies
- Researchers and students

3.2. Competitor market

Table 6 presents the installations that offer similar tests and services as those CEA might offer. They should not be considered direct competitors as the services are not exactly the same. Some of them are associated to research institutes and universities, such is the case of APEX (Oregon State University) [9] and others are part of companies from the nuclear sector.

More than competitors, these test installations constitute to exchange knowledge and experience opportunity in order to maximize the forms to operate the circuit.

Table 6: Similar Facilities

Country	Facility	Pressure and volume scale (MPa)	Pressure (MPa)	Tests
United States	APEX	1/192, 2.8	2,8	SBLOCA, ADS, CMT
	PUMA	1/400, 1.0	1	LOCA, PCCS, GDCS
Japan	LSTF/ROSA	1/48,16.0	16	SBLOCA, EOP, AMP
Germany	PKL	1/145, 4.5	4,5	LOCA
South Coreia	ATLAS	1/288, 17.5	17,5	SBLOCA, LBLOCA
	SNUF	1/1139, 0.8	0,8	LBLOCA, DVI
Brazil	CDTN/CT1	-	-	LOCA [10]

3.3. Supplier Market

The indispensable equipment and products to the reactivation of the circuit may be found, mostly, in national suppliers. However, some specific components must be bought from foreigner companies.

4. MARKETING STUDY

4.1. Pricing Policy

The main goal of this enterprise together with the interested companies it to establish a partnership in order to ensure that all services benefit the institution with financial, human and material resources. Hence, the service pricing should be based on what the customer is able to offer for the development of the institution.

4.2. Strategies to Promote

This topic is directly related to the goal mentioned in topic 2.4. The promotion strategies must be defined through a specific work related to the enterprise's marketing.

First, it is extremely important to take into account the organizational aspects of the institution. Before any publicity, it is crucial to have an internal persuasive discourse about the importance of the installation and the technological services offering.

Having such critical points solved, we can suggest the urge of a specific webpage for the presentation of the installation inside IPEN's website in order to report the services CEA will offer and so to initiate an external persuasive effort through the search for customers in a number of national industry sectors.

Many of the used tools in the development of the enterprise's marketing are already been used by IPEN, such as the website and the customer service (including after-sales), and so it would require only an adjustment for the services to be offered by CEA.

5. FINANCIAL STUDY

In order to have an overview of the future of the installation, it was essential to analyze through a calculus memorial the main financial aspects of the enterprise related to the reactivation of Loop 70. This study allowed pointing out the variable quantitative involved in the project and arranging an estimative of expenses for the three reactivation steps: project; building and operation.

The project step refers to the gather of a reactivation crew, one of the goals defined in topic 2.4, and it was set the deadline of a year to the conclusion of the project and the definition of necessary improvements. For this estimative, the work schedule of each person in the staff was considered, such as external consulting services that may be required. The amount estimated was R$ 322.800,00 to be spent along a year.

During the building step, they must be implemented all the improvements defined in the previous step, and it was estimated around R$ 5.000.000,00 for the rebuild and modernization of the entire facility. Furthermore, still in this step, it was considered the hiring of new staff

(topic 3.2.1) which would represent a future expense for the institution of approximately R$ 406.393,92 a year.

As for the operation step, it was estimated the amount of R$ 793.804,67 a term, considering training of operators, staff payment for those dedicated to the installation operation, water consumption and possible maintenance services.

7. CONCLUSIONS

The business plan methodology (adapted to the government sector) as an applied tool for the feasibility of the reaction of CEA proved to be appropriated to obtain a general overview of the scenery under discussion. The historic collection of the installation was important in the comprehension of the reasons that led to its idealization, building and also deactivation.

The chosen methodology allowed the identification of a number of critical factors (success or failure) which influenced directly in the analysis of technical and economic feasibility of the enterprise. Finally, it was possible to estimate the order of magnitude of the future project expenses. From the business plan and the collected information in the present paper, it was concluded the existence of two possible scenarios. First, there is the possibility to deactivate the installation, demount all the components and to remove the structure that is in the experiments building of CEN (Nuclear Engineering Center), allowing then the space to be used for other activities. A second possibility is to gather a crew for the reactivation proposed by this paper in order to elaborate a complete technical project and then to verify precisely the future expenses and essential moves. As expected, the expenses with the installation will be very high considering the current budget situation. From the purely scientific point of view (research only), the facility reactivation implies into high expenses in initial investment and operation forward in its current use capacity and return perspective. In terms of technological service offering and the facility reactivation, it was proved feasible, considering that, for this option, there would be held partnerships with private companies which present interest in the future available services.

ACKNOWLEDGMENT

The authors thank the financial support as scientific initiation scholarship offered by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)[3] and by Nuclear Engineering Center Commission (CNEN). They also thank to MsC Ariovaldo V. Gomes for his generous collaboration.

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