IMPROVEMENT OF RESEARCH REACTOR SUSTAINABILITY

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ABSTRACT

The Research Reactors as is well known have numerous applications in a wide range of science technology, nuclear power development, medicine, to enumerate only the most important. The requirements of clients and stack-holders are fluctuating for the reasons out of control of Research Reactor Operating Organization, which may ensure with priority the safety of facility and nuclear installation. Sustainability of Research Reactor encompasses several aspects which finally are concentrated on safety of Research Reactor and economical aspects concerning operational expenses and income from external resources. Ensuring sustainability is a continuous, permanent activity and also it requests a strategic approach. The TRIGA – 14 MW Research Reactor detains a 30 years experience of safe utilization with good performance indicators. In the last 4 years the reactor benefited of a large investment project for modernization, thus ensuring the previous performances and opening new perspectives for power increase and for new applications. The previous core conversion from LEU to HEU fuel accomplished in 2006 ensures the utilization of reactor based on new qualified European supplier of TRIGA LEU fuel. Due to reduction of number of performed research reactors, the 14 MW TRIGA modernized reactor will play a significant role for the following two decades.

1. Introduction

Sustainable development is a general notion developed some two decades ago by Brundtland Report. Since that time the term was used, diversified and applied to a multitude of human activities, for example sustainable economy, sustainable agriculture, sustainable energy, sustainable nuclear energy. The content and sense of sustainability in fact is “oxymoron” and relative belonging to social economic environment to a plurality of cultures and technologies and contain a contradiction. The contradiction appears between natural resources regeneration and consumption of natural resources accomplished by the use of materials and dumping of waste. Sustainable means to keep equilibrium between resources consumption and regeneration with the condition to protect the environment. Sustainability in any area in general terms suppose:

- A long term vision – desired state = equilibrium
- A strategic approach – Planning
- Management of strategy – setting goals
- Sustainability measurement to measure progress
- Performance indicators
- Reporting and communication of achievements
- Feed back

A relative new approach of sustainability tries to explain the complex source of sustainability by thermodynamics fundamentals:

Principle 1 – The energy is not created or destroyed, the energy through technology is “only modified in form”

Principle 2 – Matter and energy trends to disperse in time to low level in environment, increasing the entropy.

Sustainability of Research Reactors could be understood as a human complex activity part of many other life processes developed in other areas as fundamental research, materials research, applicative research for nuclear energy, nuclear safety, agriculture, medicine, education and more others. Sustainability of Research Reactors is in a strong correlation with sustainability in other fields of activity challenged by principles of thermodynamics:

Principle 1 – Resources available for research reactors are modified in form through diverse technologies/techniques of neutrons generation utilization to become resources for other processes

Principle 2 – Resources trends to disperse in time to low level in environment, increasing the entropy i.e. reducing the sustainability.

Sustainability of Research Reactors is a part of sustainable development of science, technology, energy and the demand for Research Reactor support products and resources is a subject of dynamic needs in other processes or fields of activity and can not be controlled by Research Reactor Owner, subject of risk and uncertainty. Reducing the risk and uncertainty means increase the sustainability.

Maintaining a **diversity of options** in Research Reactor application/utilization may help to avoid losses when one option is reduced or fail. **Innovation in products, services and technology** for efficient utilization of reactor reducing in the same time the radioactive waste and environmental impact is a direction of sustainability of Research Reactors. **Protecting the investments, life extension and maintenance** for research reactors is a factor of sustainability, and an indicator as well. **Radiological protection** by limiting the exposure of staff and population below standards of protection in terms of exposure could be a factor of sustainability, and an indicator as well. Radiation protection is a dynamic field subject of results of R&D and developments of new instrumentation. **Safety** of Research Reactors expressed in specific indicators reinforced by **Safety Culture** of Operating Organization giving an overriding priority to safety issues is the guaranty of sustainability of a given research reactor. **Radioactive waste management** for reactor operation/maintenance and decommissioning and research reactor spent fuel with associated costs and radiation exposure of staff and population may be an important factor of sustainability, and an indicator as well. Sustainable utilization of Research Reactors is based more on knowledge and skills and less on materials, this means valuable human resources. Ensuring **high qualified and licensed staff and Research Reactor operators** is a factor of sustainability, and an indicator as well. International cooperation and synergy is a valuable resource for Research Reactors sustainability by exchange and reciprocal support, cooperation agreements alliances, initiative, networking in order to enhance the capability of collective sustainability and reliability of products and services with less financial effects. Role of government policy in the area of energy, research and development is essential where research reactors are state owned. The role of government is essential in formatting regulatory framework and policies that will allow a coherent approach toward decommissioning of nuclear facilities and disposal of radioactive waste.

Sustainable nuclear activities developed by Research Reactors have to achieve a high level of public acceptance from community consideration and involvement in decisions concerning environmental issues.

2. Sustainability of TRIGA 14 MW Research Reactor in Pitesti, Romania

Sustainability of TRIGA 14 MW Research Reactor could be defined as the ability to maintain safe and economic operation of reactor for the next twenty years. The relative long term of operation target for 50 years in total since commissioning is an objective which was accomplished by several other research reactors. In case of 14 MW TRIGA, this objective could be achieved by:

1. management of ageing equipment systems and instrumentation so the research reactor life time could be safely extended for the next twenty years
2. human resources management, training and retraining and continuous employment of replacements in order to reduce the mean age of reactor staff from 48 years to 30 - 32 years old.
3. ensuring solutions and experimental devices for new application on material testing and preparation of testing activities for the newly designed European research reactors and sharing experience and know-how through international cooperation.

3. Vision

The reactor will be a safe and reliable neutron source for material testing, for research in the field of nuclear safety of power plants for at least 20 years and contributing to radioisotopes market especially fission ^{98}Mo from LEU.

4. Strategic approach of issues which may impact the sustainability.

4.1. Operation of Research Reactor

To ensure the resources for operation, mainly:

- human resources sufficient in number and qualification to ensure four shifts operation and replacement licensed by Regulatory Authority
- fresh fuel supply for extended operation was ensured in the framework of IAEA-TC Project by contribution of IAEA, US-DOE through GTRI and by qualification of and European nuclear fuel provider. The core conversion was successfully performed on 12 May 2006, achieving a strategic goal established some 15 years ago. The spent fuel containing HEU, as well as unirradiated HEU was shipped in the country of origin.
- To secure founds for fuel and for continuous operation, maintenance and spare parts, founds for modernization of reactor systems and instrumentation and control were obtained through IAEA-TC Project and from government
- Keeping the licensed operational facility

4.2. Cost of operation / Cost recovery

Yearly budget of TRIGA Research Reactor facility provide funds for covering the reactor operation including expenses for safety, maintenance, plant life extension and other taxes.
The yearly budget contains provisions for staff salaries, expenses with water, electric power, heating, radioactive waste transfer, conditioning and disposal, spent fuel management during intermediate storage, materials for maintenance and operation, expenses with communication, and for other services at the level of institute as physical protection, fire brigade, radiation protection and monitoring of facility and site.
Assets depreciation, costs recovery over designed life period including cost of modernization are distributed over life extended period. An important cost factor is taxes and licenses fees and contribution to decommissioning founds.
The cost of operation per hour could be computed and the cost for applications/users could be established in order to recover the expenses. The economic viability of research reactor is a strategic issue. Costs are justified and verified by the top management. Safety and economic viability are complementary issues. Developing yearly programs and plans that enhance economics also are likely to be benefic for reactor safety. This could be expressed as a well used research reactor and is safer that a shutdown one.

4.3. Licensing and regulatory aspects

Licensing concerns reactor facilities, some category of operational staff, new experiments, new products and services provided by Operating Organization, Renewing the licenses every two years is a regulatory requirement in Romania.

4.4. Quality Management, Health, Safety and Environment

Institute Integrated Management System was certified by Lloyd’s Register Quality Assurance for quality management system, for environmental management system, for occupational health and safety management system, according to the current standards.
The institute Quality Management System was authorized by National Commission for Nuclear Activities Control in Romania. The Quality Management System in institute is applicable to all processes which lead to performance of nuclear activities starting with design of nuclear equipment, installations, manufacturing, control, including among many others operation of nuclear installations (Research Reactor, Post Irradiation Examination Laboratory, Radioactive Waste Station, transportation of radioactive sources and materials).

4.5. Technical cooperation and information exchange

A large contribution of achievements of research reactors of Romania is due to technical cooperation with IAEA-TCEU and with departments of Research Reactors Nuclear Safety and physics sections. International meetings with specific topics of research reactor safety and utilization enhanced the communication and information exchange. Participation in US-DOE Project Sister Laboratories improved strategic approach of activities development and business orientation. Participation in the European Framework Research Projects, for MTR+I3, open new perspectives for TRIGA Research Reactor utilization for development of some application that in the future will be used in Jules Horovitz Research Reactor in France.

4.6. Life Limiting Factors

Following the provisions of Feasibility Study the last four years were dedicated to reactor modernization in order to increase the nuclear safety and utilization capacity. The obsolescence of nuclear safety instrumentation of reactor as well some equipments in auxiliary system was remediate through a large investment project which was commissioned in December 2009.

4.5. Organizational Structure

The Research Reactor Department is integrated in the institute structure where the same level of authorization and accreditation is applied for other departments. For this reason, Research Reactor Department is responsible for operation and maintenance; many other functions are accomplished in other departments as radioprotection and site monitoring, emergency preparedness, metrological calibration of instruments, periodic inspection and verification, physical protection, quality management and accountancy.

4.6. Personnel Development

Due to some administrative regulations, the maximum number of staff employees in institute is almost constant since ten years ago. In these conditions, the employment of young engineers, scientists or professionals is very difficult, leading to constant ageing of personnel. Training in specific areas for research reactor operation takes 3 years and this period is followed by examination and licensing by Regulatory Authority. Ensuring licensed staff in a quite large time span supposes another type of strategic approach.

5. Management of strategies

Management of strategies for sustainability of research reactor is attributing to institute as Operating Organization.

The major objectives, which management believes that will enhance sustainability of 14 MW TRIGA Research Reactor in Pitesti, are:

- Safety of nuclear installations
- Increasing the level of utilization for institute and abroad users
- Preserving the professional competence of staff threaten by depreciation by ageing and loss of experience
- Protecting the environment
- Promoting Safety Culture, Quality Culture, and Organization Culture among all staff and of organization. <u>**Sustainability comes and goes with culture and morality**</u>.

All above become objectives of Integrated Quality Management annual planning for which specific actions and responsibilities are assigned and performance and planed performance indicator are attributed.

6. Performance Indicators

Performance indicators allow measurement of sustainability and progress evaluation. Performance indicators could be qualitative or quantitative, some indicators as number of hours of reactor operation, number of irradiated samples are quantitative, others are expressed in percents of accomplishment, and those could be subjective / qualitative. The system of indicators is stable for several years in order to measure progress, to observe the latent weaknesses and to set preventive measures against degradation of sustainability. Performance indicators are also subject of continuous improvement to reduce subjective evaluation and incertitude for long term evaluation.

7. Reporting and communication of achievements

All activities related to sustainability are inspected, controlled and audited by designated inspectors, auditors, which establish reports on inspected activities and dispositions or corrective actions in real time. Annual analysis performed by management allow on the basis of a yearly report made by process responsible persons to evaluate the achievements on sustainability. Communication of achievements across organization allow the evaluation of objectives accomplishment in areas concerning safety, level of utilization and finances, status of licenses for staff and facility, environmental threat and satisfaction of client and stack holders.

8. Conclusions

Sustainability in the context of Research Reactors is defined as the ability to keep equilibrium between utilization and depreciation of complex system of resources and capacity which sustains the role of Research Reactors in production of products and services for other processes which on theirs turn should be sustained. As a general rule, sustainability trends and drivers depends on:

- Social factors – social system we live
- Technological factors – how technology change the industrial environment
- Economical factors – impact on financial system, access to finances
- Environmental factors – monitoring/reducing impact on resources consumption, waste generation, health and risk
- Political factors – political system and policy regulation/legislation

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