THE ONGKHARAK NUCLEAR RESEARCH CENTER (ONRC) RESEARCH REACTOR PROJECT: A STATUS REVIEW.

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ABSTRACT

The new Ongkharak Nuclear Research Center in the vicinity of Bangkok, Thailand is planned to replace the more than 30 years old facilities located in the Chatuchak district, Bangkok. An international team led by General Atomics (GA) is designing and constructing the new research complex. It comprises a 10 MW TRIGA type reactor, an isotope production and a centralized waste processing and storage facility. Electrowatt-Ekono Ltd. was hired by the Thai Government Agency, the Office of Atomic Energy for Peace (OAEP), as a consultant to the project.

As the project is now approaching the end of its 4th year, it now stands at a decisive turning point. Basic design is nearly completed and detailed design is well advanced. The turnkey part of the contract including the reactor island, the isotope and waste facilities are still awaiting the issuance of the Construction Permit. Significant progress has been made on the other part of the project, which includes all the supporting infrastructure facilities.

The Preliminary Safety Analysis Report (PSAR), prepared by GA, has been reviewed by various parties, including by nuclear safety experts from the IAEA, which has provided continuous support to the OAEP. Experts from the Argonne National Laboratory have been involved in the reviews as well. The PSAR is now under consideration at the Nuclear Facility Safety Sub-Committee (NFSS) of the Thai Atomic Energy for Peace Commission for issuing the Construction Permit of the ONRC Research Reactor.

The following paper gives an overview of the project and its present status, outlining the features of the planned facilities and the issues the project is presently struggling with. Major lessons of the past 4 years are highlighted and an outlook into the future is attempted.

1. Introduction

In replacement of its more than 30-year old TRIGA Mark III reactor, the Organization of Atomic Energy for Peace (OAEP) has awarded General Atomics (GA) in June 1997 a turnkey contract to provide the main facilities of the new Ongharak Nuclear Research Center (ONRC), comprising a Reactor Island (RI), an Isotope Production Facility (IPF) and a Waste Processing and Storage Facility (WPSF). This center is located approximately 60 km northeast of Bangkok in the Nakhon Nayok province in Thailand.

The facilities will be used for radioisotope production, Neutron Transmutation Doping (NTD) and Neutron Activation Analysis (NAA). Various neutron beam research facilities are planned, including e.g. a High Resolution Powder Diffractometer and a facility for Boron Neutron Capture Therapy. These facilities will strengthen Thailand's scientific and technological competence in fields such as materials research and testing, medicine, mechanical engineering and nuclear technology.

To achieve its ambitious goal, General Atomics has teamed up with companies such as ANSTO, Hitachi and ATT Consultants. Whereas GA is providing in essence the Reactor Island related facilities and the overall project management on the contractor's side, the design, procurement and commissioning of the isotope production and waste related facilities are within the responsibility of ANSTO, respectively Hitachi.

In an on-going effort, Electrowatt-Ekono Ltd. has been so far assisting OAEP in areas such as in the development of the Terms of Reference, in the technical evaluation of the bid, in the contract negotiations with the bidder, in the basic as well as the detail design review.

2. The ONRC facilities

The new research complex extends over an area of approximately 50 ha and includes, besides the reactor, isotope production and waste facilities, a number of infrastructure buildings. A summarized description of the main facilities can be found below:

2.1 The Reactor Island

Since the design features of this facility have already been presented [1] extensively at the IGORR meeting in 1999, the following table will only give an overview of its main characteristics:

Reactor type	10 MW TRIGA® pool reactor, light water cooled (forced convection) and moderated
Core	29 TRIGA clusters of 16 fuel rods each, 4 B_4C control rods, about 3 week cycle, 10 cycles a year, 1/5 of core reloaded/year.
Reflector	Heavy water, Beryllium blocks
Fuel	UErZrH, enriched to 19.7 wt.%
Pool(s)	About 354 m³ of demineralized water, 3 interconnected pools, SS liner,
Coolant	About 1300 m³/h of coolant flow at 37/49 °C, open secondary cooling loop. 2x100% plate type HX's.
Beam tubes	6: HRPD, PGNAA, NR, BNCT, SANS + 1 spare
In-core facilities	Ir-192, P-32 production facility
Ex-core facilities	+ Isotope production sites in Be reflector + 3 NAA irradiation positions + 3 locations for NTD production in the D_2O tank

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	+ 1 spare + Irradiations site for radiation damage study, gem stone enhancement
Neutron flux	$\geq 1.0\ 10^{14}\ cm^{-2}\ s^{-1}$ thermal in-core $\geq 1.0\ 10^{13}\ cm^{-2}\ s^{-1}$ fast in-core $\geq 1.0\ 10^{13}\ cm^{-2}\ s^{-1}$ thermal at beam ports

Design features of the reactor island include:

- Emergency Core Cooling System (ECCS): As an engineered design feature and a defense in depth measure, the function of the ECCS is to keep the core from being uncovered by preserving a minimum amount of water for cooling. The battery operated and redundantly designed ECCS will be able to deliver water for a minimum of 8 days whereas the possibility exists to extend this period. Automatic activation occurs on a low-low pool level signal. Beam port covers constitute an additional protection against rapid dewatering of the pool. Anti-siphon holes and isolation valves in the primary coolant pipes round up the provisions foreseen to mitigate the effects of leaks in the reactor coolant system and pools.
- A complete pool leak detection system: Drain channels are included behind each of the liner welds and leakage water is routed towards a central collection system. Beam tubes can be checked for leaks as well. Redundant flow monitors, pressure differential measurement across the heat exchanger and online radiation detection systems in the secondary cooling system round up the leak detection system.
- A confinement: The atmosphere in the reactor hall is maintained under a negative pressure of about 20 Pa to allow a controlled release through the stack of the air. A purge system made of HEPA and charcoal filters is brought online on detection of heightened radiation levels.
- A seismic scram system automatically shutting down the reactor at the onset of an earthquake.
- A watertight layer in the base mat below the entire foundations slab.

2.2 The Isotope Production Facility

The prime purpose of this facility is to provide OAEP with the capability to produce radioisotopes, radiopharmaceuticals and radioimmunoassay reagents for use in agriculture, industry, nuclear medicine and research. New production processes currently planned include:

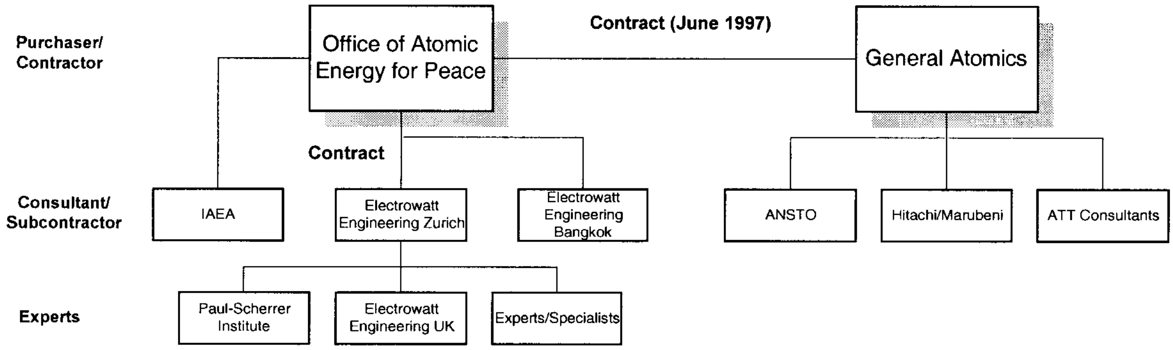
- Production of I-131 for the preparation of diagnostic and therapeutic capsules.
- Production of I-125.
- Production of Ir-192 radiography discs and wire.
- Production of P-32.

Other processes currently in use at OAEP will be implemented at a later stage (e.g. Tc-99 production). Depending on the radiological activity, the targets will be transferred from the Reactor Hall building over to the Isotope Production Facility either via the above pool cell and the connected shielded pneumatic transfer line or by a 2.0 t cask loaded in the reactor pool.
The facility is designed and built taking into account IAEA guidance, regulatory standards and good safety practice. Medical products leaving the facility will satisfy GMP (Good Manufacturing Practices) rules. Design principles such as defense in depth, reliability (redundancy, fail-safe and diversity principle) as well as proven engineering practice have been implemented from the start. Radiological dose targets for the ONRC site have generally been set at a factor of 5 (10 for public exposure) below the ICRP limits, additionally lowering the target for each facility to take into account the combined exposure due to the 3 facilities.

2.3 The Waste Processing and Storage Facility

Current plans foresee that all radioactive wastes generated in Thailand, in particular those from the ONRC, be processed and then stored in the WPSF. For this purpose, a radwaste collection, an aqueous/organic liquid waste processing and a solid waste processing system are included in the design of the WPSF. The processed (incinerated, cemented) waste is stored in a separate building, with an interim storage capacity of 20 years. The Co-60 incident in Bangkok in the year 2000 focused the publics opinion on the present radwaste storage capacity problem in Thailand and resulted in an increased interest for the erection of a new, modern facility.

3. The ONRC project organization



To assist in the development of the ONRC research complex, OAEP has hired Electrowatt Engineering (EWE) as the consultant for the project organization and overall management. EWE provides advice and assistance in the organization and implementation of the ONRC turnkey project from the preparation phase through commissioning of the research complex. The assembled project team includes specialists from various fields to provide OAEP with the appropriate experience, in particular in the field of research reactors. On a case-by-case basis, tasks are also assigned to EWE's German and British subsidiaries and to specialists from the world renowned Paul Scherrer Institute. The total independence of the EWE project organization of any company engaged in the nuclear business guarantees the fundamental objectivity required from a consultant company for such a project. A Bangkok resident project management team assures the successful administration and technical integration of the project.

4. Project Status

4.1 Present situation

As the project approaches the end of its 4^{th} year, it has now entered a critical phase. Basic design has been essentially completed and detailed design is well advanced. With a delay of nearly 2 years, the regulatory body of Thailand, the NFSS (Nuclear Facility Safety Sub-Committee) of the Thai Atomic Energy for Peace Commission, is presently considering OAEP's application for a Construction Permit of the reactor island. The lack of transparency of the licensing process makes it difficult to estimate the date of Construction Permit delivery. Consequently, progress on site has concentrated on the non-turnkey facilities, which are more than 60% complete. The turnkey area, comprising the RI (for which the Construction Permit is needed), the IPF and the WPSF, is still a "green" area. The present uncertainties linked with the Construction Permit date imply organizational problems both for the Contractor and OAEP's consultant, since contracts signed in June 1997 assumed a commissioning of the facilities in 2001. Present "best estimates" predict a commissioning of the turnkey facilities in 2003-2004.

4.2 Difficulties encountered and areas of possible improvements

Besides the many technical issues (see below) that have to be dealt with in a project of this size, partly unforeseen difficulties of another type have or had to be addressed. Among those with a major impact, the following can be mentioned:

- The often extended times to reach decisions within the client's project organization, due in part to unclarified responsibilities of an "inspection committee" in the client's project organization.
- Increasing decisional powers attributed to individuals instead of "groups" directly involved in project implementation would facilitate day-to-day project work.
- The complexity of the contractor's project organization: The involvement of several major sub-contractors, with different cultural backgrounds and responsible for the different facilities bears the risk that (1) standardization is not appropriately taken into account in the design of the overall facility and that, (2) communication and problem solving is made more difficult.
- The client's tight human and financial resources: As the design evolves from a conceptual to a more detailed level and because of the complexity of the project, a smooth implementation requires some financial flexibility on the client's side. An appropriate technology transfer and the smooth hand-over of the completed facility to the client depends heavily on the early and full involvement of the clients project team personnel, which will operate and maintain the facility later.
- Apparent lack of clear political support for the project: As the example of the FRM-2 in Germany has shown, the combination of both an efficient PR campaign and repeated, openly demonstrated political support can significantly help increase public acceptance and reduce the impact of "green activists" or other marginal "nucleo-phobes". As a side effect, such support would provide, in case of the ONRC project, an additional motivational effect on the OAEP project team members.
- The request of a country of origin review for the reactor design: The Thai regulatory body requires a safety assessment of the reactor design by the US-NRC. As the NRC has declined taking any such responsibility for a reactor to be licensed outside the United States, alternatives in the U.S. had to be found and the scope of review for such an additional, outside assessment had to be defined.
- Multiple IAEA reviews: In order to exclude potential knowledge gaps in nuclear related matters, OAEP has taken advantage of the support offered by the IAEA to promote the civil use of nuclear energy. The provided support cover specific technical areas (e.g. verification of calculations) as well as the review of the Preliminary Safety Analysis Report (PSAR). Nine different IAEA missions have so far reviewed the PSAR or parts of it. The dual role of the IAEA, which has reviewed the PSAR for both OAEP and the regulatory body, must be mentioned.
- Licensing body: The organization of regular round-table meetings and improved communication channels between the applicant for a Construction Permit and the licensing authority at an early stage would be a definite help to clear the path towards a successful application and to discard any misunderstandings or wrong expectations early in the licensing process.

5. A few technical issues highlighted

A lot of attention has been dedicated to the following fields whose inter-relationship in a nuclear facility is of tremendous importance for normal operation, maintenance as well as in fighting and mitigating the spread of potential contamination in case of an incident or accident:

- Ventilation
- Definition of controlled zones and their boundaries.
- Fire protection.

Among many other basic and detail design technical issues that were given increased attention, the following can be cited:

- Classification of the systems, structures and components.
- Waterproof layer.
- Seismic specifications for the ONRC.
- Spent resin transfer.
- Flux values.
- Uranium specifications.
- Standardization.
- Integration of OAEP hot cells in the new IPF.

7. Outlook

The Construction Permit date for the reactor island has been constantly shifting for the last 2 years for a number of reasons. As of April 2001, there are however reasons to believe that the much awaited Construction Permit will be awarded this year. Numerous parties have reviewed the PSAR and there are no technical reasons to delay the construction of the ONRC centerpiece, the reactor island. The issuance of the Construction Permit would send a strong signal to all parties involved in a project whose successful completion will benefit Thailand's scientific and medical community as well as its industry and agriculture.

7. References

[1] J. Razvi; J.M. Bolin; J.J. Saurwein; W.L. Whittemore: „Design and Safety Considerations for the 10 MW(t) Multipurpose TRIGA® Reactor in Thailand"; IGORR 7, 7th Meeting of the International Group on Research Reactors; October 26-29, 1999.