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Restarting Delayed Nuclear Power Plant Projects

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IAEA NUCLEAR ENERGY SERIES No. NP-T-3.4

RESTARTING DELAYED NUCLEAR POWER PLANT PROJECTS

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NUCLEAR ENERGY SERIES

RESTARTING DELAYED NUCLEAR POWER PLANT PROJECTS

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FOREWORD

The management of nuclear power plant projects with delays of several years with respect to the original scheduled commercial operation date presents particular issues and problem areas beyond the normal management tasks needed for projects implemented within originally planned schedules.

During the years 1997–1998 the IAEA collected information and practical examples on necessary management actions to preserve the capability for resuming work and completing delayed nuclear power projects when conditions permit. The results were published in the IAEA-TECDOC-1110 entitled Management of Delayed Nuclear Power Plant Projects. As this publication was finalized, at the end of 1998, the available information at the IAEA PRIS (Power Reactor Information System) indicated that more than 40 nuclear power plant projects had delays of five or more years with respect to the originally scheduled operation dates.

The PRIS data, collected at the end of 2007, illustrates a trend toward restarting and completing projects that were once delayed. The data indicates that the number of delayed nuclear power projects has reduced to about 25. Some practical methodologies and successful experience from the restarted projects were reviewed, summarized and included in the present publication. The purpose is to address the specific management issues pertaining to a delayed nuclear power project in the period after the decision for restarting is adopted. This publication covers those management issues not considered within the normal processes described in other IAEA publications.

It is expected that the practical experience collected from delayed nuclear power projects that were successfully restarted, completed and brought to commercial operation, can provide useful assistance to the management of similar projects considering resumption of work in the future.

This publication was produced within the IAEA programme directed to increase the capability of Member States for strengthening national and regional nuclear power infrastructures.

The IAEA wishes to acknowledge the assistance provided by the persons involved as reviewers and as contributors of practical material. These persons are listed at the end of the publication. In particular, specific appreciation is given to J.E. Costa Mattos (Brazil), who served as chairperson during the review meetings and to I. Rotaru (Romania), who prepared the drafts. The IAEA officers responsible for this publication were N. Pieroni and K-S. Kang of the Division of Nuclear Power.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

1.1. Background

The reason for this publication arose from recognition that delayed nuclear power plant projects (DNPPs) present specific issues for which the nuclear utilities need assistance and guidance based on successful practices. For the purpose of this publication, a DNPP is a nuclear power plant project that has not reached the operation stage several years after the originally scheduled date. This publication is a continuation of the IAEA programme carried on during 1997–1998 with the specific aim of providing assistance for the management of DNPPs. The IAEA-TECDOC-1110 Management of Delayed Nuclear Power Plant Projects published in 1999 [1] provided information and practical examples concerning necessary management actions to preserve and develop the capability to restart and complete these projects.

This publication offers guidance for the process of managing the restarting of a DNPP until turnover to operation. The guidance can be applied equally well to a country's first nuclear power plant (NPP) or a plant, which is a part of a larger national nuclear power programme.

Additional information is provided in the annexes. This information has been acquired from nuclear utilities around the world and represents practices successfully applied in the completion of DNPPs. Experience has shown that the practices described are effective and therefore suggested for adaptation and application.

This publication focus on the specificity of the DNPPs, taking into account that there are other IAEA publications geared towards the implementation and construction of new NPPs, which are mentioned as reference publications.

1.2. Objectives

The objectives of this publication are to:

— Provide guidance on the specific aspects concerning the process of restarting and finalizing a DNPP
— Assist management with the implementation of the particular policies and measures for DNPP restarting and finalization
— Share the experiences, successful practices and methodologies of countries that decided to restart a DNPP.

1.3. Scope

This publication covers the management key aspects and subject areas for the preparation and execution of DNPP after the decision for restarting is adopted. In particular includes issues such as preparation of restarting and structuring of the project, detailed evaluation of the DNPP before restarting, structures and materials preservation, commercial and financial arrangements, licensing, and project implementation (construction, commissioning and turnover to operation). This publication does not address operation of DNPPs.

1.4. Users

This publication is intended for use by the senior managers and engineers of organizations involved in the DNPP completion including:

— Nuclear utilities
— Project Management Team (PMT) organizations
— Supplier organizations for DNPP construction and commissioning services
— Technical support organizations
— Vendors and equipment suppliers.

The publication also includes information which may be useful for decision makers and advisors from governmental organizations such as regulatory bodies, ministries and others.

1.5. Structure

This publication consists of seven main sections, including this Section 1, which is an introduction.

Section 2 presents the identified key aspects of DNPP in the process of restarting and managing until the completion.

Section 3 describes the project management organization during the different periods of DNPP restarting process. The role and functions of the existing DNPP core group after the decision for re-starting of the work for completion is also presented. The process of establishing a specific project management organization in the different stages of DNPP completion and the management system are also presented. The last part of Section 3 identifies the technical support that the IAEA offers to the Member States in the field of DNPP re-starting and completion management.

Section 4 outlines the main issues related to the verification of basic conditions for DNPP work resumption. This includes verification and assessment of the technical and economical conditions, including the project budget and financial plan. In addition to that, Section 4 contains recommendations of effective practices for human resources management and information for the public's acceptance of the DNPP restarting. Finally, it outlines strategies for DNPP completion, mainly focused on the decisions related to the contractual approach and financing.

Section 5 presents the process of updating the DNPP to regulatory requirements and current licensing in a logical order along with the actions that need consideration for updating the DNPP for licensing and completion. The importance of the DNPP licensing schedule and of having a proper relationship with the regulatory body during the DNPP licensing process is also emphasized.

Section 6 outlines the practices and recommendations for the commercial and financial arrangements for DNPP project completion, as well as the specific risks associated with DNPP completion.

In the last Section 7, the specific activities of DNPP implementation are described, mainly in the area of project management, planning and scheduling, engineering, construction, erection, commissioning and turnover to operation.

The annexes present good practices and experiences of Member States which have already completed DNPPs or are in the process of DNPP completion at the time of issuing this publication (Argentina, Brazil, Bulgaria, Romania and Slovak Republic). These annexes should be read in conjunction with the provisions of this publication, representing country cases which have been used as bases for the guidance and recommendations included here.

1.6. How to use

This publication should be used as guidance on how to proceed with the completion of a DNPP that was interrupted during any particular project phase. This publication is not prescriptive and should be considered only as guidance.

The guide is not meant to be all-inclusive and should be utilized with due consideration given to the existing local experience and specific economical and financial conditions of each country. The suggested methods and good practices given in this publication should be adjusted by each user to fit the needs and capabilities of the country as well as the particular circumstances of the DNPP project. However, it must be clearly understood that they are only suggestions and are not to be interpreted as regulatory requirements. The implementation of these suggestions should be consistent with the organization culture and the operating environment of the project.

Other IAEA publications with additional information related to the issues covered in this publication are listed in the references.

2. KEY SPECIAL ASPECTS IN RESTARTING A DNPP

The following are relevant items specific to managing the process of restarting a DNPP until the completion:

Management aspects

- Establishment of a project management organization during the different periods of DNPP restarting process, including the dedicated Project Management Team and the appropriate management system, based on the existing “core group” which managed the DNPP during the interruption and preservation period.
- Project management configuration based on the specific physical status of DNPP at restarting.
- Human resources management, including recovery of former human resources and knowledge about DNPP.
- Knowledge management and configuration management programme development.

Technical aspects

- Detailed verification of basic conditions for DNPP resumption (physical status, existing documentation, suspended commercial contracts, preservation of existing equipment, materials and spare parts, etc.) and assessment of the technical conditions.
- Updating of specific analyses or studies related to DNPP environmental impact, required data for the meteorological, seismical and hydraulical situation including the climate change influences.
- Updating the technical specifications and procurement packages.
- Establishment of prioritization application strategy for preservaion and maintenance and the detailed preservation verifications.
- Additional works during DNPP project completion due to the delay period related with:

- Missing material traceability
- Pending factory non-conformance reports
- Corrective and compensatory measures programme implementation, additional repairs, equipment refurbishment, rehabilitation and mandatory design changes
- Special measures for systems flushing, hydrostatic test programmes and subsequent in-service-inspection programmes, due to long time of interruption of the DNPP activities
- Requirements for specific skills and qualification of the site subcontractors for equipment and components refurbishment and replacement programmes
- Identification of components obsolescence and potential suppliers/change of suppliers
- Combination of DNPP re-starting process with application of plant life extension and operational feedback from NPPs with the same type of reactor, based on existing (old) equipment

— Acceptance criteria for turnover of DNPP to operation with some acceptable exceptions, due to the long time of project finalization.

Regulatory aspects

— Updating licensing documents based on the assessment of the current standards and licensing requirements, including the definition of the mandatory design changes and revision of the technical support documentation for licensing (mainly the Basic Design, Preliminary Safety Analysis Report and Environement Analysis Report).

Economical aspects

— Economical conditions for completion, including budget, financial plan and reassessment of the original suppliers for goods and services.
— Specific risks analyses associated with establishment of the strategy for DNPP completion, including selection of contractual approach (turn-key, multi-packages, etc.).

The above mentioned key aspects are specific to the DNPP completion process and are normally not found in a NPP project implemented according to the original schedule.

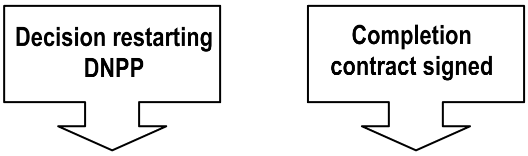
3. PROJECT ORGANIZATION

3.1. Project management organization

The project management organization, as for any large project, is essential for the success of restarting the DNPP in terms of quality, cost and schedule. This activity starts with the definition of the project as a unique system to be produced with certain inputs, constraints and goals and ends when the complete functioning system is turned over to another organizational entity that should be in charge of operation and maintenance of the completed project. The typical role and the main functions of the NPP project management organization are described in the Reference [2].

The DNPP project management organization and its supporting organizations, in the different periods of the DNPP project (interruption and preservation, pre-project activities and project implementation) are the key resources for the success of the project completion. Completion of each DNPP has particular issues, which determine the configuration of the project management organization in the different periods. The specific project management organization is also dependent on the DNPP status at the moment of restarting.

The project management organizations for each period of the DNPP completion are shown in Figure 3.1.



DNPP period	PRESERVATION	PRE-PROJECT	PROJECT IMPLEMENTATION
Project management organizations	CORE GROUP	CORE GROUP and UTILITY DEPARTMENTS	- UTILITY - MAIN CONTRACTOR - PROJECT MANAGEMENT TEAM

FIG. 3.1 Project management organizations for DNPP

3.1.1. Project management organization during DNPP interruption and preservation

The IAEA publication Reference [1] recommended that, during the interruption and preservation period of a DNPP the nuclear utilities should maintain a core group, to play the role of the project management organization during this DNPP period. The core group is made up of expert technical and administrative staff dedicated to all DNPP activities that are needed to maintain project assets and to enable project resumption. The core group acts as a small/reduced project management organization and has the main responsibility for preserving the following DNPP resources:

— Assets, equipment and facilities,
— Documentation,
— Contracts and warranties,
— Personnel.

The core group has also responsibilities for the preparation of all documentation and information necessary for the decision process leading to restarting and completion of the DNPP. Usually, the government makes that decision with inputs from various concerned groups, including the management of the utility and the plant. In this process, known as "Project decision-making", the core group is responsible for the preparation of the required information for the final decision about the future of DNPP. This process is described in detail in Reference [1]. If the DNPP has been properly managed and adequately supported, much of the required information should be readily available, but even so, the preparation of a suitable submission requires considerable effort and time. The most important document issued by the DNPP owner is the feasibility study, prepared under coordination of the core group. The feasibility study is primarily intended to provide the relevant authorities with all the necessary detailed information needed to decide on the implementation of the project. It is also needed in the negotiations for financing of the project, as all financing institutions usually request it.

3.1.2. Project management organization during DNPP pre-project activities

The overall responsibility for ensuring the fulfillment of the specific DNPP requirements for this period is placed on the utility and the project management activities should increase once the decision to restart the DNPP is made.

After the decision of the restarting the DNPP is made, the main task of the utility, to be performed using the dedicated project management organization, is to prepare the future mandatory actions for the project implementation. The existing DNPP core group should manage these activities with support from certain groups of the utility head office departments. The dimension and scope of this project management organization dedicated for this pre-project activity largely depends on the degree to which the project has advanced, and the detailed action plans established by the DNPP utility during this important period.

In the period of pre-project activities, the DNPP project management organization should require more involvement from the utility's head office departments because of the specific activities that involve interacting with national authorities such as the ministry of environment, regulatory bodies and also with the public opinion. The site activities required in this stage, which do not involve DNPP progress work, can be managed by the enlarged DNPP core group and may be based on short term contractual relations with local erection and services organizations.

The specific procedures, which describe the interaction of the DNPP project management organization with decision makers, regulatory bodies, vendors and contractors for goods and services, should be developed. In this period decisions for the future of the DNPP are adopted, especially those concerning the contractual approach and financial plan, which require the specific approval of the DNPP utility shareholders, whether that is the state, represented by the specific ministers — economy, energy, public finance — or the potential private investors. This period determines the future configuration of the DNPP project management organization, which is imposed by the contractual approach adopted.

The DNPP project management organization during the pre-project period contains typically the following departments: engineering, construction, safety and licensing, quality management, training, finance, commercial, legal assistance, administration and public relations.

3.1.3. Project management organization during DNPP project implementation

This period starts with the signature of the DNPP commercial contract completion, at the end of negotiation period, as shown in Figure 3.1 and ends with the completion of the DNPP commissioning and its acceptance (turnover to operation) which allows the utility starting commercial operation. This period can be described as project-oriented activities leading to the successful construction, commissioning and acceptance of the DNPP.

The DNPP Project Management Team (PMT), its organizational chart, obligations and responsibilities are determined by the strategy selected by the DNPP utility for project completion and the contractual negotiations with selected contractors/suppliers. Whether or not the utility is involved in the DNPP PMT, the control rights of the DNPP PMT should be kept in the utility's management or head office departments. The purpose is to ensure the organization of a utility project management group that has functions and responsibilities similar to those described in the References [2] and [3], just as they would for a new NPP.

The DNPP PMT during the project implementation period is responsible for the DNPP project completion by scheduling, budget control, engineering, construction, erection, commissioning and turn over to operation. The specific roles and activities of the DNPP PMT are described in Section 7.

The annexes present some good practices and experiences of the Member States for the DNPP PMT organization and responsibilities during the project implementation period.

3.2. Description of the restarting process

The DNPP restarting process includes two periods: (A) pre-project, and (B) project implementation, each of them containing particular activities, which are described below. The restarting activities begin after the decision for the DNPP completion is adopted and are characterized by the following activity areas:

A. DNPP pre-project activities

(1) Detailed verification of the DNPP status

- Technical verification of the existing assets, equipment, material, work already performed, history files, documentation, suspended contracts and approvals, permits and licenses.
- Economic and financial evaluation of the existing assets and assessment for the future activities.
- Evaluation of the remaining work for DNPP finalization, acquisition of materials and assessment of documentation to be issued and evaluation of potential suppliers.
- Evaluation of the existing and available human resources for the project implementation.
- Preparation of the DNPP Status Verification Report(s).

(2) Preparation for DNPP resumption

- Finalization of the required studies (Environmental Impact Assessment, etc.) for the applicable licenses.
- Public information, consultation and acceptance.
- Assessment of the new standards and new regulatory requirements.
- Specific analyses or studies to update the required data for the meteorological, seismically and hydraulically situation, including the climate change influences.
- Definition of the mandatory design changes required by new regulations and technological improvements.
- Establishment of the nuclear safety licensing bases and project licensing schedule as approved by the national nuclear safety regulatory body.
- Performance of the detailed and logical schedule for DNPP completion.
- Assessment of the local and international market for the identification of the potential suppliers for goods and services and verification of their qualification and capabilities.
- DNPP site activities such as cleaning, documentation, non-conformities, repairs, maintenance, infrastructure upgrading, limited budget work, etc.

(3) Determination of the strategy for the DNPP completion

- Selection of the contractual approach (turn-key, multi-packages, etc) and project management configuration.

— Establishment of financial approach and financing plan (commercial loans, guaranteed loans, specific financing, etc.).

(4) Contracts for DNPP completion and financing
- Preparation of Bid Invitation Specifications (BIS).
- Selection of contractors/suppliers (bids evaluation, selection of the bids, negotiations).
- Closing of the contract/contracts.
- Selection of financial suppliers/sources.
- Fulfilment of the precedent conditions for effectiveness of the commercial contracts and financing.

B. DNPP project implementation activities

(5) Project management
- Planning and scheduling.
- Finance and budget control.
- Public information and communication.
- Management of all DNPP finalization activities.

(6) Project engineering
- Basic and detailed design engineering.
- Engineering for procurement.
- Safety Analysis Reports and licensing application.

(7) Procurement and manufacturing of equipment and components
- Equipment and components design.
- Planning of manufacturing.
- Production of equipment and components.
- Inspection and control during manufacturing.
- Reception, transportation, storage and maintenance/preservations.

(8) Plant construction, erection and installation
- Civil works and mechanical erection.
- Electrical and I&C installation.
- Repairing, refurbishment, inspections and maintaining of equipments and systems.
- Inspection and testing (pre-commissioning) of equipments and components.
- Turn over to commissioning.

(9) Plant commissioning and acceptance
- System commissioning tests.
- Optimization of the plant system functions.
- Verification of the operating procedures.
- Familiarization of the operating personnel with the plant systems.
- System and plant acceptance and turnover to operation.

The route map for the DNPP project completion is shown in Figure 3.2, which presents all above mentioned activities and also the corresponding management organizations involved.

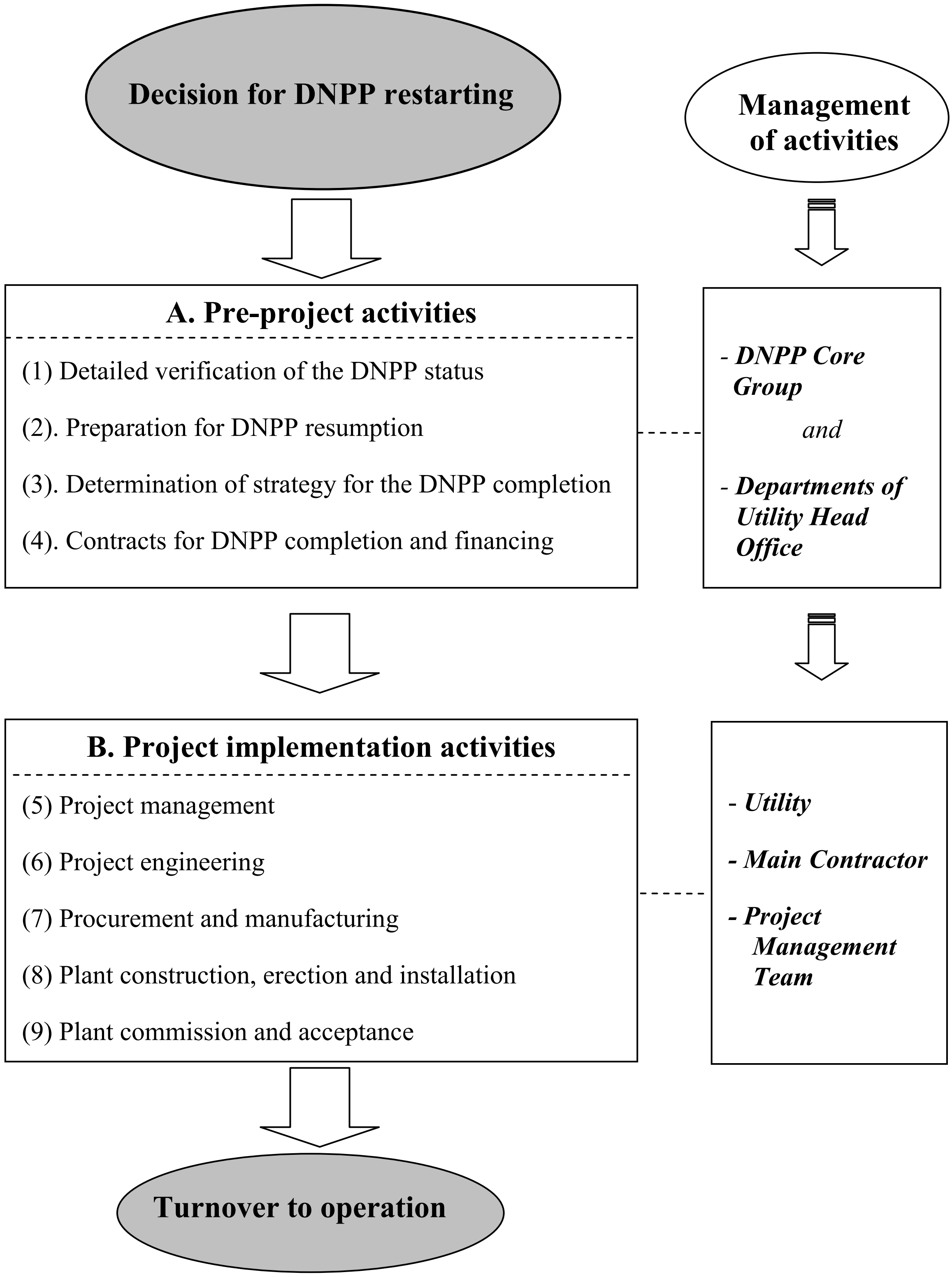


FIG. 3.2 Route map for the DNPP restarting activities and involved managing organizations.

3.3. Management system

The completion of the DNPP project is a major undertaking and requires the implementation of an integrated management system directed to provide a single framework for the goals, arrangements and processes of the organization. The goals include safety, health, environment, economic, communications, security, quality and others such as social responsibility.

Personnel, equipment and organizational culture as well as the documented policies and processes are integral parts of the management system. Requirements and guidance for integrated management systems are established in, for example, IAEA Safety Standards [9] and [10] and other IAEA technical documents identified as References [2]–[6].

The main aims of an integrated management system are:

— Bringing together in a coherent manner all the requirements for managing the organization and the project;
— Describing the planned and systematic actions necessary to provide adequate confidence that all these requirements are satisfied; and
— Ensuring that health, environmental, security, quality and economic requirements are not considered separately from safety requirements, to avoid the possibility of their potential negative impact on safety.

Safety is paramount within the management system, overriding all other demands. The management system identifies and integrates the requirements contained within the applicable codes, standards, statutory and regulatory requirements of the Member State as well as any requirements formally agreed with stakeholders.

The management system promotes and supports a strong safety culture by:

— Assuring a common understanding of the key aspects of the safety culture within the organization;
— Providing the means by which the organization supports individuals and teams to carry out their tasks safely and successfully, taking into account the interaction between individuals, technology and the organization;
— Reinforcing a learning and questioning attitude at all levels of the organization; and
— Providing the means by which the organization continually seeks to develop and improve its safety culture.

An announcement of the PMT highest management level should be issued immediately following signature at the DNPP completion contract to present the PMT organization chart, project manager, level of authority and responsibilities within the organization, basic information on the type of project organization chosen, budget codes, and preliminary communications and signature procedures inside PMT.

The implementation and control of project definition and the communication of decisions are continuous tasks during project execution, but are particularly important at the beginning of the PMT activities. As far as possible, front-end definition of all DNPP project management aspects may be achieved, even if corrections have to be made later. The interpretation of contractual terms into concrete project requirements usually involves a special effort by DNPP project management. Whatever is decided for the project organization should be established in writing and collected in an appropriate form, i.e. in manuals and procedures. The role and characteristics of such project manuals and procedures are described in Reference [2].

The DNPP PMT project manual and procedures should describe the interaction with contractors, suppliers, regulatory bodies or any other participants in the project completion. The turnover process to the DNPP utility operation team, including the owner's or utility's participation in the commissioning, should be defined, as well as the relationship and boundaries between the DNPP PMT and DNPP utility. This should include the DNPP utility information system about the status of the completion as carried out by the DNPP PMT and the control rights of the DNPP utility over the PMT's activities and performances.

The practices and experiences of Member States for the DNPP PMT implemented during the DNPP pre-project and project implementation periods are presented in the annexes.

3.4. IAEA technical support for DNPP

The IAEA collects related information and supports the management of the DNPP projects by identifying the most common issues, transferring available experience and addressing specific problems and needs.

The IAEA may provide technical support services, described in Annex VI, which are tailored to the needs and requirements of the requesting organizations responsible for DNPP project completion. These services are based on international expertise and address areas such as:

- Project management
- Quality management
- Safety culture
- Peer reviews
- Public information and communication
- Technical support
- Schedule and budget control
- Risk analyses
- Human resources and human performance improvement
- Updating to technological and regulatory requirements
- Design analyses/review
- Environmental issues
- Cost-benefit analyses
- Instrumentation & control modernization
- Safety systems and engineered safety features
- Co-operation with regulatory body

The IAEA can also provide technical support for the DNPP owner or operator for several different issues such as assessing if upgrades are needed and if the technology is kept up-to-date, suggesting managerial approaches to use during the implementation of the DNPP and to make sure it operates safely and economically. The sort of support the IAEA cannot offer is where commercial decisions are concerned, as these do not fall under the IAEA scope.

The Member States can benefit from IAEA technical support in a number of ways, including making requests for an advisory or review mission through a national technical co-operation project. It is also desirable that the Member States and owner/operating organizations obtain advice from appropriate international organizations and commercial suppliers.

4. VERIFICATION OF BASIC CONDITIONS FOR DNPP WORK RESUMPTION

4.1. Technical conditions

The technical verification of the existing assets, equipment, material, work already performed and existing documentation was a task of the DNPP core group during the interruption and preservation period (delay phase). The results of this verification serve as input to the feasibility study for DNPP restarting and completion. After the decision to re-start the DNPP has been made it is useful to perform additional detailed technical verification, in order to obtain more precise information for the next periods of the DNPP project restarting.

4.1.1. Evaluation and assessment of the existing conditions

The current condition of resources already at DNPP site should be determined by detailed technical verifications in the following areas:

A. Documentation

- Documentation (engineering and design packages) already completed and manufacturer's documentation for equipments and components already supplied.
- Records (history dockets) for all work already done, including all the non-conformity reports and site field changes or dispositions.

B. Physical status of the plant

- Establishment/verification of the exact point where each building, component, equipment or system has stopped when the construction, erection, commissioning or maintenance were suspended.
- Inventory and inspections of all existing buildings, components, equipments or systems and facilities for detailed technical assessments, including the preservation status and real condition, and assessment of the ageing effect.

C. Licensing

- Status of licensing process, including required support documentation (Preliminary Analyses Safety Report, etc.).
- Approvals, permits and licenses validity.

D. Contracts

- Suspended commercial contracts with vendors, suppliers, site contractors, especially for the local construction and erection subcontractors.

E. Material control and warehouses

- Management of the existing materials (material identification system, material traceability, storage/warehousing, preservation, material and spare parts inventory, quarantine of non-conforming material).
- Warehouse evaluation and verification of the warehouse preservation.

The above-mentioned activities should be performed by the DNPP utility, under the management of the core group and with the specific support of the departments of the DNPP utility head office. The following are good practices based on the experience of the Member States that may be used.

- Verification and assessment of the existing DNPP, in the areas mentioned, by an independent consultant of DNNP utility, with experience in the particular type of DNPP and management of NPP projects.
- Engineering organization involved originally in the DNPP design activities may be used for these verification and assessment activities.
- The verification of the existing buildings, components, equipments or systems and facilities should be based on the specific technical criteria and inspection program developed by the engineering organization involved in these activities. Examples of these technical criteria are the following:

- Conformity with the original applicable engineering packages
- Results of the preservation procedures applied during the plant delay period
- Fulfilment of the new applicable codes and standards and establishment of the deviations and nonconformities, including quantitative and qualitative analyses.

- The performance of the activities should be supported by a modern and complete record and information system which includes the construction, erection, commissioning and maintenance information, engineering packages and project documentation, commercial contracts and licensing information.

- The results of these assessment and evaluation should be included in the specific technical reports (Status Verification Reports) and studies, which will be used by DNPP utility for furthers decisions.
- Verification and assessment activities should be considered input data for the preparation and implementation of the DNPP technical restarting programme.

In the annexes good practices, identified issues and solutions successfully applied in the Member States are presented.

4.1.2. Evaluation and assessment of the required work for the DNPP completion

The amount of work remaining to be done for the DNPP completion should be accurately verified and assessed in the following areas:

A. Engineering

- Verification of project safety design guides, design requirements and engineering design solutions, in the light of changes during the delay period into codes, guides, standards and regulatory requirements.
- Establishment of the revised project Design Bases for engineering, licensing, construction and commissioning.
- Assessment of the experience gained during construction of similar new NPP units.
- Evaluation of the feedback from commissioning and operation of similar new NPP units.
- Definition of design changes and engineering upgrades (possible to be implemented), as consequence of new regulatory requirements, operational assessment and technological developments.
- Performance of the analyses or support studies for the climate change influences (in the period of delay and prediction for the future period), which may have an impact on parameters that may affect the DNPP operation (external air temperature, flow/level/temperature of cooling water, tornado, etc.).
- Performance of analyses or studies for updating the required data for meteorological, seismic and hydraulically situation.

— Evaluation of the engineering and design packages required to complete the DNPP project.

B. Planning and scheduling

— Performance of detailed and logic schedule for advancing and completing the project, covering the following major elements: engineering, procurement, construction (including refurbishment), pre-service inspection, checking, and testing and commissioning.
— Definition and submission for approval of the regulatory body of the project licensing schedule and required technical support documentation for the different phases of the project (engineering, procurement/acquisition, equipment and components manufacturing, construction, erection, commissioning and turn over to operation).

C. Licensing

— Assessment of the IAEA Safety Standards (in their evolution and revision) in order to determine the impact on the licensing process, specific changes and improvements.
— Identification of the impacts on design or construction work already performed due to the additional or new requirements from regulatory body.
— Finalization of the Licensing Bases Document, to be submitted for approval by the regulatory body, which includes all the specific regulatory requirements for all project finalization phases (design, construction, erection, commissioning and turn over to operation).
— Revision of the Preliminary Safety Analyses Report (PSAR) for DNPP finalization that must reflect all the changes imposed by new licensing requirements.

D. Acquisition, procurement and supply

— Equipment obsolescence (especially on electrical and I&C), definition and evaluation of its impact on engineering, erection and commissioning.
— Determination of existence on the market of original equipment and services suppliers or identification of new sources for procurement and evaluation of their ability to provide support for the DNPP finalization.
— Determination of additional equipment and services to be ordered for the project completion.

E. Construction, erection and commissioning

— Assessment of the local and international market for the construction and erection organizations potentially available and qualified to perform the balance of the work (civil, mechanical, electrical, I&C, commissioning, etc.) required for DNPP finalization.
— Evaluation of the balance of the work to be performed for the DNPP completion for each discipline (civil, mechanical, electrical, I&C, commissioning, etc.) calculated in manhours.
— Assessment of pending non-conformance reports issued during manufacturing
— Site acceptance test before operation of systems

F. Communication and public information

— Performance of the Environmental Impact Assessment (EIA) study and all technical support documentation for the public consultation and ESPOO convention consultation, through the minister of environment.

— Evaluation of the required actions for public information during project implementation period, including public information centre on the DNPP site.

G. DNPP site infrastructure

— Assessment of the new site office buildings for PMT organization (if required) and evaluation of the refurbishing of the existing site offices and infrastructure on the DNPP site.
— Evaluation of the additional buildings required for accommodation (town site) of the DNPP utility, PMT and contractors personnel.

H. Human resources

— Evaluation of the human resources training requirements for the engineering, project management, construction, erection, commissioning and commercial operation of the DNPP.
— Assessment of the required training facilities (training centre, laboratories, welding school, full scope simulator, etc) and services (training in similar NPP or in the "reference plant", etc.).

I. Nuclear fuel cycle, radioactive waste management and decommissioning

— Establishment of nuclear fuel supply plan and financial evaluation of all required specific actions.
— Preparation of the radioactive waste management program (including the spent fuel management), during the normal plant operation, for the entire life time of DNPP.
— Assessment of the final disposal and radioactive waste management plan (including spent fuel disposal) and legal provision for the DNPP utility financial contribution.

The above-mentioned activities should be performed by the DNPP utility staff, under the management of the core group and with the specific support of the departments of the DNPP utility head office. The following are good practices and experience of the Member States that may be used for the performance of the above-mentioned activities:

— Verification and assessment of the required work for the DNPP finalization, in the areas mentioned, by an independent consultant of DNNP utility, with experience in the particular type of DNPP and management of NPP projects.
— The success of the above mentioned activities is very dependent on the relationships and cooperation with the different potential participants to the DNPP project completion.
— Relationships of the DNPP utility and its consultants with the regulatory body should be sincere and open, but formal. The following good practices and recommendations may be used:
  - Clear and unobstructed lines of communication should exist between the DNPP utility and the regulatory body.
  - The regulatory body staff should have open and unrestricted access to the project information, databases and personnel.
  - Official contacts between regulatory body and DNPP utility should take place through designated personnel.
  - Regulatory body representatives should have easy access to the DNPP utility designated personnel and pertinent information.

- Long-term and co-operative relationship with vendors of nuclear technology and specialized architects-engineers may be very beneficial.
- The DNPP utility team involved in performance of these activities and their consultant should have access to the records of work already done (Feasibility Study, Status Verification Reports, Inspection Reports, approvals, licenses, permits, engineering, documentation, construction, erection, commissioning, maintenance, equipment, materials, spare parts, suspended contracts, etc.).
- If there is a similar NPP unit/plant in construction, commissioning or operation this may be used as a "reference project" for the DNPP.
- The Licensing Bases Document should take into account the actual physical status of the DNPP and the real possibilities to implement specific changes imposed by the new licensing requirements.
- The impact of new requirements, including codes and standards, would be better defined if some additional safety studies and clarification of the requirements are performed. The proposed solutions should be presented to the regulatory body.
- The assessment and evaluation of the new requirements should be concluded into a design changes list applicable for the DNPP completion, subject to regulatory body approval.
- The design changes lists should be required before the definition of the balance of engineering documentation developed for the DNPP project completion.
- Equipment and components suppliers' assessment and evaluation should start with the suppliers of the existing equipment and materials for which the contracts were suspended during DNPP delay period.
- Assessment and evaluation of the services suppliers, especially for the construction, erection and installation activities, may start with the contractors that performed the existing work in the DNPP.
- DNPP utility may establish a co-operative "experience programme" with other DNPP utilities, for the purpose of exchanging information and learning from experience of others.

Good practices and solutions in this area are presented in the annexes.

4.2. Economic and financial conditions

The evaluation of the economic and financial conditions is mainly referring to the determination of the DNPP project budget for completion and the required financial plan. These activities should be performed and finalized in order to create the basement for the establishment of the overall and specific strategies for DNPP completion.

4.2.1. Project budget

The evaluation of all capital expenditure required to complete the DNPP project is typically part of the feasibility study. After the decision to restart the DNPP has been adopted it is recommended to do additional detailed economic assessment and verification, mainly for the project completion capital expenditure (project budget). All the indicated capital/investment cost components should be carefully assessed and evaluated. The capital cost breakdown structure is dependent of contract approach and project management and varies from country to country. For example, in some countries the initial nuclear fuel load and other special material (e.g. initial load of heavy water for PHWR) are included in the capital cost. The information and recommendations included in the Reference [16] may be used for the DNPP project budget assessment and evaluations.

These assessment and verification should be based on the detailed reports that described the results of technical verification activities, mentioned above in paragraph 4.1. These types of activities are not so much different from similar cost assessments for a new NPP. The differences, specific for DNPP, are identified in the following areas, for which particular economical (cost) evaluations may be performed:

A. Engineering

- Incorporation in the engineering packages of the design changes due to new regulatory requirements, changes in applicable codes/guides/standards, equipment obsolescence, operational assessment and technological development.
- Producing the additional safety design studies and licensing technical support packages required by the new regulatory requirements, including project Design Bases, Licensing Bases Document, Preliminary Safety Analyses Report and Licensing Schedule.
- Performance of the additional engineering work (environmental impact assessment study, climate change influences, inspection of work already performed, additional tests and inspection of equipment and components after refurbishment, etc.).
- Finalization of the engineering and documentation packages as required for the DNPP completion.

B. Acquisition, procurement and supply

- Old supplier commercial contracts negotiation, including the warranties and guaranties for existing equipment and materials.
- Replacements of equipment or materials defined as obsolete or undesirable for further use in operation.
- Acquisition of new components due to the missing documentation and quality management records.
- Materials, tools and instruments defined for the equipment/systems refurbishment and additional testing program.
- New equipment based on the modern and up-to-date technologies.
- Nuclear fuel required for DNPP commissioning (first criticality) and other nuclear special materials (heavy water, chemicals, etc.).

C. Construction, erection and commissioning

- Specific verification of preservation, inspections, retesting of the existing building, structures, equipment and systems.
- Additional testing that should be performed early enough in the program to take corrective action if required.
- Implementation of the refurbishment program on identified equipment, including manpower for specific checking and testing.
- Implementation of modern construction methods (modularization, open-top, etc.).

D. Project management

- Additional manpower required on DNPP site to manage the project completion (site engineering, construction, erection, commissioning, procurement, material management, planning and scheduling, financial and administration).
- Implementation of modern tools (software and hardware) for the management of the specific areas of DNPP (electronic document management system, scheduling, procurement and material control, 3D CAD, etc.).

E. Training of human resources in the specific area for DNPP (engineering, project management, inspection, testing, etc.).

F. Insurance, including — when available — the Construction All Risk (CAR) insurance for construction and erection period and the Nuclear All Risk (NAR) insurance applicable starting with the first criticality of the nuclear reactor.

G. Administrative and social costs, including the site infrastructure, refurbishing of the existing site office buildings and town site for accommodation of the owner and contractors personnel.

The above-mentioned activities should be performed by the DNPP utility, under the management of the core group and with the support of the departments of the DNPP utility head office. The following are the good practices based on the experience of the Member States which may be used for the performance of the above-mentioned activities:

- Cost evaluations and assessment in the mentioned areas specific to the DNPP completion may be performed using an independent financial consultant of DNNP utility, with experience in the particular type of DNPP and management of the NPP projects.
- Evaluation of the costs and assessment for the above-mentioned area should be based on the financial evaluation included in the approved DNPP Feasibility Study and also on the inputs received from the similar DNPP projects, new NPP and information from the potential suppliers of goods and services for project finalization.
- Complete scope of work definition as well as a realistic project schedule is required for the preparation of the DNPP finalization project budget.
- The DNPP project budget should contain an evaluated and assessed contingency amount, which should cover undefined work and risk of possible major changes. The amount of contingency for a DNPP project depends on the extent different factors (example: physical status of the DNPP, inspections and reviews required to be done prior to the implementation of the commercial contracts for finalization, defined risks for the DNPP finalization, etc.).
- Due to the greater unknowns associated with DNPP project completion, the contingency should be increased to 10 to 12% of the DNPP overall budget, depending on the degree of scope of work definition. This recommendation is based on the contingency used for a new NPP unit, mentioned in Reference [2] and international experience (contingency for a new CANDU 6 NPP unit is approximately 8% applied to the overall project budget — see Annex IV).
- As for the new NPP construction projects, it is recommended that the overall DNPP budget to be cash flow, in order to clearly identify the required resources (personnel and cash flow) for the DNPP project completion.

Good practices and solutions in the field of DNPP project budget evaluation are presented in the annexes of this document.

4.2.2. Financial plan

The availability of adequate and secure financial resources is probably one of the most crucial constraints affecting the completion of a DNPP project. In the context of competitiveness of total electricity generating costs, financing is a key issue to be addressed before the successful implementation of a DNPP project. Financing of nuclear power plants generally has been facilitated by the need for base load electricity at stable projected production costs, competitiveness of the nuclear option, stable regulatory regime and indirect or direct government support.

Total financing arrangements for a DNPP project completion are influenced by the cost of capital and schedule. The financial credibility of the DNPP utility in front of the financial institutions plays a very important role in financial arrangements for DNPP project completion.

The financial plan includes the collection of relevant data (as a function of time) on program related factors. These comprise the total capital investment, the nuclear fuel cycle cost, and the establishment of debt/equity targets and the assessment of the potential financing sources. There are no differences between the financial plan for a new NPP and a DNPP, except the required capital investment for DNPP completion. The good practices, recommendations and details for the NPP financial plan are presented in the References [2], [3], [6] and [19].

In some countries the role of the state is very relevant for the financing of the DNPP completion. This statement is referring not only to the state participation to the financing of DNPP completion but also to the financial facilities granted to the DNPP, like taxes discount for the imported equipment and materials, for documentation and engineering packages, etc. These measures should have a positive impact on financing of the DNPP completion.

The financing agreements should be negotiated and finalized typically after the commercial contracts were negotiated and concluded. The parties in a financing agreement are the financing institution and the owner/utility of DNPP. The main suppliers/contractors of the DNPP completion can provide specific assistance to the owner in the process of obtaining and negotiating loans, in the best possible terms and conditions.

4.3. Human resources

The DNPP completion process, like a new NPP project, requires adequate competence of the NPP utility to manage such a complex project. The adequate human resources are the key factor to successful restart and completion of DNPP project. Effective measures to preserve human resources should be taken by the DNPP utility management. The duration of the delay period may have significant impact on the DNPP dedicated human resources (core group), with losses and ageing of qualified personnel.

After the adoption of the decision for DNPP completion the following specific actions, measures and good practices in the field of human resources should be implemented:

— Evaluation and assessment of the level of competence of DNPP staff (core group) and utility head office staff dedicated to the project.
— Development of a knowledge and information transfer process from the DNPP core group to the future PMT, in the pre-project period.
— Recovery of former human resources and knowledge about DNPP, starting with the pre-project period.
— Preparation and implementation of the specific training program performed by vendors and equipment suppliers in the adequate training facilities.
— Implementation of the additional training and knowledge updating program, including the particular aspects of DNPP (preservation, verification, checking, rehabilitation, refurbishment, etc.).
— Finalization of the recruitment/selection plans and put into action at the proper time, so the necessarily staff is in position in required numbers and quality.

— Training of the managerial, supervisory, operating and maintenance personnel in sufficient numbers in all the knowledge and skills required.
— Development of a succession plan for human resources of DNPP utility organization.
— Clarification of the personnel licensing requirements and process with regulatory body.
— Re-licensing of the authorised NPP shift supervisors, main control room operators and local operators (if required).
— Refreshment of DNPP operation team (operation, maintenance, etc.) training (if needed).
— Preparation of a plan for sharing of human resources (skill and trained people) with others utilities from the geographical area, during construction/erection/commissioning.
— Development of the incentives and motivation program (bonuses, salary increases, attractive conditions and infrastructure, etc.) for the personnel involved in DNPP finalization.

These measures should be adequately planned and supported with enough resources by the DNPP utility. Good practices and recommendations in the area of human resources for NPP are presented in the reference [17].

Data, information and knowledge critical for the DNPP completion were generated from the initial stage of the plant. The DNPP utility should be strongly involved in the knowledge preservation and knowledge transfer in the process of the plant completion. Specific knowledge on risk assessment has to be performed by the DNPP utility at the earliest stage of the restarting. The fundamental elements needed for an effective knowledge management system and guidance concerning the methods for knowledge management implementation is described in the Reference [26].

The above-mentioned activities should be performed by the DNPP utility, under the management of the core group and with the support of the departments of the DNPP utility.

The annexes of this document present good practices of the Member States in the field of human resources, the recovery of staffing for the DNPP project management and training of the DNPP personnel in the project critical disciplines.

4.4. Public information and consultation

Public attitude towards nuclear power is one of the decisive factors for implementation of a nuclear power project. Regarding public acceptance there are no specific aspects for restarting DNPPs in comparison with new NPPs. It is supposed that when the DNPP was started the public accepted the nuclear power option in the national energy mix.

The following are several good practices based on the experience of Member States and may be used for the purpose of the public information and consultation:

— The experience has shown that an effective way to influence public opinion is through a carefully designed long-term public information programme based on correct and neutral information, developed by DNPP utility.
— Public information programme requires a major effort and its importance should not be under estimated.
— Public information programme should be developed taking into account the following criteria and measures:

  - Define the goals, messages to be delivered, key target audience, method of communication, and existing assets that can be drawn upon.

- Include teaching about energy and electricity including nuclear energy in schools, universities, information centres, a strong media relationship programme, and a separate information programme for legislators and politicians.
- Present benefits and advantages of the DNPP finalization, as well as risks, in a balanced manner to bring in the benefits and the risks, and that there are adequate provisions to mitigate the perceived risks.
- Use socio-economic, strategic, technical and environmental aspects related with the nuclear power project and alternatives, showing advantages of project and analyzing the case of having no project at all.
- Explain the justification of the DNPP finalization in terms of its economic viability, its contribution to energy independence and how it fits with economic development plans on a national level, and its impact on economy, development and employment at a local level.
- Use information from the Environmental Impact Assessment (EIA) study and feasibility study for the project finalization.
- Include conferences, dialogues and seminars directed at communications media and at various civic, professional, social and educational organizations.
- Use films, lectures and group discussions giving factual information on both the benefits and risks involved in the project.
- Prepare information in a manner and at a level that the layman should understand and appreciate.

— Public information programme should be aimed to:
  - Population around the site and at the general public.
  - Governmental officials, political parties, labour unions, universities, schools and other non-governmental or civil organization.
  - Local leaders and person of influence (elected municipal officials, teachers, local company administrators, health and safety managers, religious leaders, etc.).

— Public information program should be implemented by preparation a package of documents, including popular brochures and a specific campaign. News media should have an important role in the implementation.

— In the implementation process, the DNPP utility should seek full support from all relevant authorities, at the local and national levels.

— Experience has shown that in order to facilitate public information about nuclear power activities, there is also a need to supply the public with timely, adequate and easily understandable information on safety principles and regulatory requirements applied to the NPP.

— Public consultation and participation in decision making is another tool towards public confidence building.

— The public consultation should be carefully organized to a wide range of stakeholders and sufficient time to respond to the views of the participants and to receive public opinions.

— Develop a social program in the area of the DNPP, supported by the DNPP utility and its shareholders. This program may assist in investment programs for the implementation of particular community projects with benefits for the DNPP local community (schools, hospital, etc.). In some countries the national or local Government may help the social program by funding the specific community projects using state budget.

- In order to be conducted a public consultation by the appropriate authorities (local environmental agency, etc.) the EIA study should be used by the DNPP utility.
- EIA study should address all the specific aspects of the nuclear power plant, its content be in accordance with national law/standards/guidelines and take into account the guidelines issued by the World Bank, OECD and Export Credit Agencies, involved into the nuclear power project financing.
- Based on the national environmental regulatory requirements and financing institutions (Export Credit Agencies) rules, the result of EIA study or an EIA executive report should be used for the cross boundary public consultation, mainly in the neighbouring countries, in order to fulfil the international requirements (ESPOO Convention). This process should be managed by the national environment ministry with contribution from the DNPP utility.

The above mentioned activities for public information and consultation should be performed by the DNPP utility, under the management of the core group and with the support of the departments of the DNPP utility head office.

The good practices and solutions in the field of DNPP public information and consultation, already successfully applied by the Member States for the DNPP completion are presented in the annexes.

4.5. Establishment of overall strategies for DNPP completion

4.5.1. Contractual approach

Based on the information available from the previous stages, the overall strategy for the DNPP completion should be developed by the utility, subject to approval of its shareholders. This strategy should establish at least the contractual approach and adequate financing sources for the DNPP completion.

The overall strategy for DNPP completion should be developed and proposed by the core group with the support of the departments of the DNPP utility and should be subject to DNPP utility high level management approval.

Nuclear power plants have been contracted in a wide variety of ways. The contractual alternatives for a new NPP, described in the Reference [2], are applicable also for the DNPP completion. Basically, there are the following three different types of contract approach:

- **Turnkey approach,** where a single contractor or a consortium of contractors takes the overall responsibility for the whole works;
- **Split-package approach,** where the overall responsibility is divided between a relatively small number of contractors, each responsible for a plant building or a large section (discipline) of the works;
- **Multi-contract approach,** where the NPP owner/utility or his architect-engineer (A/E) assumes overall responsibility for engineering the station, and is issuing a large number of contracts for different sub-contractors.

The following specific measures and good practices in this area should be taken into account:

- The status and completion of the DNPP at the moment of interruption should determine the adequate contractual approach for the completion.

— If the DNPP was stopped at the beginning of the work, with only civil work started and no mechanical or electrical installation, it may be recommended to use the turnkey contractual approach.
— If the DNPP was stopped in an advanced stage, with mechanical and electrical work partially completed, then the turnkey approach should be difficult to implement. Therefore, it may be more convenient to utilize a multi-contract approach.
— The selection of the type of contract for DNPP finalization should be based on a careful analysis of all aspects described in the Reference [2]. Particularly, for the DNPP (the reactor vendor was already chosen), special attention should be given to following aspects:

  - Utility experience in management and handling large projects.
  - Availability of qualified project management, coordinating and engineering manpower.
  - Guarantee and liability considerations.
  - Development of national engineering and industry capabilities for future NPP.
  - Government and industrial relationships.
  - Competitive and economic considerations.
  - Foreign financing possibilities.

— Based on the experience of Member States which finalized DNPPs, the DNPP utility should be involved in the project finalization, solution which impose a split-packages contract or multi-contract approach. In both alternatives, the number of contractors or subcontractors should be carefully analysed, in order to allow an effective management with clear interfaces.

— In the selection of the contractual approach the specific strategy for recovery of the old and suspended commercial contracts for goods and services should be developed by the DNPP utility in agreement with the old existing supplier.

— Special consideration should be given to the sole source contracts justification, situations imposed by the characteristics of the DNPP, which was started (procurement and acquisition began) and interrupted for a period of time.

— The adopted strategy must clarify also the final solution for the following aspects:

  - Nuclear fuel acquisition/procurement for the commissioning and long-term operation of the DNPP.
  - Radioactive waste management, including spent nuclear fuel management, during the NPP operation and in final disposal.
  - Elements for the DNPP decommissioning and preliminary plan.

— DNPP utility and its shareholders or Government should decide and include in the selected strategy the sharing of the infrastructure, resources (skill and trained people) and suppliers with other utilities from the geographical area, based on the careful examination of the national resources for the different stages of the DNPP finalization (especially for the engineering, construction, equipment and material manufacturing and commissioning). Good practices and recommendations in this field are included in the Reference [7].

The different contractual approaches and models adopted in the Member States for the successful cases of the DNPP completion are presented in the annexes.

4.5.2. *Financing project completion*

Based on the evaluation of the total capital investment and project budget, and selected contractual approach, the DNPP owner/utility should establish a strategy, in the early stages of the project, for the financing the project completion. The difference between the financial plan for a new NPP and a DNPP is the required capital investment for DNPP completion that reflects the physical status of the plant to be finalized. Financing of a DNPP project could be possible through multi sourcing, a combination of export credits, commercial loans and owner’s resources. Based on the traditional financing arrangement in the construction of a NPP, the principal sources of local financing for the DNPP completion may include:

- Utility’s resources;
- Domestic bonds issues;
- Domestic loans from local banks credits;
- Credits from public entities;
- Funding from local government budget;
- Local suppliers.

Also based on the same experience, for the foreign scope of the DNPP completion, the principal financing sources are:

- Export credit agencies;
- Commercial banks;
- International development agencies;
- International bond markets;
- International suppliers.

Other financing mechanisms or arrangements, like project financing, multi-country financing, multilateral counter-trade, joint ventures and leasing may be considered. These particular financing schemes are imposed by the electricity market, deregulation and non-involvement of the government in financing of the DNPP completion.

The financing package arranged for the DNPP completion should depend on the level of financial resources that are available to the utility, in the form of utility’s equity, subordinated loans or appropriation from the national budget. An important element for financing of the foreign scope of the DNPP completion is the state guarantee for the loans from export credit agencies.

The good practices, recommendations and details for the NPP financial plan are presented in the References [2]–[4], [6] and [19].

The annexes of this document shows experience in the Member States, presenting also other solution for financing which involves the state and the DNPP utility.

Before the contractual stage for the DNPP completion, the necessary national legal frameworks for use of nuclear energy must be in place including treaties, conventions and agreements that need to be taken care of with the same time consideration as above. Non-proliferation treaty, international safeguards, physical protection and protection against terrorism, international co-operation and trans-boundary conventions are some of the elements necessary to be properly managed. Detailed information in this area is presented in the IAEA References [2] and [12]. Technical assistance in this area is available from IAEA at the request of the IAEA Member States.

5. UPDATING TO THE REGULATORY REQUIREMENTS AND CURRENT LICENSING BASIS

The DNPP utility, having the responsibility to obtain necessary licenses from the regulatory body based on the applicable national regulations, should facilitate the regulatory process by:

- Providing to the regulatory body information as required,
- Involving the regulatory body in the project activities early enough,
- Informing the regulatory body regularly of the project status and milestones.

During the interruption and preservation period, changes in the nuclear safety regulations and standards might have appeared as a result of operating experience feedback or additional research and development. Main factors to be considered for the updating of the DNPP before restarting, described in Reference [1], are the following:

- Changes and revisions of the licensing requirements, as compared to the ones in force at the time of original design and need to meet current licensing requirements (development or changes in safety concepts, special safety systems, seismic and environmental qualification, fire protection, radiological protection, emergency preparedness and accident management systems, climate changes influences on the extreme events, etc.).
- Ongoing DNPP design evolution in the delay period developed by the vendors or design authorities and implemented in similar NPPs.
- Needs to fulfil the current standards and updated technological practices (technological developments) in the areas of NPP process system, nuclear and process instrumentation and control, in-service inspection, maintainability, remote tooling, etc.

The above mentioned factors should be closely monitored during the delay period by the DNPP core group, as described in the reference [1]. After the decision for the DNPP restarting is adopted, the assigned nuclear safety and licensing application group should undertake these activities based on the input and technical reports provided by the core group. The following actions, presented in a logical sequence, should be considered in the process of updating regulatory requirements and current licensing basis:

1. Revision of the DNPP project Design Bases based on the assessment of the last edition of the applicable regulatory codes, guides, standards and IAEA Safety Standards (in their evolution and revision).
2. Identification and assessment of the impacts on construction, erection or commissioning work already performed, of the additional or new regulatory requirements.
3. Definition of the design changes and engineering upgrades (possible to be implemented), as consequence of new regulatory requirements, operational assessment and technological development.
4. Conclusion of the Licensing Bases Document for the DNPP finalization, approved by the regulatory body. The nuclear safety fundamentals principles described in Reference [10] should be taken into account in this task.
5. Performance of the specific analyses or support studies for the climate change influences and for updating the required data for meteorological, seismical and hydraulical situation.
6. Revision of the Preliminary Safety Analyses Report (PSAR) for DNPP finalization reflecting all the changes imposed by new licensing requirements.
7. Completion of the DNPP project Licensing Schedule, agreed with the regulatory body.

The above-mentioned activities should be performed by the nuclear safety and licensing application group, under the management of the core group and with the support of the departments of the DNPP utility.

The following are good practices based on the experience of the Member States and may be used for the performance of the mentioned activities.

5.1. Design changes and engineering upgrades definition and completion

- Design changes and engineering upgrades should be categorized and prioritized for the implementation based on the inputs received from designers, vendors, equipment and materials suppliers and PMT.
- The prioritization should be based on the evaluation and assessment of the design changes and upgrades contribution to the plant safe operation, and determine the important modifications that must be implemented before plant operation begins. The other modifications may be phased as part of the long term plan for updating after plant start-up.
- Design changes and engineering upgrades should take into account cost-benefit analysis, specific studies and their impact analyses (degree of enhancement of safety and operation of the plant, effect on the project cost and schedule, availability of material, etc.).
- Design changes and engineering upgrade modifications lists should be prepared and formally submitted to the regulatory body for acceptance, before preparation of budget and schedule for DNPP completion.
- Modifications list for design changes and engineering upgrades approved by the regulatory body should be part of the future commercial arrangements, in order to be implemented by contractors into design, construction, erection and commissioning of the DNPP.
- Based on the approved list, some engineering activities may be started in advance of the project implementation, at least for the development of the conceptual design package for the important changes and upgrades.
- Assessment and qualification to the requirements of the codes and standards in effect at the time of construction the existing civil structures should be performed and the specific action plan should be established, if the physical status of DNPP allows the implementation of required designed changes.
- New licensing requirements might impose specific studies (severe accident, Probabilistic Safety Assessment, security, etc.) which should be performed by DNPP utility and its consultants. These additional studies should provide bases for the required design changes, compensatory measurements and actions imposed due to the status of the DNPP.
- New environmental qualification requirements for safety related systems, equipment and components for the DNPP licensing should be clarified and solved, if necessary, by design changes and upgrades.
- Probabilistic Safety Assessment (PSA) level 1 and 2 studies are useful tools for the engineering verification and assessment and for the future operation of the DNPP.
- Measures and specific actions for the DNPP initial lifetime extension should be identified an established through the specific design changes.
- The DNPP utility’s licensing application group should develop close contact with the regulatory body as early in the project as possible, to understand fully the new requirements of the regulations and to avoid problems of misinterpretation later on.
- Relationships with the regulatory body should be sincere and open, but formal, with clear lines of communication between the project and the regulator and easy access of the regulator to the DNPP owner/utility designated personnel and pertinent information.

- DNPP utility should support the licensing process of the DNPP by fostering the good relationship between the local regulatory body and regulatory body of the DNPP nuclear reactor vendor country, in order to clarify any particular aspects of licensing issues in the country of origin.
- DNPP utility should clarify the interfaces with other national authorities involved in the licensing of the DNPP finalization. The specific strategy for updating to new requirements of other regulators (pressure vessel, fire protection, security, industrial safety, etc.) should be established and agreed.
- Co-operation with the utility of similar NPP units or the reference plant of the DNPP can be extremely helpful in the establishment of the proposed design changes and upgrades.
- Missions from the international organizations (IAEA, WANO, EC, etc.) for analyzing the final design changes and engineering upgrades, especially for the safety improvements should be required and arranged by the DNPP utility.

5.2. Licensing bases document

- All the specific regulatory requirements applicable for each stage of the DNPP project finalization (design, construction, erection, commissioning and turn over to operation) should be included in licensing bases document (LCB).
- Actual status of the DNPP and real possibilities to implement specific changes imposed by the new licensing requirements should be taken into account in the LBD preparation.
- Technical discussions between regulatory body and DNPP utility should clarify the requirements to be included in LBD.
- Approval of LBD by the regulatory body should be requested before preparation of the budget and the schedule for DNPP completion.

5.2.1. Safety analysis report

A. Preliminary Safety Analysis Report (PSAR)

- PSAR should be based on the necessary and required support studies in order to reflect all the changes imposed by new licensing requirements to be implemented in the DNPP.
- PSAR should contain the strategy to manage the non-compliances with new licensing requirements, due to physical status of DNPP, and identified compensatory measures and actions.
- Specific attention should be given in the PSAR revision to the DNPP security and physical protection, based on the latest national or international requirements.
- Essential elements of safeguards to be considered are described in the Reference [13].
- Concept of the DNPP physical protection system should be based on a mixture of hardware (i.e. security devices), procedures (including the organization and training of the security force for the performance of their duties) and facility design.
- Recommendations to be considered for minimum levels of physical protection for nuclear power plants are included in Reference [24].
- Based on the agreed Licensing Bases Document, Licensing Schedule and specific safety documentation packages, prior to the completion of PSAR for the DNPP a limited (temporarily) construction permit should be required from the regulatory body for the preparatory and rehabilitation work (Non conformance report (NCR) resolutions, etc.). This helps the future progress work for the DNPP finalization.

B. Final Safety Analysis Report (FSAR)

- Issued during project implementation by DNPP utility and his consultants, as per provision of the agreed Licensing Schedule.
- FSAR should respect the content established by regulatory body.

5.2.2. Climate change analyses and support studies

- Climate change analyses refer to any change in climate over time, due to natural variability or as a result of human activity.
- Result of these investigations in relation to climate change performed within the framework of the Intergovernmental Panel of Climate Change (IPCC) may be used to analyse the possible impact on NPP.
- Reference [22] offers information about projections of future change in climate, which may be used for the DNPP safety margins initially selected.
- Impact of the natural extreme events (such as tornados, earthquakes, surges, floods, etc.) and the extreme man-induced events (disastrous events produced by activities of man, such as air crashes, chemical explosions, drifting explosive clouds, etc.) should be carefully revised and analysed by specific studies, in comparison with the initial analyses and data. The specific recommendations for these types of analyses are included in the IAEA Safety Guides [11] and [23].
- DNPP utility should update the environmental licensing process based on the performance (or re-evaluation) of Environmental Impact Assessment (EIA) study and associated studies and climate change analyses. In this process, particular attention should be given to the EIA report for DNPP which deals with issues such as radiological impact under normal and abnormal conditions, non radiological impact and socioeconomic impact of the DNPP.
- DNPP environmental licensing process and schedule should be clarified and agreed with the responsible authorities (e.g. Minister of Environment, Environment Agency or Regulatory Body from the region/district of DNPP site). This agreement should cover the aspect of the ESPOO convention, especially the neighbouring countries consultation based on the report of the EIA study.

5.2.3. Licensing schedule

It should contain at least the following:

- Technical documentation support for the different licensing milestones should be transmitted by the DNPP utility to the regulatory body as per the time scheduled, in order to be granted with necessary licenses and permits according to the applicable national regulations.
- Time (as duration) requested by the regulatory body to analyse the technical support documentation submitted by the DNPP utility as support to the applications for the different licensing milestones.
- Reviews and assessments required to be performed by the regulatory body during the process of the DNPP finalization.
- Regulatory body inspections, hold points and planned licensing meetings on the DNPP site, at the different licensing milestones, before issueing the requested licenses and permits.
- Resources allocations (included financial) for all scheduled activities.

5.2.4. *Emergency preparedness*

— DNPP utility should clarify interfaces and responsibilities for the DNPP emergency preparedness plan, which should be revised (if originally was issued) or performed like new document.
— On-site emergency preparedness plan and responsibility of the DNPP utility should be revised as per the updated requirements.
— Off-site emergency preparedness plan, responsibility of the regulatory bodies and national authorities (e.g. Minister of Internal Affair, Ministry of Defence, Ministry of Health, etc.) should be revised and DNPP utility should participate in this process.

Good practices in the field of the DNPP updating to the regulatory requirements and interfaces with regulatory body during the DNPP completions, based on the experience of the Member States, are described in the annexes.

6. COMMERCIAL ARRANGEMENTS

6.1. Commercial and financial contracts

The commercial arrangements for the DNPP completion are similar with the acquisition process for a new nuclear power plant, described in the References [2–4], [6], [14–16]. The specific issues of the commercial arrangement for DNPP are described below.

The commercial arrangements include the necessary steps leading to the completion of the required contracts with vendors/suppliers for the DNPP completion. This activity includes the following tasks:

(1) Preparation of specifications and invitation of bids (Bid Invitation Specification).
(2) Qualification of suppliers.
(3) Receiving bids.
(4) Evaluation of bids.
(5) Selection of supplier(s).
(6) Negotiation and finalization of commercial contracts.
(7) Arrangements for financing.

After the necessary commercial contracts are negotiated and the amount of financing is clearly defined, the DNPP utility finalizes the arrangement for financing. There are no major differences between financing a DNPP and a new NPP. Indications for the DNPP financing are included in Section 4.5.2.

The above-mentioned activities should be performed by the DNPP utility under the management of the core group with the support of the departments of the DNPP utility and involvement of the high level management of the DNPP utility for decision purposes.

The following are good practices based on the experience of the Member States and may be used for the performance of the above-mentioned activities:

— If the approved overall strategy includes the services of an Architect/Engineer (A/E), this selection and finalization of the commercial contract should start first.

— Usually an A/E is contracted to manage the project and to perform services in engineering, procurement, construction and commissioning together with the DNPP utility. The portions shared by the A/E depend on the DNPP utility's experience and capabilities.
— The A/E should provide experienced and readily available staff, which acts on the orders of the DNPP utility in the next acquisitions of required suppliers.
— Depending of the DNPP status and adopted strategy, the DNPP utility or its A/E should produce a large part of the required work and supervise construction/erection and commissioning, performed by local subcontractors.
— One particular aspect of the DNPP is the process for the renegotiation of suspended contracts for goods (equipment and material) and services, which were stopped in the delay period. These contracts cover also the existing/old equipment on the DNPP site, erected or not, which need rehabilitations and refurbishment identified through the detailed verifications performed in the pre-project phase.
— Particular attention should be given by the DNPP utility to the possibility of restoring warranties for the old equipment and guaranties from the suppliers.
— The Bid Invitation Specification (BIS) for the new contracts should be prepared by the DNPP utility and its A/E.
— The BIS is used by the DNPP utility to inform the potential bidders of his wishes and requirements, based on the status of the DNPP and verification process performed in pre-project stage.
— The BIS contain the conditions and circumstances under which the supplier will have to perform his tasks, the information required, the form of presentation of this information in the bids and the basis on which the bids should be evaluated.
— BIS for the new contracts should take into consideration the recommendations included in the Reference [14].
— Before the contracts closure with selected contractors, the DNPP utility management should ensure the following:

  - Contractors are reliable.
  - Chosen contractors complete the deliverables contracted as per DNPP status.
  - Responsibility and level of authority of each chosen contractor is clearly defined.
  - Interfaces between the chosen contractors and between utility and contractors are clear and very well defined.
  - Licensing Schedule, approved by regulatory body, is part of the contracts for construction, erection and commissioning of the DNPP.
  - Supplies of equipment and nuclear fuel, and their financing as well as any other long-term items, have the backing of bilateral or multilateral government-to-government agreements.

— During this acquisition and financing arrangement process the DNPP utility may employ competent consulting services. Especially the analysis of rather complicated structure of financing proposals requires specific know-how, which can be provided by hiring a financial consultant. It is obvious that there would be advantage in retaining the same consultant for every phase of acquisition process, but it is also necessary to ensure that the best possible advice is obtained at each stage.
— The DNPP utility can never delegate its prime responsibilities to a consultant.

Guidance on how to proceed with the nuclear power acquisition and which are the organization and staffing requirements are provided in References [2], [3], [15], [16] and [18].

The project implementation starts when the commercial contracts become effective. The main condition for the effectiveness of the commercial contracts is represented by the existence of the financial resources, or in another words, the loan agreements are effective. There are specific conditions for the effectiveness of the loan agreements, sometimes technical conditions imposed by the results of the EIA study, and the DNPP owner/utility is required to demonstrate to the bank and financial institution (export credit agencies) that these are fulfilled and or there are clear action plans to be implemented. This process takes sometimes several months and in this period of time it is advisable that the project implementation is started, as per contractual provisions, using for that period DNPP utility financial resources (utility equity) or bridge loans. This approach facilitates progress in the completion of DNPPs.

6.2. DNPP project risks

The contractual arrangements for DNPP completion should allow for a balanced distribution of risks between the utility and the contractors and between the utility and the lenders. Nevertheless, the responsibilities of the contractors are always limited and consistent with their obligations in the contractual clauses. The plant utility has the ultimate responsibility for plant safety and reliability and, therefore, should take an active part in project management for DNPP completion.

Some examples of DNPP project completion risk related aspects are:

A. Construction risks: completion of the DNPP construction and erection according to the schedule and within the contract budget. The main drivers behind the potential delay in construction works, resulting in cost and /or schedule overruns, could be:

— ***Under-performance of duties by the contractors.*** If cost overruns are due to the quality of the contractors' performance of duties (under-performance, labour restrictions or supplier delays within the terms of their contract), the risk must be assumed by the contractors. However, under a multi-package approach, the DNPP utility should need to assume the residual risk associated with the co-ordination and scheduling of contractors' work.
— ***Contractors insolvency.*** The contractor(s) should be required to provide performance bonds in the form of letters of guarantee issued by international financial institutions. If any of the contractors go insolvent, the DNPP utility should execute the letters of guarantee covering any instances of non-performance/under-performance by the contractor. If any other claims are to be made against the contractors, the DNPP utility should need to follow the statutory regulations in force regarding insolvency procedures.
— ***Fluctuations in currency exchange rates with adverse impact on the costs of imported equipment and services.*** This risk is specific in case of private financing for DNPP completion without state sovereign guarantee.
— ***Changes in specific legislation by the regulatory body.*** Based on the described process for the DNPP licensing (careful analyses of applicable legislation before restarting) this risk is minimal for DNPP.
— ***Negative developments in local labour market (shortages or increase in costs).***
— ***Delays due to suppliers of equipment or materials.***
— ***Force majeure.*** Force majeure is defined as events outside the control of the parties involved in the DNPP finalization. There are three varieties of force majeure: acts of nature, acts of man (war, terrorism) and Government acts. Any force majeure instances due to acts of nature should be assumed by the DNPP utility, but are insurable, whereas acts of Government and acts of man are considered as political risks. Force majeure

related delays that are not insurable should be assumed by the DNPP utility. Accidental events need to be preventively covered by suitable construction insurance.

B. Commissioning risks: completion of DNPP commissioning according to the schedule and respecting the contractual budget. There are specific DNPP drivers behind of commissioning delays and cost increase, like long period of interruption with old equipment installed or in preservation, which require refurbishment or rehabilitation, in order to fulfil their initial functions or to respect additional technological requirements. A particular risk for the DNPP is replacement of the equipment after commissioning tests due to non-conformance, which might impact on DNPP project schedule and budget.

C. Technology risks: the lenders would want to be assured that the DNPP, when completed would be able to reach the design technical parameters.

Other risks that are common to DNPP and NPP are presented in Reference [27].

After the DNPP completion and the turnover to operation is complete, other types of risks should be considered (operational risk, nuclear fuel supply risk, safety and licensing regulation risk, political risk, nuclear accidents risk, terrorism risk, etc.). These are specific for all nuclear power plants in operation and are described in Reference [2].

In the operational stage, there is one associated risk related to the DNPP construction period. This is related to the environmental or other public interest damages risks due to DNPP construction deficiencies. Any claims raised against the DNPP utility for environmental or any other damages brought to the public interest that prove to be due to construction deficiencies, should be handled with the intention of allocating this risk to the constructor(s), subject to the warranty terms and conditions. The constructor(s) should be held to indemnify for such claims and perform any remedial works required at no charge for the DNPP utility.

7. PROJECT IMPLEMENTATION

This is the period immediately following the closure of the contracts for DNPP completion and can be described as project-oriented activities leading to the successful construction, commissioning and acceptance of the NPP that allows the utility to start the commercial operation. The main activities performed during this period are related to:

1. Project management, including planning, scheduling and budget control.
2. Project engineering, including basic and detailed design engineering, technical support documentation for licensing application and engineering for procurement and acquisition.
3. Procurement and acquisition of the required services, equipment and materials.
4. Manufacturing of equipment and components.
5. Plant construction, erection, installation, checking and testing.
6. Plant commissioning and acceptance.
7. Turnover to operation.
8. Public information.

Good practices and recommendations for the project implementation for a new NPP are described in the References [2–6]. In this Section only the specific aspects and good practices for the DNPP project implementation are described.

7.1. Project management

The project management organization in the stage of DNPP project implementation is dependent on the contractual approach. In all contractual alternatives, the DNPP PMT typically contains the following working areas:

— Planning & Scheduling
— Quality Management
— Human Resources
— Legal
— Public relations and information
— Industrial Health & Safety
— Finance and budget control
— Contracts supervision
— Licensing and compliance (includes nuclear safety, environmental, and others
— Engineering and quality surveillance
— Acquisition and procurement;
— Material management and warehouse
— Structures, equipment and systems preservation (specific for DNPP projects)
— Construction, erection and installation
— Commissioning and turn over to operation
— Training
— Environmental control
— Turn over to operation

The following good practices are recommended for the DNPP PMT activities:

— DNPP utility, through existing core group should be fully involved and integrated in the PMT for the project implementation period.
— Safety and quality should always be considered in the solutions for the different identified issues. This should be included in the Quality and Safety Policy established in PMT from the beginning of the DNPP restarting activities.
— Utilization of recent and modern tools for project management activities.
— Application of integrated project management system amongst different groups of PMT dealing with various issues in order to sort out the problems of construction, commissioning and turn over the systems to operation.
— Project management should make sure that construction performance is monitored and controlled in accordance with the DNPP project schedules and all concerned personnel are informed of the determined short-term objectives and expectations.
— Motivation and bonuses (provided in the project budget) for the site construction subcontractors and PMT personnel could be an useful tool for the PMT high level management, in agreement with DNPP utility, especially for the periods in the project were delays appear and recovery programs must be implemented.
— Tracking and monitoring of construction completion should be included in periodic meetings (monthly or quarterly) of the DNPP utility with PMT and the contractor/subcontractors.
— Utilization by the DNPP utility of a single point inside the PMT to control the schedule, quality and finance of the DNPP project, through audits and updates.
— PMT top management should use different methods (e.g. bonuses, etc.) for human resources motivation at the important milestones of the DNPP project completion.

— Manpower requirements of the DNPP PMT are dependent on the completeness of the plant in the moment of restarting, as well the technical qualifications necessary for DNPP completion. Recommendations in both areas for the new NPP are included in Reference [2].
— Based on the decision of the DNPP utility, after careful analyses of the local human resources, sharing of the infrastructure, resources (skills and trained people) and suppliers with others NPP utilities from the geographical area should be considered. The recommendations and good practices in sharing regional expertise are described in the Reference [7].

The annexes present experiences and good practices in the area of project management for restarting DNPPs.

7.1.1. Planning and scheduling

The PMT planning and scheduling staff should be well aware of the DNPP project objectives, organizational arrangements (commercial contracts), particular tasks and measures to control the project progress. In addition to the new NPP planning and scheduling principles and requirements underlined in Reference [2], the followings good practices for the DNPP are recommended to be implemented in developing an effective and efficient planning and scheduling process:

— Objectives and scope of the DNPP completion should be clearly defined in integrated schedule, together with the cost estimation and the PMT unit/department or subcontractors responsible for performance.
— Integrated schedule (coordination and control) and detailed and logical scheduling processes should be defined and implemented earlier, based on the clear definition of the scope of work before schedule completion.
— Licensing Schedule agreed with regulatory body and containing information described in Section 5, should be integrated in the DNPP completion schedules.
— Final list of DNPP changes and upgrades, approved by regulatory body, categorized and prioritized as described in Section 5, should be scheduled as per project requirement.
— Appropriate time for performance, verification, documentation and development of manpower performance is allocated, based on the productivity evaluated according with specificity and reality of the local industry.
— Equipment refurbishment and rehabilitation activities, as defined by the PMT Engineering Department, should be included in the DNPP project completion schedule.
— Additional verifications of the equipment preservation and specific test during erection and commissioning should be added in the schedule.
— Incomplete items for systems should be controlled and managed properly.
— Detailed planning and schedules, usually developed by suppliers and subcontractors, should be integrated by the PMT in the specific areas (building, structures, systems, rooms, etc.), as required.
— Analysis of the DNPP overall schedule should be done to correct any logic problems and to ensure that the project critical paths are well defined.
— Critical issues in the project should be continually identified and controlled.
— Planning and scheduling processes should maintain flexibility and adapt to priority changes required by unforeseen situations specific to DNPP.

- DNPP specific performance indicators should be developed by PMT and used to measure and document the performance records of individuals and organizations. These indicators should be changed and adapted during the DNPP completion work.
- Subcontract payments should be based on the performance against the goals in quality and schedule provisions.
- Plans and schedules should be reviewed frequently and corrected as per DNPP project requirements. Every 6 months the detailed schedules should be reviewed deeply and based on the existing status of project completion.
- A process/system to control planning and scheduling should be established, which may include:

  - Mechanism to report monthly work performance and project progress;
  - Process for changing, modifying and updating detailed schedules;
  - Measures to deal with contingency and adverse impact;
  - Actions to capture schedule status and analyze trends.

- Critical items list is needed in the different stages of the implementation for reports to upper PMT management and should be communicated among DNPP project partners.
- Experience from the reference plant of the DNPP (if exist) or similar new units should be used in order to improve and to adjust the sequences and planning of erection and commissioning activities, including the design changes and operational improvements implementation.
- The major factors affecting the NPP project schedule are indicated in Reference [2]. Additional DNPP specific factors affecting the project schedule are the following:

  - Time needed to adopt decisions inside PMT and DNPP utility organization;
  - Licensing requirements and procedures changes during DNPP completion;
  - Unforeseen manufacturing problems discovered during old equipment and components tests performed during the erection or commissioning, which require refurbishment and rehabilitation programs or replacement with new products;
  - Problems identified at existing buildings, structures or systems during detailed verification and tests;
  - Delays in procurement of components and spare parts for the rehabilitation and refurbishment programs for existing equipment and systems due to the original suppliers or new qualified suppliers;
  - Project management efficiency due to the complicated and unclear interfaces with all participants (subcontractors for construction, erection or commissioning, equipment, components, spare parts suppliers, regulatory bodies, etc.).

Good practices in this area and solutions for different problems provided Member States with experience in DNPP completion are presented in the annexes.

7.1.2. Budget control

The DNPP completion budget should be based on the complete scope of work definition as well as the contractual project schedule. The scope of definition requires having a clear status of work prior to restarting the project determined by the verifications and assessment performed in the DNPP pre-project period described in Section 4.

Recommendations and good practices for the new NPP project budget are included in the Reference [2]. DNPP projects are no different from new NPP projects in that respect. In addition to the new NPP, the followings good practices for the DNPP are suggested:

— DNPP planned and targeted budgets for all participating organizations should be usually set up along with the contractual conditions.
— DNPP budget should be refined at the start of the project implementation by PMT in agreement with the DNPP utility.
— The amount of contingency included in the DNPP finalization budget should be carefully evaluated taking into account that it depends on the extent of inspections and reviews to be done in the pre-project and implementation periods. The DNPP project carries a greater risk of schedule extension due to some of the uncertainties mentioned in this publication.
— DNPP utility is ultimately responsible for project funds and should be aware of the overall financial situation at all times.
— When additional costs are inevitable, the PMT should promptly inform the DNPP utility management and possibly the governmental bodies and financial institutions whether cost changes should affect the overall plant financing and cash flow requirements.
— For each major deviation from DNPP finalization budgeted costs the PMT and DNPP utility should initiate corrective actions together with the affected organizations (contractors, suppliers, etc.).
— Undefined work should be financed when required but only with DNPP utility approval.
— DNPP construction budget should include an allowance for the possibility of bonuses or overtime for suppliers and/or construction contractors required in case the project falls behind schedule.
— In some situations, suspension of payments and penalties may be enforced against poor performance of the construction subcontractors.
— DNPP procurement budget, especially the material and spare parts acquisition budget, should be based on the inspection reports of DNPP existing inventory and rehabilitation and refurbishment program established, and described through specification and bills of material by engineering.
— The PMT and DNPP utility should control the project budget by implanting a cost control system. This cost control system should define levels of authority and responsibilities of all managers from PMT and from DNPP utility and have a mechanism to report the cost performance and to take actions. The cost control system should describe:
    - Cost breakdown structure and procedures;
    - Process for obtaining approval for budget changes;
    - Cost contingencies and how they should be managed;
    - Measures to capture costs and evaluate cost performance.
— Monthly the PMT should provide a detailed report about the budget situation and at every 6 months the project budget should be revised as per the status of the work and be submitted for the DNPP utility approval.

The annexes of this document present experience and good practices in the Member States in the area of DNPP budget management and control.

7.2. Engineering

Depending of the status of the DNPP at the restarting, engineering provides services in the form of basic and detailed design, preliminary and conceptual designs for the changes and upgrades, equipment specifications, procurement support, licensing documentation, erection and commissioning support, as-built and as-commissioned documentation.

Recommendations and good practices in engineering for a new NPP are included in the Reference [2]. The followings good practices and recommendations are applicable in engineering during the DNPP implementation period:

— Engineering services for the DNPP finalization should be supplied on contractual bases, because it would hardly be justifiable and difficult to have an engineering department of appropriate type and size in the DNPP utility organization. For this reason, qualification of the local available engineering resources in advance of the decision to restart the DNPP completion should be performed by the utility.
— Engineering work for the DNPP completion should be started in the pre-project phase. During the DNPP pre-project phase, the engineering should be involved in the process of verification and assessment of the existing technical documentation, buildings, structures, systems, equipment and components. These activities, correlated with the new requirements of the codes, standards and regulations, should establish the bases for the future rehabilitations and refurbishments, for which detailed engineering solutions should be provided during the DNPP project implementation phase.
— DNPP utility should play an active role in engineering and enforce surveillance and control that the project develops in close conformity with and strict adherence to the applicable safety standards established in Licenses Bases Document.
— DNPP utility should verify not only that the engineering supply is within the established scope of the work but also in strict conformity to the requirements for licensing compliance.
— Performance of the engineering activities should ensure that the design conforms to codes, regulations and standards as specified in the Licensing Bases Document.
— Engineering review of equipment and component technical specifications for the procurement preparation, including the spare parts for existing equipment, replacement of the old existing equipment and obsolesces, should be part of the detailed engineering task.
— Engineering for procurement should be responsible for:
  - Assessment and verification of the existing inventory and warehouses, including spare parts inventory;
  - Updating the technical specification and procurement packages;
  - Identification of components obsolesce and potential suppliers/change of suppliers;
  - Identification of out of the market suppliers;
  - Re-qualification of the old suppliers, including their QM program.
— PMT should authorize specifications for manufacturing and installation of equipment and components. PMT should be responsible for set up purchasing procedures and controls for equipment and components procurement support.
— Necessary correspondence and information (input data) for the engineering completion should be available in modern /electronic tools, prepared in advance of DNPP restarting.
— DNPP existing documentation should also be transferred to electronic files and introduced in modern databases.
— Various engineering tools, such as 2D CAD [including intelligent Process and Instrumentation Diagrams (P&ID) and Elementary Diagrams], 3D CAD (including General Arrangements and Isometric Drawings) and engineering databases for each design discipline should be used. These tools allow use of design data among engineering disciplines, which increases engineering efficiency and accuracy.
— New engineering packages and documentation should be electronic made and use appropriate rigor specific to configuration management [20] inside the project and for future plant operation.

— Detailed design and engineering solutions for DNPP structures, buildings, systems and equipment rehabilitation and refurbishment should be continuously reviewed to verify that safety criteria, the security requirements and other relevant technical requirements are satisfied. In particular, design guides for piping, valves, storage tanks, cables, control panels, limits of allowable vibrations, temperature rise in bearings of rotating machines, etc. have to be in compliance with applicable standards for the DNPP.
— DNPP re-starting process should be combined with plant life extension through establishment by engineering of the life extension program based on existing (old) equipment of DNPP.
— Given the delayed nature of the NPP project, the total scope of engineering work could not always be accurately defined at DNPP restart and some extra needs might be found during the execution of the project that could affect significantly the scope definition and estimates.
— Special technical instructions should be prepared by engineering for inspection and assessment of existing DNPP equipment or component families.
— Inspection program should be applied only to equipment and component parts, which are susceptible to modification during the storage time (such as sealing systems, bearings, etc), avoiding unnecessary disassembling costs and great risk of damage.
— Special inspection program should be implemented for rotating equipment.
— Old equipment and components/materials suppliers/vendors should be involved in the refurbishment program, starting with preparation of the procedures by engineering.
— Engineering should also responsible for the resolution of the inspection reports findings, providing technical solution for repairs, replacement of aged parts or replacement of equipment and components.
— Depending of the DNPP status, the modern construction methods (open top construction, modularization, parallel and modern construction techniques which involves the integration of civil and mechanical works, pipe work and welding by prefabrication shops, etc.) should be introduced in the engineering packages of DNPP completion. Reference [21] presents the Member States experience and good practices in this area.
— Engineering documentation should include the design changes in order to introduce new architectural material for coating and room finishing for saving time and taking advantages of new technologies.
— Good connection/communication between site and office engineering should be implemented, possible to be done by modern electronic means.
— Common engineering database, documents and drawings should be available on the DNPP site for all construction and erection subcontractors.
— Confirmation of the engineering activities completion, in a form of Design Completion Certificate, should be issued by the DNPP engineering involved organizations, for the licensing purpose. This statement should be verified and accepted by the DNNP utility and/or PMT, before submission to the regulatory body.

Member States experience and solutions to the different problems in the DNPP engineering are described in the annexes.

7.3. Procurement

With a turnkey arrangement for the DNPP completion, the main contractor has the responsibility for procurement of every item of equipment and of materials within its scope of supply, which could be the entire project. With non-turnkey arrangements the responsibility for procurement is either with the DNPP utility, or can be shared among the utility, A/E and system suppliers or contractors, each within its specific scope of supply.

Recommendations and good practices for the new NPP project procurement and acquisition are included in the Reference [2]. DNPP projects are no different from new NPP projects in that respect. In addition to the new NPP, the followings good practices for the DNPP are recommended:

- PMT may handle directly the procurement and acquisition activities of the required equipment and components.
- Inside PMT, the specialized procurement and acquisition unit consisting of both business and engineering talent may be organized, having the following tasks:
  - Establishment of procurement criteria;
  - Procurement planning;
  - Supplier qualification and selection, including the DNPP old suppliers;
  - Bidding and bid evaluation;
  - Contracting;
  - Contract monitoring and enforcement;
  - Expediting;
  - Handling of warranty claims.
- If a centralized independent unit performs procurement and acquisition, this would be required to work with and for PMT within the framework of a matrix organization.

7.4. Manufacturing of equipment and components

Depending of the DNPP status, equipment and components could represent the largest direct cost item for project completion. Based on the specifications produced by project engineering and approved by PMT, the equipment and components are manufactured and delivered to the site as finished and approved products ready for installation.

Recommendations and good practices for the new NPP equipment and components manufacturing are included in the Reference [2]. DNPP projects are no different from new NPP projects in that respect. In addition to the new NPP, the followings good practices for the DNPP are recommended:

- Manufacturing of equipment and components for DNPP completion should start in the early stages of the project shortly after the contract effective date, when the purchase orders are ready.
- Essential for DNPP completion is that facilities for the localized manufacture of equipment and supply of material be operational early in the project schedule.
- Any support by the government to maximize the local scope of supply should be in place well in advance of the decision to restart DNPP completion.
- Due to lack of orders from NPPs for several years, many of the local suppliers could no longer have adequate engineering capability to support the manufacturing of equipment and materials as per DNPP project requirements and consequently the PMT engineering department should give them technical support or provide detailed manufacturing drawings.
- DNPP utility and/or PMT should be involved in the manufacturing surveillance, using permanent staff in the equipment and components manufacturing organizations during the process.

— Particular support should be given by DNPP utility and/or PMT to the manufacturing organizations of components and spare parts required for the refurbishment and rehabilitation programs of DNPP existing equipment.
— Suppliers of equipment and components, especially of the components and spares required for the refurbishment and rehabilitation programs, should be contracted for technical assistance for erection and installation on the DNPP site.

Member States experience, and solutions to the different problems experienced in the DNPP equipment and components manufacturing are described in the annexes.

7.5. Construction and erection

The construction of a DNPP includes a multitude of activities, which are performed by various organizations with specific responsibilities assigned to them, based on the contractual provisions. Depending of the DNPP status at restarting, these activities include building, manufacturing, erecting, installing, handling, shipping, storing, cleaning, inspecting, testing, modifying, repairing and maintaining. The DNPP construction requires many overlapping activities in civil works, mechanical erection, electrical installation and testing of components, equipments and systems. The specific rules, principles and recommendations for the construction stage of a new NPP, described in the Reference [2], also apply for the DNPP. In addition to these, the following good practices and recommendations specific for the DNPP project should be considered:

— DNPP site construction subcontractors should be pre-qualified before re-starting the project.
— Early development of site construction subcontractors is recommended, for example about 10% mobilization advance for the development of their infrastructure (communication network, storage area for equipment, offices, workshops, procurement of specific tools, etc.).
— A recovery and updating program of the existing infrastructure, temporary installation and site facilities (offices, warehouses, barracks, canteen, parking, refurbishment of temporary power supply, re-conditioning of temporary systems for potable water, fire water, drainage and sewage, etc.) should be implemented early, after the decision for the restarting the DNPP project was adopted. Facilities (laboratories, workshops, etc.) for additional required training should be developed on the DNPP site. Timely completion of the permanent administration buildings, workshops and warehouses to be used by the utility operating organization should be properly included in the schedules.
— DNPP utility and site construction subcontractors' warehouses evaluation should be early implemented on the DNPP site.
— Existing Site Field Changes, Dispositions and Non Conformities Reports may be solved in the DNPP restarting period.
— DNPP site construction subcontractors should be responsible for the establishment and implementation of their QM programs, which should be accepted and supervised by the PMT and DNPP utility. QM programs should be reviewed and revised in accordance with the specific actions of DNPP (audits, surveillance inspections, procedures, non conforming materials and conditions, corrective actions).
— A protection program for the erected components and equipment should be implemented early in the construction stage. This should complement the cleaning and housekeeping program implemented by the PMT with all site construction subcontractors.
— Equipment and components refurbishment and replacement programs should be based on the specific skills and qualification of the site subcontractors.

— Vendors and equipment suppliers should be used for construction subcontractors training as appropriate.
— Utilization of suppliers and vendor's representatives is recommended during preservation and refurbishment periods.
— Acquisition of the specific tools for refurbishment program by the DNPP utility is recommended.
— Operation of the preserved equipment should be verified by specific tests during construction period.
— Common electronic tools for PMT and site construction subcontractors should be used.
— Utilization of new technology in several areas of civil construction would save time and money in the process of DNPP completion.
— DNPP site construction subcontractors should be managed with effective co-ordination and integration within construction sequences, including the improvement of the PMT sub-contractors communication interfaces.
— Modern construction techniques may be implemented in the process of DNPP finalization. These potential modern construction methods include:
  - Modularization;
  - Open top construction;
  - Slip-forming techniques for containment walls and liners or large structural building including the turbine hall;
  - Parallel and modern construction techniques involves the integration of civil and mechanical works;
  - Pipe work and welding by prefabrication shops, including the radiographic examination of welds;
  - Improvements in instrumentation and cabling installation, referring to the installation of cable trays, cable and terminations by identification of the areas where the bulk cable pulling and termination could be performed before the start of other electrical installation;
  - Application of computer technologies in cable installation.

  These modern methods, described in References [21] and [25], could reduce the DNPP construction costs and improve the schedules in the cases that their implementations were possible during the DNPP completion. The implementation of these methods includes site construction subcontractors personnel training, tools procurement and specific procedures preparation.

— Establishment inside PMT of the Supervisory (Walkthrough) Group with the goal of ensuring erection completeness and elimination of possible issues arising from the discipline interfaces.
— Provisions and conditions of the Construction License granted by regulatory body should be fully respected and good cooperation with regulatory bodies maintained during DNPP construction and erection period.
— Licensing meetings should be organized periodically, as per Licensing Schedule provisions, in order to present the status of the DNPP work and the fulfilment of the applicable requirements, including Construction License.
— Inspection of regulatory bodies should be performed on the DNPP site, as per agreed Licensing Schedules and PMT and DNPP owner/utility should solve issues identified with priority.

— DNPP site resident inspectors of regulatory bodies should have permanent access to the working area and identified issues should be clarified by PMT or DNPP utility.
— Old turnover from construction to commissioning packages (prepared in the past, before DNPP was stopped) should be re-evaluated.
— Construction and erection subcontractors should prepare as-built documentation with technical support from PMT engineering department.
— Trained and qualified human resources of the site construction subcontractors should be permanently supervised and evaluated by PMT, together with the management of site subcontractors and DNPP utility. Depending on the identified issues, it may be recommended to use the existing expertise in the region, for similar NPPs. The specific recommendations and good practices in sharing regional expertise are described in the Reference [7].
— The construction and erection of DNPP should be finalized by the turnover packages from construction to commissioning, prepared for each structure, building, system and installation, which — in addition to the normal practices — should have indications of the specific identified issues, due to DNPP stoppage period.
— Confirmation of the DNPP construction activities completion, in a form of Construction Completion Certificate, should be issued by the PMT and its subcontractors. This statement should be verified and accepted by the DNNP utility.

Good practices, identified issues and solutions to the different problems in the DNPP construction by Member States are described in the annexes.

7.6. Commissioning

Before a NPP is put into commercial operation, the functional adequacy of the installed components, systems and the plant as a whole must be tested to demonstrate that the plant can be operated safely and reliably. Commissioning is one of the major stages of the project implementation. Some commissioning activities may coexist with construction or operation activities. Commissioning activities start with the initial operation of the individual components or equipment that has been tested by the construction organizations. Some commissioning tests may be performed by commissioning groups well ahead of the formal turnover of the entire plant to the commissioning organization.

The main objective of the commissioning is to confirm that the design intents of the components, systems and the plant as a whole are achieved. Commissioning objectives include optimization of the plant system functions, verification of the operating procedures, familiarization of the operating personnel with the plant systems and the plant initial start-up. The contract type should determine the nature of the commissioning management. In the non-turnkey contracts, the commissioning organization is likely to be directly managed by the plant owner, with the help of an A/E organization.

The recommendations for the commissioning stage of a new NPP, described in the Reference [2], should be also applied for the DNPP. In addition to these, the following good practices and recommendations specific for the DNPP commissioning should be applied:

— Planning and coordination of commissioning and testing activities should be assessed and improved by re-evaluation of commissioning sequences, as per the new applicable requirements.
— Permanent control and optimization of the commissioning schedule should be implemented in parallel of the major process systems, daily and weekly planning

meetings, establishment of the current priorities and programs and identification and tracking of all significant issues affecting the schedule.

- Complete commissioning management information system should be required and this should include all the information related to commissioning such as documentation, human resources, handover, project targets, tools and feedbacks. The information system should provide a common working platform for all commissioning staff and other relevant PMT departments.
- Appointed system engineers for a plant system or a group of systems, should be responsible for preparation of the commissioning documentation, interfacing with engineering and construction, providing technical support for field test and preparing the commissioning reports.
- Special attention should be given to process systems flushing and hydrostatic test programs, due to long time of interruption of the DNPP activities.
- Overall training and authorization of the commissioning personnel, prior to job assignment and based on the specific training programmes, should ensure commissioning effectiveness and quality.
- Equipment vendor should be required for training and support for commissioning, in order to offer possibilities for better and quickly resolution of identified problems and issues.
- Technology upgrades in electrical and I&C equipment should require the implementation of new processes and additional training of commissioning staff.
- Some important major refurbished equipment and components require more exhaustive testing including repeating of initial factory acceptance tests.
- Earlier initiation of the licenses renewal for DNPP existing operating staff and licensing process for new operating staff is recommended.
- DNPP require larger number of staff for maintenance during the commissioning stage, imposed by old equipment and long period of interruption, higher level of discovery work and a large contingent of staff working on spare parts review and ordering/acquisition for old equipment.
- Unanticipated problems discovered during the commissioning test should be promptly managed.
- Close interface with construction for the management of the open items from the turnover process to commissioning should be implemented.
- Existing inventory of special tools, instruments, materials and consumables for commissioning and required spare parts should be revised by commissioning group and procurement actions adopted in advance.
- Equipment, components, system and area turn over process performed before restarting should be re-evaluated and the new acceptance criteria established as per revised DNPP design bases.
- Close interface of commissioning department with PMT engineering should be implemented in order to address any design related issues using a formal Commissioning Clarification Request.
- Establishment of the Commissioning Control Points (CCP) in order to check and confirm that the plant systems required to support the different commissioning milestones were duly commissioned and the results are documented.
- Provisions and conditions of the Commissioning License granted by regulatory body shall be fully respected and good relationships and cooperation with regulatory bodies should be maintained during DNPP commissioning.
- Licensing meetings should be organized periodically, as per Licensing Schedule provisions, in order to present the status of the DNPP commissioning and the fulfilment of the applicable requirements, including Construction License. Licensing meetings should

be organized more often than during DNPP construction in order to analyse the Commissioning Reports and test results.
- Depending on the national regulations and nuclear reactor type, for the relevant milestones of the commissioning (manual nuclear fuel load, first criticality of the nuclear reactor, reactor power increase to 25 % of nominal power, first connection of the plant to the grid, etc.) the DNPP utility (supported by PMT with appropriate technical and commissioning reports) might be required to apply to regulatory body for specific milestone permits.
- DNPP site resident inspectors of regulatory bodies should have access to the commissioning tests and to the PMT meetings on commissioning results analyses.
- Modifications implemented during commissioning, especially in the electrical and I&C systems, should be incorporated in the as-commissioned documentation, required for the DNPP operation.
- Trained and qualified human resources for the DNPP commissioning should be permanently supervised and evaluated by PMT, together with the management of DNPP utility. Depending on the identified issues, it may be recommended to use the existing expertise in the region for similar NPPs. The specific recommendations and good practices in sharing regional expertise are described in the Reference [7].
- Confirmation of the DNPP commissioning activities completion, in a form of Commissioning Completion Certificate, should be issued by the PMT. This statement should be verified and accepted by the DNNP utility, before submission to the regulatory body for licensing purpose.

IAEA Member States experience and solutions to the different problems in the DNPP commissioning are described in the annexes.

7.7. Turnover to operation

Turnover of the DNPP to operation is generally an administrative action by which responsibility for physical, economic control and for safety and security of the plant systems, areas and the whole plant is transferred from PMT (commissioning department) to the utility operating organization. This is a typical process for any NPP, not specific for DNPP and the rules and good practices are described in Reference [2]. Some specific aspects of turnover to operation of a DNPP are the followings:

- DNPP system turnover procedures, clearly identifying the participants, responsibilities, duties and documents necessary for the turnover process, should be established by DNPP utility.
- Complete and update system turnover packages should include all changes and revisions of the commissioning program, testing procedures and commissioning reports containing the test results.
- Structures, buildings, systems, equipment, materials and components deficiencies should be identified effectively in the turnover documents.
- Turnover documents should describe boundary deficiencies and exceptions existing at the time of turnover in comparison with commissioning program and test procedures.
- Design changes and upgrades agreed with regulatory body to be implemented after start of the plant commercial operation should be clearly identified and described in the turnover documents.
- Specific inputs and elements for the preparation of the specific inaugural and in-service inspection program, taking into account the delayed period, should be part of turnover package.

- Turnover documents should contain recommendation for the medium and long term corrective and preventive maintenance programs, based on records of the DNPP.
- Operating organization should review the DNPP turnover documents and assess the test results and the exceptions/deficiencies identified during the plant commissioning.
- Pre-turnover walk downs and specific assessments should be performed by qualified individuals representing necessary disciplines from both project management organization (commissioning) and utility operating organizations.
- Turnover of DNPP to operation might be made with some acceptable exceptions, due to the long time of project finalization. Decision for acceptance of these exceptions should be made at the DNPP utility upper management level.
- Responsibilities for closing the exceptions after turnover should be clearly defined, including performance and control of the construction work and commissioning testing on the incomplete components or systems.
- During the turnover process the commercial contracts with main contractors and suppliers should be closed.
- Special procedures should be developed for the contracts closure, which may include the warranty test performance and the acceptance criteria of this test by the DNPP utility.
- Specific attention should be given to the initial guarantee included in the contracts and contractors responsibilities for these guarantee.
- The contract closing issues and list of open points should be clearly recorded with the established and agreed action plan for solving, including responsibilities and allocated cost.

7.8. Public information

This is a typical process for any NPP project implementation, not specific for DNPP. Good practices are described in Reference [2]. Some specific aspects of turnover to operation of a DNPP are the followings:

- PMT should appoint an information officer, preferably a native of the immediate DNPP vicinity, as a liaison between the community and the DNPP utility.
- Good public information abilities and effective communication with potential interveners might require years of on-the-job experience.
- Permanent DNPP exhibition pavilion should be established with models of the NPP and visual presentations of the activities being undertaken by the DNPP utility to ensure public safety and minimize impact on the environment.
- A full-time staff dedicated to this activity, including manning of the exhibition pavilion should be of the order of two to four experienced public relations people with general nuclear education and specific technical knowledge of the project as well as of the main safety issues involved.
- Engagement and/or development of additional part-time speakers with the adequate technical knowledge and a gift of communication with the public, preferably from the safety and project engineering departments of PMT are advisable.
- Popular literature on nuclear power has also proven to be an effective instrument in a public information campaign.
- Permanent information of the public and mass media about the status of DNPP finalization and achievement of the important milestones of construction, erection and commissioning should be systematically performed by the DNPP utility.

Member States experience and good practices in the DNPP public information during project implementation are described in the annexes.

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ABBREVIATIONS

A/E	Architect Engineer
BIS	Bid Invitation Specifications
BOP	Balance Of Plant
I&C	Instrumentation and Control
CAD	Computer Aided Design
CAR	Construction All Risks
CCP	Commissioning Control Point
DNPP	Delayed Nuclear Power Plant
EC	European Commission
EIA	Environmental Impact Assessment
ER	Environmental Report
ESPOO	Convention on Environmental Impact Assessment in a Transboundary Context
FSAR	Final safety analysis report
HLRW	High Level Radioactive Waste
I&C	Instrumentation and Control
IDC	Interest During Construction
IPCC	Intergovernmental Panel of Climate Change
LBD	Licensing Bases Document
NAR	Nuclear All Risks
NCR	Non Conformance Report
NDE	Non Destructive Examination
NPP	Nuclear Power Plant
NPT	Treaty on the Non Proliferation of Nuclear Weapons
NSSS	Nuclear Steam Supply System
OECD	Organisation for Economical Cooperation and Development
O&M	Operation and Maintenance
P&I	Process and Instrumentation
PHWR	Pressurized Heavy Water Reactor
PMT	Project Management Team
PRIS	Power Reactor Information System
FSAR	Final Safety Analysis Report
PSAR	Preliminary Safety Analysis Report
QA	Quality Assurance
QM	Quality Management
T/O	Turn Over
WANO	World Association of Nuclear Operators
WEC	World Energy Council
WNA	World Nuclear Association

ANNEX I
PROJECT RESUMPTION MANAGEMENT EXPERIENCE
ATUCHA II NPP, ARGENTINA

I-1. SUMMARY

The purpose of this report is to describe Management Measures implemented and Project Strategies adopted in order to handle problems encountered during the first stage of resumption of Atucha II DNPPP, from the official decision of the Argentine Government to complete it in August 2005 until the current moment (April 2007, just before starting the massive activities of electromechanical erection).

Some of the problems presented might not be exactly related to the case of Delayed Nuclear Power Plant Projects, however, they were included since, probably, other DNPPP might face similar problems.

I-2. GENERAL INFORMATION

I-2.1. General history of the Project

In 1980, the Atomic Energy Commission of Argentine (CNEA) requested Bids from international companies for the supply of a PHWR NPP. CNEA received proposals from AECL and Siemens-KWU. The offer presented by Siemens-KWU was awarded the Contract for a 745 MWe (gross) plant and implemented like an open scheme (not “turn key”) composed of different contracts as follows:

- Contract of Supplies for imported components and equipment;
- Contract of Services for engineering, technical support, commissioning, etc.
- Contract of Warranties;
- Contract ELA (Engineering Licensing Agreement) for technology and basic engineering know how transfer and associated licenses;
- Contract for Design and Technology of Fuel.

The contracts were signed in May 1980 and the activities on site started at the end of 1981. From 1983 until 1991, there was a permanent negative change of rhythm affecting the Project (slow advance, low activity periods, partial and general delays) mainly due to financial problems.

From 1991 until the beginning of 1994, a significant increase of the work rhythm was registered due to the availability of funds assigned to continue with the Project.

After 1994, financial problems returned again and caused a definitive reduction of activities.

From 1995 onwards, the organization was reduced and concentrated mostly on tasks related to the preservation and maintenance of components, installations and documentation of the plant with the objective of preserving them adequately until the re-launching of the Project.

The decision of completing the Project was taken by the Argentine National Government in August 2005, through the Executive Act 981/05 which triggered, in consequence, all the necessary restarting tasks.

I-2.2. The situation at the moment of resumption

I-2.2.1. Main reasons for resumption of the Project

These reasons can be summarized as follows:

- Balance of Argentina's energy source matrix (natural gas restrictions);
- Cost of fossil fuels;
- CO2 emissions;
- Decision to continue with NPP's.

NPP's represent approximately 4% of the gross installed electrical power generation capacity in Argentina, with 1005 MW out of a total of approximately 23000 MW (2005). In terms of electrical energy produced, the contribution of nuclear power plants to the energy matrix of Argentina is of 8% (2005), twice its proportion of total installed capacity. The rest of the electrical energy matrix composition is divided approximately equally between hydro and fossil-fuel thermal plants.

The participation of nuclear in the total energy produced has slowly decreased from 14% since 1984 (the year of the start up of the last of the two operational NPP's: Embalse-648 MW). The other NPP operational in Argentina is Atucha I (357 MW), commissioned in 1974. Both plants are of the heavy water-natural uranium reactor type, being Embalse a CANDU pressure tube reactor while Atucha I is a pressure vessel reactor.

While for the last decade almost all the growth of the argentine electrical system has been based on natural gas fuelled combined cycles, restrictions in the availability of natural gas and a persistent increase in the cost of fossil fuels have called for a different approach towards the future balance of the energy matrix.

Atucha II (745 MW, PHWR) will produce more that 5000 GWh/yr, the equivalent of 5% of total production of electricity in Argentina in 2005. This amount of electrical energy, if produced using a natural gas fueled combined cycle, would require more than three million cubic meters of natural gas per day, almost three percent of total natural gas injection in the argentine system (2005).

The absence of Carbon Dioxide as a direct sub product of the nuclear production of electricity has also been an important factor considered in the decision of re-starting the construction of Atucha II. Production of the same amount of energy with a natural gas fueled combined cycle would add to the global emissions to the atmosphere more than 3,500,000 ton of CO2 per year of operation.

Annex 4.3 indicates the status of construction progress at the time of restarting the project.

Annex 4.2 indicates the remaining engineering activities identified at the time of restarting the project.

I-2.2.2. Identification of boundary conditions for the Project

Three aspects were taken in account in this respect:
- Time to completion.
- Participation of local resources.
- Recovery of former investment.

The schedule for completion of the project (Annex 4.4) includes three phases as follows:

Phase	Duration	Objective
I	12 months	Re-launching
II	30 months	Construction
III	14 months	Start-up & Commissioning

The total completion time of 56 months was entered into the medium term national plan for the expansion of the electrical system and, in the context of a persistent growth of electrical demand, was determined to be a key factor supporting the decision to resume construction of the NPP. Consequently, the completion of the NPP in the shortest possible time was assigned absolute priority over other project considerations.

The extremely positive influence of the former NPP design, construction and operation processes on the local scientific, technical and industrial development was also considered a very important factor in the considerations supporting the decision to continue with the project.

Considering that most of the required equipment and materials for Atucha II was already delivered, adequately stored and preserved at the jobsite, electromechanical erection of the plant is the most important, in terms of physical volume of work, of the remaining activities. The recovery of the applicable local capacities has been assigned relevant priority, subordinated, however, to the shortest achievable completion time, as indicated above.

Finally, it was taken into account in the decision process that the amount invested in the former stages of Atucha II should become a total write-off in case of canceling the Project. Consequently, the economical evaluation of the Project was based on the comparison of the remaining amount of investment up to completion versus the discounted value of future cash flows.

This economical evaluation indicates that, in a context of growing prices of hydrocarbons, restrictions in the availability of locally produced natural gas and limitations to the emissions of carbon dioxide, completion of the Project is amply justified.

I-2.2.3. Status of contracts with the Original Designer

In order to proceed with the Project it was considered essential to close the original contracts signed between CNEA and Siemens-KWU in 1980 and take a different approach towards the completion of the Project considering, among other factors, that Siemens had left the field of nuclear activities by 2001.

As a result of the completion of negotiations among NA-SA and Siemens PG, mutually satisfactory agreements were achieved in July 2006 for various matters including the transfer of the Intellectual Property of the design, the transfer of engineering documents and tools, the final reception of formerly supplied materials, equipment and services, the settlement of accounts and the future mutual cooperation for the conventional sector of the Plant.

As a consequence thereof NA-SA became the Design Authority for the Project. An important consequence of this has been the broad scope of activities implemented as part of the Project Team, as described in point I-3.5. Another consequence has been the implementation of agreements with various technological suppliers who will contribute with specialized activities towards the completion of the Project (as indicated in I-3.5 below).

A very important National Technical Cooperation Project for completing Atucha II NPP was executed in 2005 with IAEA. The overall objective was that of strengthening NA-SA's abilities for the completion of the plant.

I-2.2.4. Financial scheme

For the completion of Atucha II two sources of funds have been allocated by the Argentine Government.

- Contributions, in the form of long-term loans to NA-SA, from the National Treasury.
- Funds generated by the operation of NA-SA's two other nuclear power plants in operation.

The addition of these two sources of funds shall supply the total amounts required for the completion of Atucha II NPP.

Both sources of funds will be contributed to a single Fiduciary Fund, specifically instrumented for the completion of Atucha II, which is administered by an independent banking institution, which will disburse funds, under the instructions of NA-SA, only for expenditures required for the completion of Atucha II.

I-3. MAIN PROBLEMS ENCOUNTERED AND MEASURES IMPLEMENTED

I-3.1. Problem: Preservation programme of components during the reduction period

Measures implemented and lessons learned

In these cases, after several tests of different procedures, the lessons learned can be summarized by the optimum results obtained during the reduction period in order to avoid corrosion and condensation on the components by the application of a combination of the following measures:

- Wrapping of components with sealed metallic foils, keeping inside desiccant bags and using external humidity indicators for periodical surveillance;
- Painting welds on installed carbon steel pipes and fittings with protective lacquer;
- Wrapping installed stainless steel pipes and fittings with plastic ribbon;
- Maintaining temperature and humidity control in buildings and some warehouses.

I-3.2. Recovery of Human Resources for staffing the Project Management Organization and training of personnel in critical disciplines

Measures implemented

A minimal core group of about 50 engineers and 100 technicians and workers was maintained by NA-SA during the reduction period with the following main objectives that included the support to the other two operating NPPs:

- Preservation and actualization of know how, technical and commercial documentation, warehouses inventory, environmental conditions, etc.;
- Preservation and maintenance of buildings of the plant, and all the electromechanical equipment installed and stored;

- Preservation and maintenance of the temporary facilities of the site (this task had, for obvious reasons, second priority to the preservation of plant facilities and was performed partially due to financial restrictions);
- Operation and Maintenance of systems and equipment already turned over to commissioning;
- Supply of services, equipment, tools and personnel for planned outages and special jobs to the other two operating NPP's (Atucha I and Embalse). These activities covered tasks related to engineering, maintenance, construction and commissioning and had a considerable influence on maintaining the motivation of the work group during the reduction period of the Project.

After the decision to restart the project was made, an important activity started related with the hiring and mobilization of the large team required for complementing the core group. This was a great challenge, the first and very arduous stage was the search and re-establishment of contact with experienced professionals interested in participating in the Project. After that a data base was created and negotiations carried out between responsible sectors of different disciplines within the organization interested in obtaining the services of the selected personnel.

The origin of the engineers and technicians was diverse, but mainly related to former experience in the Argentine nuclear sector, such as, for example:

- Recovery of experts formerly employed by ENACE (the original architect-engineer of the Project) and NA-SA;
- Recruitment of personnel from CNEA, assigned temporarily to the Project thanks to the strategic partnership with NA-SA described below in I-3.5;
- Personnel from Local Companies of different industrial sectors. Active or retired;
- Contracting of foreign experts, active or retired; and
- Development of young professionals interested in joining the nuclear power plants design and construction sector.

A very flexible mechanism for contracting people or and/or personal services had to be developed, taking into account different situations like services full-time, part-time, personnel already retired, payment per month, day, hour, payment against specific deliverables, etc.

An important training organization had to be budgeted and implemented, and considerable efforts had to be employed in the implementation for all disciplines and requirements, ranging from developing the skills of workers like welders, pipe fitters and others, up to engineers and technicians required for the design, construction, commissioning and start up of the NPP.

An example worth mentioning in the subject of developing worker's skills is the Welding School, implemented by the Project at the very first moment of re-launching completion of the NPP, in order to supply an adequate stream of qualified welders for its own use and for the future Piping Contractors in order to save time and inconveniences for the future activities.

A broad approach was taken in the implementation of these measures in order to meet, not only the requirements of Atucha II but also to cover the requirements of future nuclear Projects.

Annex 4.1 indicates the Organizational Chart adopted for the completion of Atucha II.

Annex 4.5 indicates the estimated total manpower requirements for completion of the project.

I-3.3. Problem: Recovery of infrastructure and temporary installations and facilities on site

Measures implemented

In order to avoid delays in the Schedule of the Project, the organization responsible for the Management of the Project implemented a process for recovery and refurbishment of temporary jobsite installations and facilities, in parallel to the selection and contracting of electromechanical contractors.

It is advisable to start these activities at least one year before the arrival of main contractors on site. The issues considered were mainly:

- Updating of communications and data processing networks up to new requirements and modern IT technologies;
- Refurbishment of temporary power supply systems to current requirements;
- Re-conditioning of temporary systems for potable water, fire water, drainage and sewage;
- Recovery and updating of existing temporary facilities (offices, workshops, warehouses, on-site barracks, parking, kitchens, canteens and mess facilities, personnel access control, etc.);
- New workshops, facilities and labs for the implementation of the Inspection and Refurbishment Programme for electromechanical components and equipment;
- New facilities for training (classrooms, welding school, etc.);
- Reorganization of personnel transport systems by bus to site;
- Reconditioning of security installations.

Assessment of the availability of external infrastructure for lodging and housing personnel employed on site was a critical issue. Some of the facilities existing during the first phase of the Project were no longer available because of new requirements from other industries and projects that had been installed in the area of the NPP; this situation made necessary fostering the development of new capacities.

I-3.4. Definition of major work packages and participation of local companies in construction and electromechanical erection

Measures implemented

- Assessment of resources required, resources available and selection of alternatives
- Division in major work packages of electromechanical erection work
- Selection of construction strategy for each work package and qualification of contractors
- Recovery of old/suspended commercial contracts.

I-3.4.1. Assessment of resources required, resources available and selection of alternatives

After many years of practically no activity in the field of construction and electromechanical erection of nuclear power plants in the country, the main problems were originated from the scarce availability of experienced personnel. This situation had a considerable impact on the starting phase; an important contingency of cost and time had to be allowed for taking into account the "Learning Curves" required for learning, training on the job and skill development of the different disciplines (engineering, procurement, construction, quality management and control, commissioning, etc.).

Many of the former specialized electromechanical erection companies have either disappeared or dedicated themselves to other activities during the last fifteen years. Consequently, the local capacities for erection of NPP remain mainly with the specialists that directly participated in previous NPP electromechanical erection activities ("know-how bearers"). Priority in the qualification process for nuclear electromechanical erection activities (Point I-3.4.2 below) has consequently been assigned to the contractors who can prove they have those specialists in their staff.

The resources available for the electromechanical erection of the NPP were evaluated and classified in the following categories:

- Direction and supervision to be performed by NA-SA;
- Local contractors adequately qualified;
- Local specialists directly contracted by NA-SA;
- Erection work to be performed directly by NA-SA with its own supervision and labor supplied by contractors;
- Foreign companies to be contracted directly by NA-SA for special assignments;
- Supplier's supervisors for erection of equipment and components.

An "ad-hoc" Committee of Experts integrated by relevant specialists of the Project Team evaluated that, with different combinations of these resources, all the remaining activities of construction for completion of the NPP could be satisfactorily performed.

I-3.4.2. Division in major work packages of electromechanical erection work

All the main electromechanical erection activities of the NPP were analyzed and divided by building, area and system in accordance with the logic sequence of a construction process which could fit into the overall programme. The requirement of construction resources for each so determined work package was then established.

A classification system with four levels of qualification for erection packages was simultaneously established as follows, with maximum degree of qualification and experience required for the first level, subsequently decreasing up to the fourth level:

Level 1: Nuclear erection works in the reactor containment building, including the primary and moderator circuits.

Level 2: Nuclear erection works in other divisions of the NPP (Reactor auxiliary and annular buildings, spent fuel pool building, etc.).

Level 3: High qualification conventional erection works (Turbine building, steam and compressed air building, pump houses, extra high voltage switching yard, etc.)

Level 4: Normal qualification conventional erection works (external services, storage of diesel fuel, lighting installations, etc.)

Subsequently one of the Levels was assigned to each work package, which then became characterized with two attributes, namely [Resources required] and [Level].

I-3.4.3. Selection of construction strategy for each work package and qualification of contractors

After completion of the processes indicated above in I-3.4.1 and I-3.4.2, an "ad-hoc" Committee of Experts integrated by relevant specialists of the Project Team matched the [Resources required] of I-3.4.2 with the [Available Resources] of I-3.4.1.

For each work package a combination of the available resources was selected and established as the preferred alternative for performing the erection process. The procedure was given an adequate degree of flexibility for the introduction of changes, in case some of the expectations about the capabilities of contractors and suppliers were not fulfilled or contractual insurmountable difficulties arose. The tendering and contractual procedures to be adopted are specifically determined for each of the major work packages at the beginning of the process that leads to the issuance of a request for quotation.

Simultaneously, an initial process of selection of local potential contractors for construction work packages was started in December 2006 and concluded by the end of March 2007. Potential contractors were invited to present the background and qualifications of their companies, including those of their specialists with specific experience in erection of NPP's, following guidelines established by NA-SA. The invitation was widely publicized and a substantial number of companies responded.

Another "ad-hoc" Committee of Experts integrated by relevant specialists in electromechanical erection of NPP's evaluated the presentations, qualified and classified the selected potential contractors in the four Levels indicated in I-3.4.2. The short list of contractors to be invited was specifically determined in each case, considering other factors like size of the work package in question versus other current contractual commitments already in force, availability of equipment, etc.

The process of developing and qualifying contractors will be open and continuous during the existence of the Project, the intention of the Project Team being to incorporate new incumbents at the lower Levels and promote to higher Levels for future activities those contractors who will demonstrate their capacity and willingness to invest in the development of their organizations.

I-3.4.4. Recovery of old/suspended commercial contracts

Considering the absolute priority assigned to shortening the processes, the procedure of recovering some old contracts was used, when deemed feasible and useful, provided the original contractual counterpart was still active and deemed capable of performing the remaining work package.

Maintaining the useful characteristics of their original structure, conditions and guidelines, old contracts were used as a base for new contracts, achieving substantial time savings in the process. Successful examples of this procedure are the new contracts for the erection of the primary and moderator systems in the reactor building.

The same criteria were applied to the few remaining civil construction activities, like in the case of the Contracts for completion of the hydraulic works and systems.

I-3.5. Problem: Change of Design Authority, technical services

Measures implemented

Since the Design Authority role for the NPP originally covered by Siemens-KWU had to be taken over by NA-SA for the reasons explained above in I-2.2.3; different management measures were implemented with the Project's own resources. In addition to that a considerable effort was made to obtain other sources of technical support and supply of technological services, through execution of contracts and agreements with national and international companies and institutions.

Some examples of contracts and agreements currently active at the present time (April 2007) are the following:

— International Atomic Energy Agency (IAEA)

A National Technical Cooperation Project for Completing the Atucha II NPP was established with the overall objective of cooperation in further strengthening the owner's abilities to complete the plant for a safe and reliable operation. The main topics considered are:

- Project Control Issues.
- Updating to Technological and Safety Requirements.
- Revision of licensing documentation (FSAR, PSA).
- Preservation and Maintenance of equipment and facilities.
- Instrumentation and Control.
- Preparation for Commissioning and Start Up.

— National Atomic Energy Commission of Argentina (CNEA)

As a result of the decision to recover the former strategic partnership of NA-SA with CNEA for the design and construction of NPP's, different activities for Atucha II are performed by CNEA like:

- Design, technology and afterwards inspection of the manufacturing of fuel elements for the first core, manufacturing to be performed in Argentina by CONUAR.
- Participation of CNEA in various technological activities of the Project executing work packages of different disciplines.
- Participation of CNEA's personnel in diverse on-line activities on site seconding members of their own personnel to the organization responsible for the Management of the Project.

— University of Pisa (Italy)

- Analysis of Design Basis Accidents scenarios needed for the licensing of the plant.
- Coupled neutronic thermo hydraulic analysis of relevant scenarios in Atucha II.

- Design verification of mass flow distribution in the lower part of the Reactor Pressure Vessel.
- Analysis of the behavior of the fast boron shutdown system during accidents.

— Atomic Energy of Canada Ltd. (AECL)

- Assessment of requirements and redesign of Safety Injection Pumps anti-clogging filters.
- Verification of Atucha II Seismic Qualifications and production of applicable technical documents (seismic analysis reports, stress reports, etc.).
- Feasibility study for implementation of the TRAK Document Management and Control System.

— Belgian Nuclear Research Centre (SCK-CEN) and National Atomic Energy Commission of Argentine (CNEA)

- First phase for feasibility studies and subsequent design of a system for surveillance of remnant life of the Reactor Pressure Vessel during operation of the plant (programme of control, modifications in moderator vessel, device for installation and extraction of probes, PTS evaluations).

— Siemens PG

- A Frame Agreement, including in its scope the services and supplies required by NA-SA for the completion of the conventional part of the plant.

— AREVA NP GmbH

- An Agreement (in a developing stage as of April 2007) including in its scope some services and supplies required by NA-SA for the nuclear part of the plant.

— INVAP S.E.

- A special agreement for obtaining technical services during the different phases of completion of the Project has been signed. Verification and completing the design of some components of the Fuel Reloading System and the verification of the thermo-hydraulic design of the reactor core are examples of services covered for it.

— Gesellschaft fuer Anlagen und Reaktorsicherheit GmbH (GRS)

- Execution of Probabilistic Safety Analysis level 2 (PSA level 2).

I-3.6. Problem: Technical revision of components for installation in the plant before commissioning

Measures implemented

An Inspection and Refurbishment Programme was developed and implemented so as to ensure the functionality of components and parts, said programme being made necessary due to the long time elapsed since delivery.

Contacts with original suppliers are being established and some of the main components included up to now (April 2007) in this plan are: main coolant pumps (ANDRITZ), tilt device and transfer channel of fuel elements transport system (NOELL), main steam turbine and generator (SIEMENS), hydraulic turbine (PESCARMONA), etc.

Judging by the experiences up to the present, the contacts with the suppliers must be made with enough anticipation because the availability of factory Supervisors is normally scarce. The estimated time to get a Supervisor on site depends on supplier and/or type of component but could be as long as 12 months in some cases.

Inspection of steam generators, moderator and other heat exchangers, condenser and tanks will be performed by a NASA special team as part of the pre-service programme.

I-3.7. Problem: Updating the Licensing Plan

Measures implemented

The main activities are centered in the scheduling and execution of the following activities:

- Re-evaluation of the design concepts applied for the Project Atucha II;
- Core design verification using modern coupled neutronic thermo-hydraulic models;
- Fuel element behavior in case of Loss of Coolant Accidents;
- Safety Systems verification (control rods, fast boron shutdown system, emergency core cooling system);
- Probabilistic Safety Analysis (PSA), levels 2 and 3;
- Operational transients;
- Final Safety Analysis Report (FSAR).

I-3.8. Problem: Review of the status of I&C hardware and definition of actions to be implemented during following phases of Project lifetime

Atucha II has the same I&C concept and technology as the last Siemens NPP's (Konvoi Plants, Trillo, Angra 2) which could be described as follows:

The I&C system is organized in functional groups, which means that all associated electronic modules necessary for controlling a given process system are concentrated in a group of separated cubicles with a minimum of signal exchange with other functional complexes.

The central Instrumentation is placed in four redundant rooms in the Switchgear Building. In each room the operational and the safety related I&C are located together with special decoupling measures.

The following results were obtained after performing a detailed status assessment of the present situation (April 2007) from the point of view of the hardware:

- Some hardware technologies (Teleperm C; Iskamatic A, B and C; Sinuperm C) and the Supervision computer are out of standard production;
- Some modules of the original supply for the erection of the operational I&C are missing;
- The amount of spare parts already supplied is considered not sufficient;
- The majority of the cabinets belonging to the central instrumentation (about 375), are already installed and wired.

Measures implemented

In order to precede with the Project completion activities, the strategies to be employed include the following measures:

- Obtain the missing modules from alternative qualified suppliers already contacted.
- Replace some operational functional complexes with a new technology before starting the plant, in order to obtain spare parts for other functional complexes. This will be done within the frame of the Plan for I&C Modernization to be implemented in steps during the operational life cycle of the Plant.

The main challenge to execute this work will be the organization of a task force requiring highly qualified human resources in both technologies, the original and the new one. An important effort of engineering and planning will be required due to the considerable percentage of equipment already installed and wired.

I-3.9. Problem: Special planning requirements due to the specific conditions of a Delayed Project

Measures implemented

Some special issues related with the points previously treated are to be considered during the phases of planning and scheduling allocating sufficient time and budget for activities like:

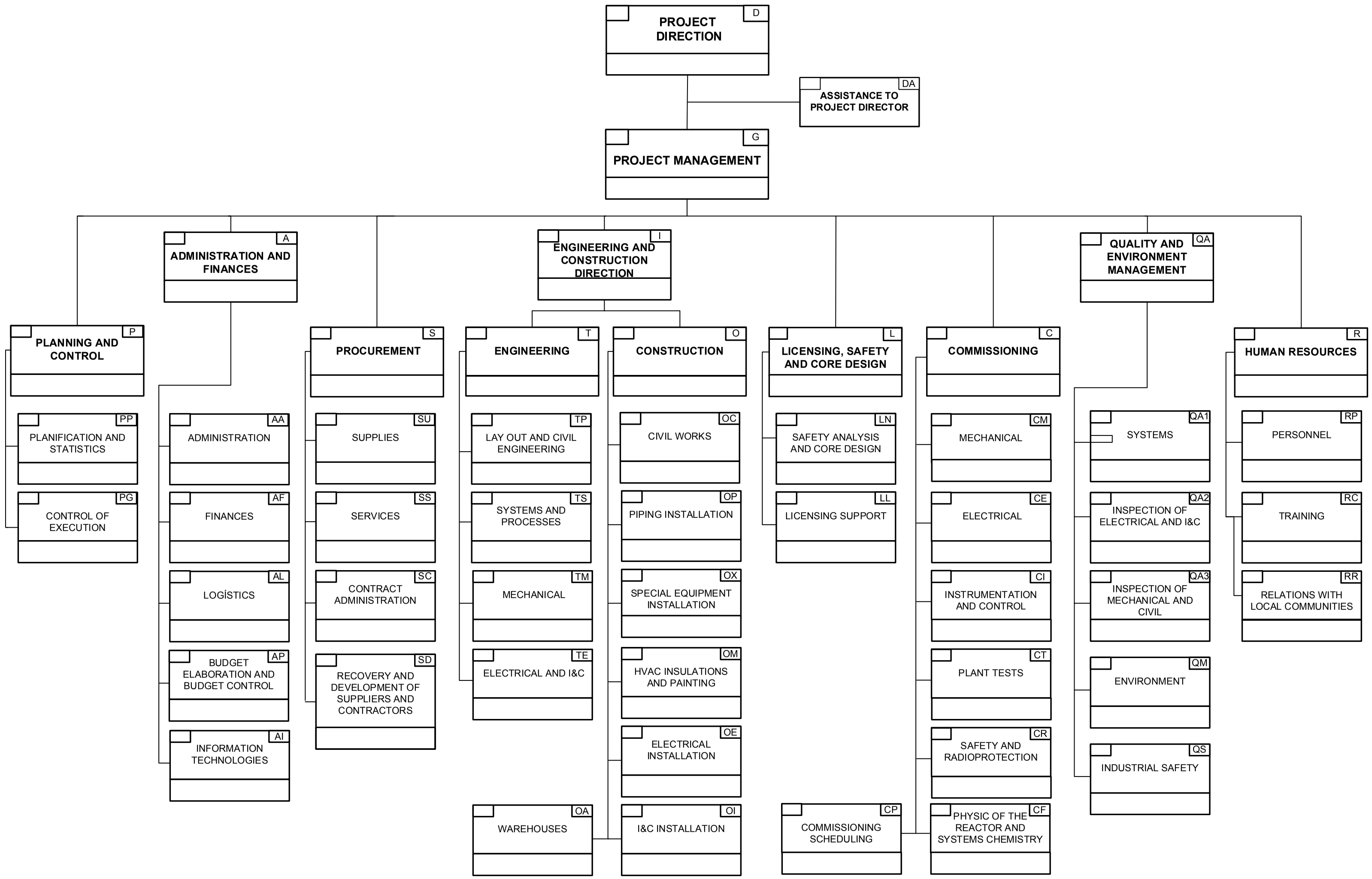
- Detailed assessment of Project status, in all aspects, during the first phase of re-launching.
- Additional workload resulting from the fact that NA-SA is currently the Design Authority for the Project (refer to Point I-3.5 above).
- Inspection and refurbishment of components and equipment.
- The effect of the "Learning Curves" (described in Point I-3.4.1 above).
- Qualifying suppliers for components and spare parts.

An important task already performed was the change of the old scheduling software towards modern software, transferring all the existing data bases.

I-4. ANNEXES

The following Annexes (4.1 to 4.5) are attached as additional information for reference related with the general situation of the Project and preliminary planning at the moment of resumption of the activities for completion.

Annex 4.1 Organization Chart for ATUCHA II Project Completion



Annex 4.2 Status of main engineering activities

Estimated percentages still to be performed:

PROCESSING SYSTEM ENGINEERING	15 %
PROBABILISTIC SAFETY ANALYSIS	70 %
SAFETY ANALYSIS REPORT (input)	60 %
OPERATING MANUAL (input and edition)	75 %
CHEMICAL MANUAL	70 %
COMMISSIONING ASSISTANCE	95 %
REMAINING SUPPLIES PROCUREMENT	10 %
PIPING ENGINEERING	20 %
CABLING AND WIRING ENGINEERING	30 %
I&C AND ELECTRICAL ENGINEERING	25 %
HVAC (detailed documents for erection)	30 %
CIVIL ENGINEERING (cooling water buildings)	5 %

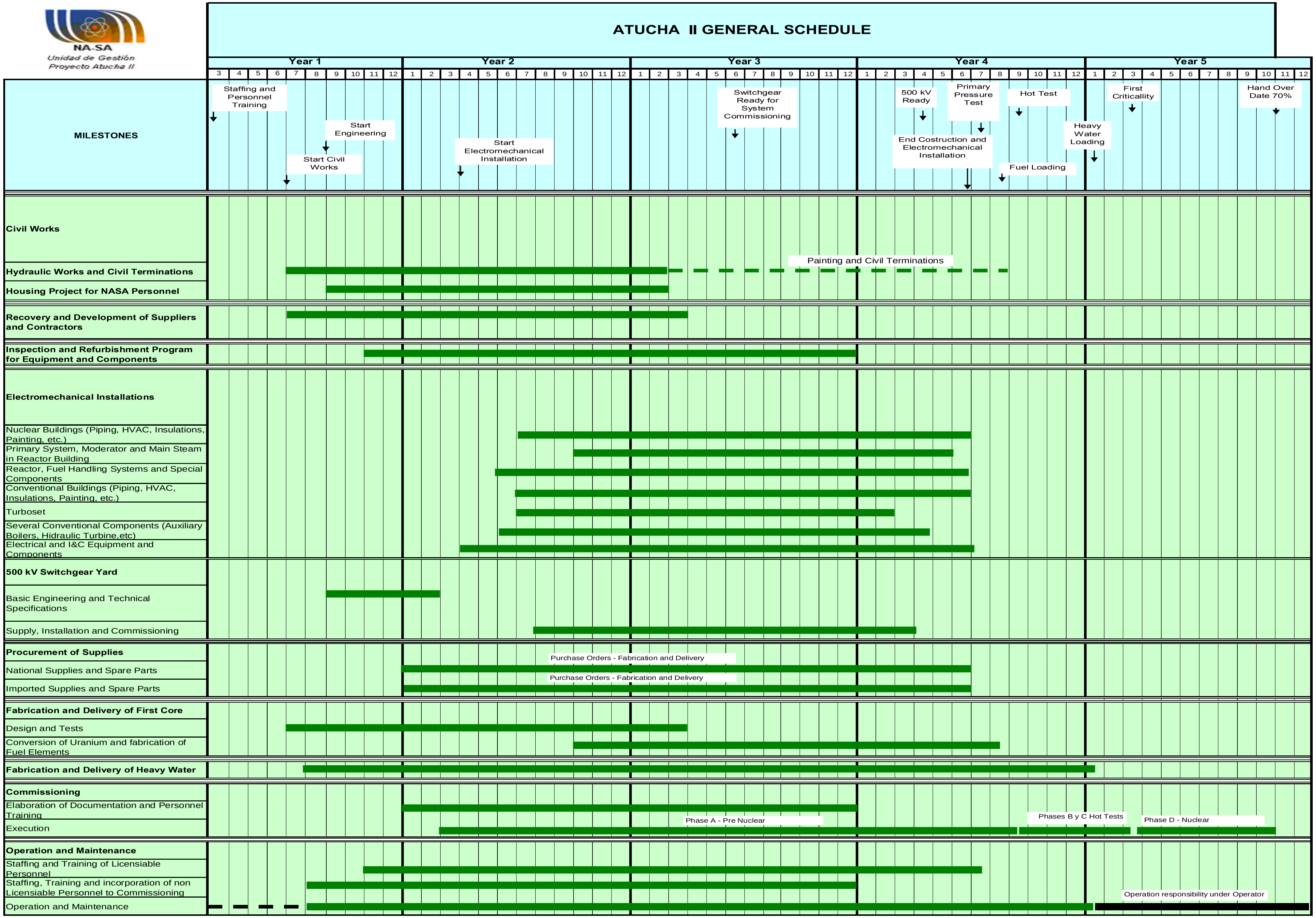
Some remarkable Engineering tasks to be finished:

- Updating of the Break Concept.
- Updating of Thermohydraulic and Emergency Core Cooling design.
- Updating of H2/D2 recombination system.
- Preparation of I&C modernization strategy.
- Seismic Qualification analysis.
- Rules and Regulations to be applied.
- Design review of calculation of components and piping (ex. fatigue analysis).
- Inspection and Refurbishment Program for components and equipment.
- Completion of detailed civil engineering.
- Completion of detailed piping and HVAC engineering.
- Completion of detailed cabling and wiring engineering.
- Completion of detailed electrical and I&C engineering.
- Detailed design of 500kV switchgear yard.
- Detailed design of Plant Security System.
- Technical Specifications for purchasing remaining components and spare parts.
- Implementation of nuclear computer programs.
- Preparation of physical measurements at zero power.
- Determination of the set point parameters for the reactor control system.
- Probabilistic safety analysis level 2.

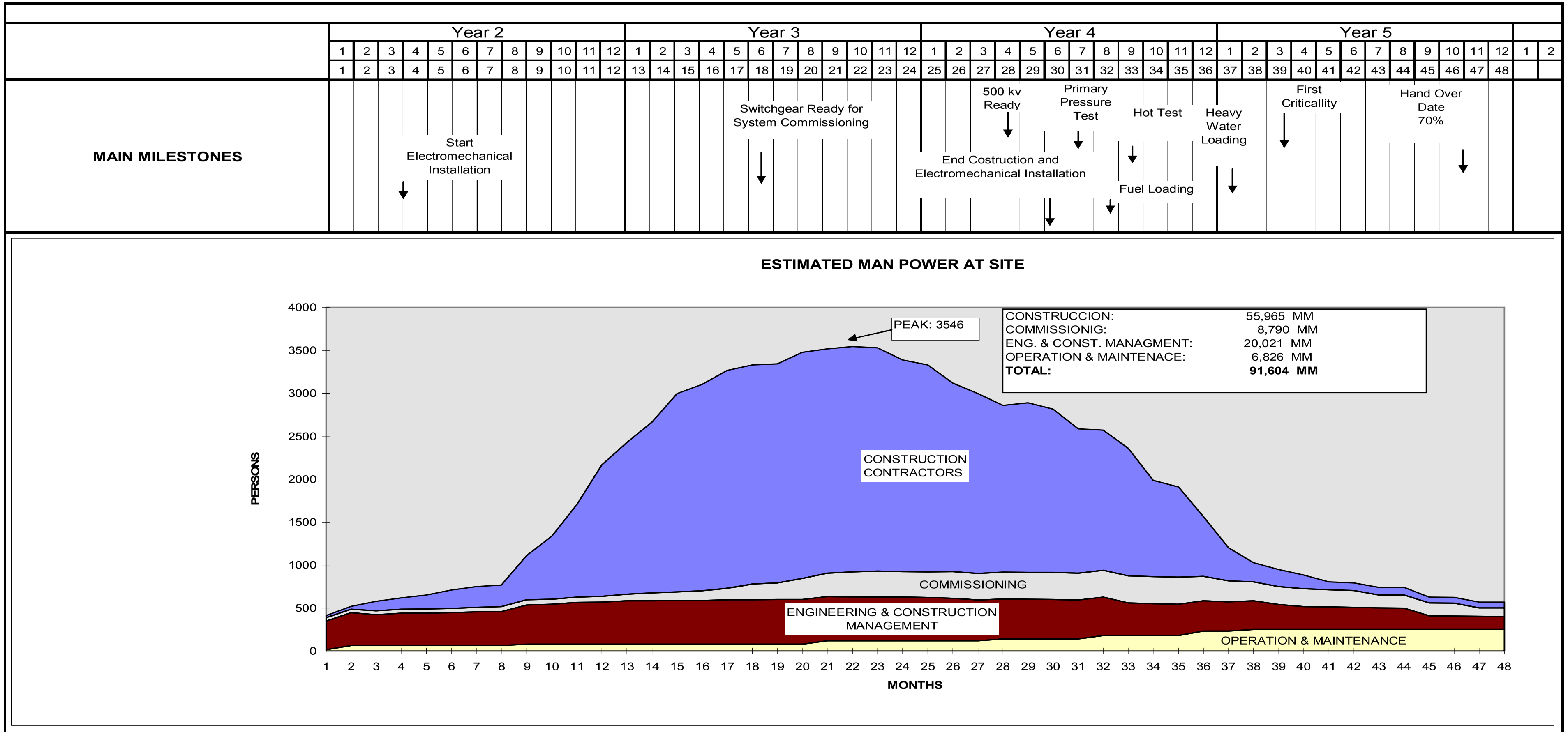
Annex 4.3 Atucha II estimated construction progress classified by building and main disciplines

MAIN BUILDINGS	Civil	Mechanical	Electrical and I&C
NUCLEAR AREAS			
UJA: Containment Inner Structure	**95%**	**20%**	**20%**
UJB: Reactor Building Annulus	**97%**	**30%**	**20%**
UKA: Reactor Auxiliary Building	**93%**	**30%**	**20%**
UFA: Fuel Storage Pool Building	**95%**	**15%**	**10%**
CONVENTIONAL AREAS			
UMA: Turbine Building	**93%**	**40%**	**20%**
UBA: Switchgear Building	**98%**	**90%**	**90%**
UBP: Emergency Power and Chilled Water Supply Building	**98%**	**65%**	**50%**
UGD: Demineralizing System Building	**97%**	**90%**	**80%**
UTA: Auxiliary Boiler and Air Compressors Building	**80%**	**5%**	**0%**
UYA: Staff Facilities and Offices Building	**75%**	**0%**	**0%**
CONVENTIONAL HYDRAULIC AREAS			
UPC: Cooling Water Intake Building	**50%**	**5%**	**0%**
UPD: Service Cooling Water Intake Building	**95%**	**30%**	**10%**
UME: Water Turbine Building	**0%**	**0%**	**0%**
UQB: Service Cooling Water Pump House	**50%**	**30%**	**0%**
UQJ: Cooling Water Seal Pit	**98%**	**50%**	**0%**
UQM: Service Cooling Water Collecting Pit	**98%**	**50%**	**0%**

Annex 4.4 Preliminary General Schedule with milestones and main activities



Annex 4.5 Preliminary Curve of Total Man Power Estimated for Completion of the Project



TOTAL PER MONTH	412	519	577	616	649	709	750	768	1112	1337	1706	2166	2426	2665	2997	3103	3264	3332	3342	3476	3516	3546	3529	3390	3332	3118	2997	2859	2889	2816	2586	2570	2359	1986	1911	1565	1202	1028	949	882	804	792	741	739	627	624	569	568		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2
	Year 2												Year 3												Year 4												Year 5													

MONTHS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
OPERATION & MAINTENANCE	15	15	15	15	15	63	63	63	63	63	63	63	80	80	80	80	80	80	80	80	80	80	80	80
ENGINEERING & CONSTRUCTION MANAGEMENT	168	202	251	293	334	382	358	376	379	384	394	395	456	463	484	490	503	504	506	508	518	518	520	520
COMMISIONING	15	15	27	27	40	41	46	47	47	49	50	57	60	60	64	65	76	92	102	112	133	183	193	243
CONSTRUCTION CONTRACTORS	21	21	21	23	23	33	110	130	160	213	243	253	516	734	1078	1531	1767	1989	2309	2403	2533	2551	2549	2633
TOTAL	219	253	314	358	412	519	577	616	649	709	750	768	1112	1337	1706	2166	2426	2665	2997	3103	3264	3332	3342	3476

MONTHS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	53	54
OPERATION & MAINTENANCE	120	120	120	120	120	120	120	140	140	140	140	180	180	180	180	230	230	252	252	252	252	252	252	252	252	252
ENGINEERING & CONSTRUCTION MANAGEMENT	513	511	511	506	501	495	473	466	464	459	452	445	379	371	363	353	342	333	288	265	262	255	249	247	158	155
COMMISIONING	273	288	298	298	298	308	308	310	310	315	315	315	315	315	315	285	245	220	210	210	200	195	150	150	150	150
CONSTRUCTION CONTRACTORS	2610	2627	2600	2466	2413	2195	2096	1943	1975	1902	1679	1630	1485	1120	1053	697	385	223	199	155	90	90	90	90	67	67
TOTAL	3516	3546	3529	3390	3332	3118	2997	2859	2889	2816	2586	2570	2359	1986	1911	1565	1202	1028	949	882	804	792	741	739	627	624

ANNEX II
DELAYED NUCLEAR POWER PLANT PROJECT RESUMPTION MANAGEMENT EXPERIENCE, ANGRA 2 AND 3 NPP, BRAZIL

II-1. INTRODUCTION

II-1.1. Summary

The purpose of this Annex is to report lessons learnt from the resumption of Angra 2 NPP construction and to analyze them with a view to resumption of Angra 3 NPP project. Angra 2 is in operation since February 2001, and Angra 3 is close to resumption. In 1976, at the beginning of the Project, a twelve-month time gap between the conclusion of the two plants was planned. Later this time gap was changed to 18 and then to 24 months until the investments were greatly reduced in the period from 1984 to 1994. A programme for equipment storage and preservation was implemented and inspections were planned. Personnel were maintained to continue with the engineering work and site structures. Construction was resumed only for Angra 2 with full cooperation of the foreign supplier. Many challenges had to be overcome before Angra 2 could be successfully concluded; the core loading took place in April, 2000, the operational commissioning phase followed and was concluded in December, 2000. Therefore, Angra 2 Project was in development for 25 years. At the time Angra 2 was concluded, the utility tried to start the construction of the third unit, but the Authorities did not allow it, claiming funding problems and requiring additional studies to demonstrate the economic feasibility of the project. These studies were developed and approved and the Angra 3 project resumption decision is expected to be made in the next months.

II-1.2. General information

The construction of Angra 2 started in 1976 and met the project time schedule in its early phase. In 1978, discussions with the Licensing Authority led to a recalculation of the containment foundation. This caused a schedule delay and Angra 2 foundations were completed only in 1982.

From 1984 onwards the economic situation in Brazil has had a serious effect on the implementation of the nuclear power programme as well as on the construction of Angra 2 and Angra 3.

This situation led the utility to proceed only with the rock excavation in Angra 3 area in order to provide material to be used as shore protection against flooding and wave design basis accidents.

The project progress especially concerning the supplies and services to be provided in Brazil was limited and had to be managed according to the annual budget authorized by the Brazilian government.

This caused several project postponements. Notwithstanding these adverse circumstances, all parties in the project had done their absolute best to finish the construction of Angra 2. However, this was not possible for Angra 3, since the rock excavation and, therefore, the whole project were stopped in 1986.

In March 1996, mechanical, electric and I&C erections were started and all the systems whose erection is a pre-condition for core loading, were installed and ready for operation in March, 2000. Angra 2 was declared operational in December 2000 and Angra 3 still remains on hold, but has the same construction resumption possibility as Angra 2 did in the past.

During this period 20 million man-hours were spent on Angra 2 erection, performing services as follows:

- Engineering Preparation work folders .... 71000 units
- Erection of piping, supports and valves .... 6300 ton
- Erection of mechanical components .... 17 000 ton
- Erection of electrical components .... 3100 ton
- HV/LV transformers .... 30 units
- HV/LV/DC "Switch gears" and Package System.................... 1 300 cub
- Grounding and lightning systems .... 110 km
- Power cable pulling .... 800 km
- I &C cable pulling .... 1 700 km
- Power cable and I&C connections ....1 000 000 units

Also during the same period, 13 million man-hours were spent on civil construction works, which resulted in 20.000 m3 of concrete, a finish coat area of 400.000m2 and 2000 ton of manufactured and installed steel platforms.

The commissioning was originally estimated to last 17,5 months, but ELETRONUCLEAR did its best to shorten this period to 10,5 months. However, based on the experience from BROKDORF NPP, a commissioning time of 12,5 months was scheduled for Angra 2. This represented a very challenging target, as the commissioning of BROKDORF lasted 12 months and was performed by very experienced SIEMENS commissioning personnel, who had already performed identical tasks in GROHNDE and GRAFENRHEINFELD NPP's.

The main scheduled events achieved were:

- Primary pressure test ....from 15/05/1999 through 19/05/1999
- First hot operation ....from 19/09/1999 through 16/11/1999
- Core loading ....from 30/03/2000 through 02/04/2000
- 2nd Hot Operation..from 13/04/2000 through 29/05/2000
- First criticality 14/07/2000
- End of trial run...from 24/11/2000 through 21/12/2000

II-2. PROBLEMS FOUND AND MEASURES IMPLEMENTED

II-2.1. Problem: Before the project resumption, evaluation of the real amount of work to be performed for construction completion

Solution

In order to correctly evaluate the pending electromechanical erection, ELETRONUCLEAR hired studies with different companies in order to have the best estimation of the amount of the job to be performed and also the best estimation of schedule to be considered. To this effect, Eletronuclear had prepared the database to be used by international companies contracted for the associated advisement. With the results of these studies, it was possible to define the important milestones. These were reviewed in connection with the studies performed by Eletronuclear, giving the utility the necessary confidence to require a feasible erection time schedule in the bidding process.

II-2.2. Problem: Updating the design in order to facilitate the licensing process. Keeping also the control over material and design availability

Solution

In order to optimize the construction and operation of Angra 2,both technically and economically, and in accordance with a contractual commitment, the Brazilian Partners in the project have been kept informed of progress by the foreign supplier SIEMENS – KWU, now known as AREVA NP, about updating measures in the reference NPP, German Convoy 1300MW PWR.

The Project Management had to face the problem of needing enough resources to maintain a support group to study and design a review of the effects of changes in the basic design of the reference plant Angra 2. The preservation of a core group to support the project allowed us to keep the design updated and facilitated the licensing process. This also allowed development of the design and track keeping of the bulk material supplied previously. By means of this procedure, it was possible to keep supplied material ready for use before project resumption.

II-2.3. Problem: Preservation of human resources (core group to face problems)

Solution

As mentioned before, the preservation of the core group was one of most effective actions undertaken by the Project Manager in order to have highly skilled manpower ready to work at the required time. Furthermore, major partners also maintained dedicated staff in their organizations:

- The civil contractor maintained its personnel on site. They were engaged in planning all activities like structural concrete work, execution of steel platforms and finishing of structures. It also maintained and preserved the site installations.
- The Brazilian architectural engineering company (NUCLEN), which was incorporated into the utility in 1997, after the merger of the companies also kept several engineers and technicians, and some subcontracted personnel. These people were kept engaged to preserve the knowledge.
- The foreign supplier also maintained the Coordination Group waiting for the government decision.
- Expert personnel have been kept on site, to manage proper preservation of the equipment.

Although the above mentioned actions have been taken, this was not sufficient to face all the issues related to manpower, and the utility had to hire people to meet the personnel demand. Especially for this issue, it was possible to hire recently retired, highly experienced people available for the Project. This programme was started as the construction was resumed.

II-2.4. Problem: Technical updating of components for installation in the plant before commissioning — A programme to refurbish the components — General Inspection Programme

Solution

Angra 2 components were supplied 15 years before the erection and were preserved in accordance with written procedures provided by the main supplier. These procedures in principle aimed at protecting components against humidity and keeping them completely dry.

This principle assures the preservation of the metallic parts, but affects the grease and the parts subject to aging process.

In order to remedy this, a programme called "General Inspection Programme-GIP" was established, covering the previous replacement of internal parts.

The purpose of this programme was to assure the functionality of the components and parts due to the long time elapsed since delivery and to check for storage damages which could lead to inadequate functioning.

This programme also aimed to avoid cost and time-intensive repair and modification work during Erection and Commissioning Phases, assuring the meeting of the plant construction time schedule.

Finally, the programme aimed at assuring the maintenance of insurance and contractual warranties.

The Inspection of components was based on special technical instructions prepared for different component families, replacing, as far as necessary, damaged/aged parts.

The Established Pre-Conditions were:

Availability of Spare Parts and Special Tools and, in special cases, Supervisors to conduct inspections; Avoiding interference with Erection and Commissioning Time Schedules; Availability of specific Technical Instructions

To implement the inspections, the components were grouped according to their types as presented below:

(1) Group A: Structural Components such as Tanks, Pressure Vessels, and Heat Exchangers.
(2) Group B: Black Box Equipment and Components with Organic/Synthetic Parts, such as:
The Turbo-Generator set, the Diesel Generators, High-Pressure Charging Pumps etc. defined to be inspected due to their complexity and importance to plant operation and safety.
(3) Group C: Rotary Equipment and Components with Organic/Synthetic Parts, such as pumps, compressors and other equipment with rotary/sliding movements.
(4) Group D: Valves of different types.
(5) Group E: Electric/Electronic Equipment such as Motors, Panels and instruments.

For inspection performance, specific technical instructions were prepared for each of the component groups. For the Black Boxes, the respective Instruction was prepared on site by the Supervisor in charge of inspection performance.

Due to the impossibility of inspection on all components, a sampling criteria was adopted to define which items should be inspected:

Group A:	Tanks, Vessels, etc	All rubberized components
Group B:	Black boxes	All selected black-boxes
Group C:	Pumps, Compressors, etc	25% of each type and manufacturer
Group D:	Valves	10% of each type and manufacturer
Group E:	Motors, Panels, Instruments	25% of the items

Only Components stored for more than 3 (three years) should be inspected.

Detailed lists of items to be replaced from each component group were also established (based on the storage time, functional importance, inspection criteria), and harmonized with main Supplier.

The necessary Spare Parts for the inspection were ordered based on these lists and Time Schedules were established, taking into consideration:

- Availability of Spare Parts and required special tools
- Availability of Specific Instructions
- Availability of Supervisors, for black-box equipment
- Conformance with Erection or Commissioning Time Schedules.

The Basic Plan was:

Valves:

- Replacement of gaskets and packing for valves delivered more than 3 years before- Total: 3100 valves
- Change of asbestos packing by graphite and Teflon
- Valves inside the containment – total: 304 valves, prioritizing
  - Safety-related valves
  - Remote-controlled valves operated with extensions

Valves and Actuators:

- Inspection of the corresponding actuator of all selected valves
- Visual Inspection
- Functional Test/Adjustment of moments and limit switches
- Change of the lubricant for each actuator stored for more than 5 years

Pumps and Compressors:

- All equipment supplied by SIEMENS
- Pumps which should not be opened during commissioning
- Critical equipment for primary and secondary circuits

Electric Motors:

- Inspection of the motors for all pumps and compressors selected for GIP
- All Electric Motors delivered for more than five years — Electric Tests and Bearings inspection

Inspection Results

Valves and Actuators:

- The complete set of Globe Valves from a specific supplier was sent back to manufacturer due to problems detected in their stems
- Detection of interference with the body valves in the lining of Butterfly Valves
- Corroded or contaminated stems after long time assembled

Pumps and Compressors:

- Before erection and commissioning phases no significant deviations were detected;
- Removal of dried grease, cleaning and lubrication of bearings
- Change of bearings
- Removal of foreign material detected after flushing and blow-out of pipes
- Adjustment of bearing gaps and inspection of mechanical seals
- Replacement of aged elastomers

Electric Motors:

- Change of bearings, cleaning and removal of dried grease
- Electric tests — recovering
- Vibration elimination

Turbine-Generator Set:

Problems were avoided after performing GIP (preservation device removal, replacement of gaskets, regulation, etc) in the following groups of items:

- Pumps, valves, fans, etc
- Governing racks
- Motors
- Generator equipment, oil supply unit, etc.

Main Problems detected in other equipment

Pressure Vessels and Heat Exchangers

- Corrosion, contamination and rubber lining defects

Refrigerating Machines

- Cleaning of the tube bundle in 2 (two) units, replacement of valves

Generator Circuit Breaker

- Change of components, rubber hoses, valves, etc

Stud-Tensioning Device — RPV

- Replacement of diaphragms in hydraulic system, change of hydraulic oil specification, new arrangement of the feed cable fastening

Relevant Points which have permitted satisfactory results after the 1st Hot Operation

- 24-Month Inspection Programme

This programme, together with the preservation system implemented to store the components, with the participation of SIEMENS, Insurance Company and ELETRONUCLEAR, kept good internal conditions inside the packing. Since 1982, approximately 25 inspections have been performed.

- 24-Month Inspection Programme

Planned initially for implementation to follow a statistical criterion, this programme was adapted to permit the execution of the main events scheduled for the Plant (Primary Circuit Test, Secondary Circuit Test, 1st Hot Operation) covering the main components of the involved systems.

Recommendation to be followed in the future:

- General Inspection Programme (GIP) should be applied only to large components, allowing enough time to inspect and repair (if necessary), without interfering with the main events of the Plant time schedule (Primary Circuit Test, Secondary Circuit Test, 1 Hot Operation).
- GIP should be applied only to component parts, which are susceptible to modification during the storage time (such as sealing systems, bearings, etc), avoiding expensive disassembling costs and great risk of damage.
- The planning and the scheduling criterion should be established as soon as possible, in order to integrate the General Inspection into the 24-month Inspection, following its scheduling and preservation procedures.
- The planning should also take into consideration that components, which will be necessarily opened during erection and/or commissioning, e.g., valves and some pumps, are to be inspected during these phases.

II-2.5. Problem: Preventing failure to supply important components in due time — Planning — Supporting the erection company in recovery programmes

Solution

Even after a good verification for material and component completeness, the utility often has to cope with component failure or inadequacy, thus leading the management to take remedial actions to supply the missing/ inadequate/replacement part in due time. Often, the supplier is not or the components are not available on the market. To overcome such difficulties the Manager has either to deal directly with the supplier or with another supplier or substitute for newly designed components that meet the main requirements.

However, what is really at stake is the effect on the schedule and the need for a recovery programme.

The Management has to be prepared to face this situation and allocate some amount in the budget to support this kind of recovery programme negotiated directly with the Construction Company.

II-2.6. Problem: Repair of main components that failed in commissioning tests

Solution

A major issue to be considered is component failure during plant commissioning. The failure of important components such as a diesel set, or a transformer or large pumps or cranes can be considered normal. Many projects had to cope with some of those failures and even carry out good refurbishing programmes or replace internal parts of main components.

In order to be able to withstand such situations, the Management should be prepared to negotiate with suppliers and try to avoid their effects on the critical path of the Project. Similarly, it is very common to perform commissioning work with the erection completion, and in this case the I&C is normally affected in terms of damage to sensitive components, thus increasing the need for more spare parts than normally required.

II-3. ADDITIONAL INFORMATION

Below is some useful information reflecting the experience gained in the Project, though none of it is specifically about Delayed Power Plant Projects. Still, they detail good practices worth knowing about.

II-3.1. Improvement actions in future plants — Recommended Practices

II-3.1.1. Training

Integrate and training in advance the engineering and planning staff of the Construction and Erection Company in the relevant techniques of the Project to prevent planning mistakes.

Train the manpower of the Companies in design engineering, mainly in the basic design details, in design modification criteria and in correct evaluation of inside building work difficulties, preparing people adequately for better document elaboration.

Emphasize during this training that the use of mock-ups is fundamental to define the geometry of parts to be manufactured and to minimize future interference.

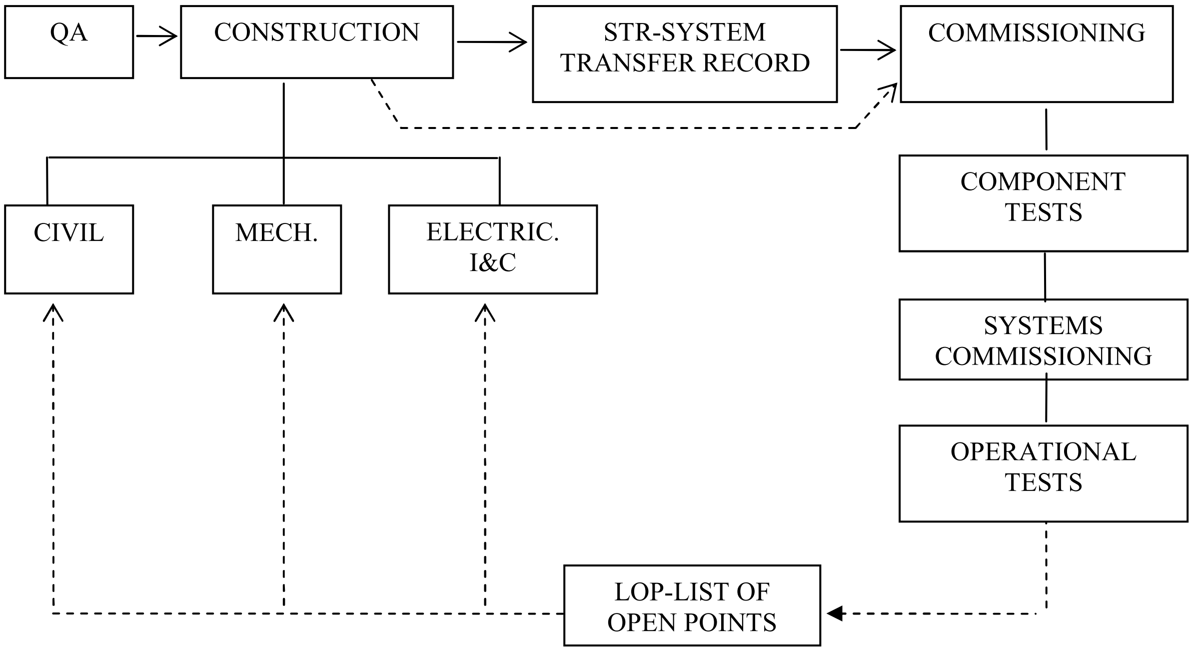
Convey to the Companies full knowledge of the software systems and database and the basic time schedules.

Implement a training programme, with the participation of ELETRONUCLEAR’s employees, for the different activities of production to be developed together with the Contractor, observing and emphasizing the specific workmanship training in relation to knowledge of design, buildings, data base documents, etc. for correct execution of its activities, preservation of the areas and adequate use of the work tool rack.

Additionally, recommending specific workmanship training, for erection of special components such as Electric Generators and Components of the Primary Circuit, in this case under supervision of a representative of the manufacturers.

II-3.2. Erection Company organization chart for completion and transfer of systems — walkthrough

The Erection Company should be advised to have the documentation complete and ready at the end of the erection so that it can be easily transferred to Commissioning as follows:



Angra 2 commissioning group performed operating tests in 136 systems. The construction organization should take into account all work areas such as:

- engineering
- components
- piping and supports
- welding training and pre- qualification of welders
- system pressure tests
- test area for sample-welding process
- documentation.

II-3.3. Walkthrough Group

To assure high standard quality at the end of construction/erection services, a Walkthrough Group was set up with the goal of eliminating possible problems arising from the discipline interfaces and of ensuring erection completeness. The group was composed of technicians and engineers who were acquainted with the systems and had had great experience in Angra 1 NPP, and its function was to verify the correctness and completion of the mechanical, civil and finishing works, ventilation, electrical cables, I&C and cleanliness of each room, with proper records.

II-3.4. Facilities

Set up a work group to analyze all conditions of provisional work areas and to suggest an adequate layout for the correct, integrated accomplishment of the Angra 3 Project. This group should take in to account the construction, erection and commissioning activities and should set a lay out based on the available areas.

Set up a study group to prepare a plan for implementation of all systems and respective databases, with improvements based on the Angra 2 experience, that are necessary for erection development. These systems are to be installed using a computer network connecting all the institutions involved in the construction and erection of the plant.

II-3.5. Materials

Make a survey of necessary equipment, materials and consumables to be used for erection, in order to complete the procurement target required by the Angra 3 Unit design, defining origins of supply and possible replacement of components used and/or modified during Angra 2 implementation.

Establish a General Inspection Programme (GIP), considering the Angra 2 commissioning experience, as well as checking the various stored components, mainly piping and electric cables, in order to begin their selection and preservation.

II-3.6. Design

Transfer Angra 2 as built piping and support drawings to CAD, with their subsequent updating for the design of Angra 3, adding specific recommendations in the isometrics, supports, flow diagrams and plant drawings, enabling access through the network of the inherent information about design and materials, as well as interaction with other areas such as civil construction, steel structures, ventilation ducts and cables racks.

Modify and completing the Erection Instructions with improvement suggestions based on Angra 2 experience, thus enabling the Erection Company to prepare the Service Instructions in a simplified and global way in order to reduce the number of documents and to facilitate handling and filling-in of the respective records.

II-3.7. Planning

Revise the General Time Schedule, considering the most appropriate time period according to the Angra 2 experience, to improve the erection sequence. In particular, for Angra 3, note what must be kept as a basis for planning/ scheduling of piping and support erection to adjust the erection step sequence, ad all the suggested operational improvements and the mentioned data processing in network.

Develop and implement the activities of Electric and I & C systems and databases that allow meeting the schedule and similar controls as mentioned above.

Define in advance and prepare a detailed procedure containing the rules for use of the Erection Examination Sheets, as well as the standardization of the time schedules and production follow-up and control sheets and rescheduling of the erection work.

II-3.8. Construction and Erection Actions

Implement a proper training for manpower concerning standards and control scheduling, and the use of materials and quality control procedures. This philosophy is required as a precondition for erection completion without any risk of delay.

II-3.9. Quality Control

Implement a computer network to control the proper activities, including hold-points.

II-3.10. System Transfer

The Erection Company will have a specific team of control and surveillance to speed up and guarantee efficiency in the system transfer to the commissioning teams and their completeness.

The System Transfer should take place when the systems are completely finished in terms of cleaning and testing, so that it must not be opened again, thus preventing a large amount of damage mainly due to instruments and insulation.

II-4. Angra 3 Project Resumption process

II-4.1. Design Control

Angra 3 design control is the big issue to be faced, considering that a long time has passed since the beginning of the construction and many modifications have been introduced concerning legal, environmental and other requirements .The easiest item to be faced is the technical one and is related to the design that will be the same as Angra 2. This will be valid for all activities except for the instrumentation and minor changes. Digital instruments in the control room are to be used instead of the analogical instruments used in Angra 2.

As to personnel, the impact could be minimized if the project is quickly resumed, since manpower is still available at the design, construction and erection companies that worked in Angra 2. However, mobilization of the large team, which is required to complete the whole project, is a great challenge.

The greatest problem we are facing is the political issue along with the economic aspects which add many difficulties to the decision process, requiring a great deal of effort from the Utility to convince the Government that the project is economically feasible, that it is strategic for the country and necessary to help balance the power matrix.

To minimize the problem and find a way to help us proceed with the project, we are inviting those persons who can influence the public opinion to visit the site so they may observe the degree of quality still preserved in stored components and to consider how much we have spent on this project.

Public acceptance of the project outside of the Angra region among people unaware of its benefits is a problem that has to be considered, since there are some non-governmental organizations are working against the project.

The decision-making process is under the responsibility of CNPE--National Energy Policy Council, made up of Government Ministers and set up to evaluate and support energy policy decisions.

The CNPE has authorized Eletronuclear to proceed with the activities for project resumption and requested an independent assessment of the estimated budget. To perform that a specialized international company was contracted and the studies are in progress.

II-4.2. Preservation of stored equipment

Angra 3 equipment has been stored and preserved in the same way as it was performed for the Angra 2 equipment, maintaining the preservation inspections in accordance with IAEA–TECDOC–1110 on Management of delayed nuclear power plant projects.

Procedures were implemented to assure adequate storage of this equipment, as follows:

- Requirements for long-term preservation of all components
- Storage and inspection instructions
- Specific instructions and procedures for materials requiring special storage.

For Angra 3, Eletronuclear already has 85% of the imported equipment for conventional and nuclear buildings in storage.

This means 10,000 tons of equipment is stored on site, taking up a storage area of 27,000 square meters.

II-4.3. ANGRA 3 NPP — CURRENT STATUS

II-4.3.1. Civil Construction

Angra 3 construction started in 1985, when the site CONTRACTOR was mobilized and the rock excavation work began. The construction was interrupted in 1986. Recently, some civil works were allowed to be performed to adjust the environmental conditions required by Authorities.

II-4.3.2. Decision-Making Process

The government was expected to make a decision by mid 2001, but it did not and is still considering whether Angra 3 construction should be resumed. The project was considered in the Brazilian Energy Matrix Plan to be resumed. Based on this plan, Angra 3 is expected to go into operation during year 2014. The decision depends on the evaluation mentioned above and have taken into account the feasibility studies conducted by EDF, IBERDROLA, INPO and ELETRONUCLEAR, showing that the project is economically feasible.

At the present, much work has been done to support CNPE, which had asked for many studies and evaluations. The decision was done to proceed with the development of the project and perform an independent assessment of estimated budget. Most of the required studies deal with economic aspects in order to support the financing of the whole project. The implementation of the project should only be resumed if it is guaranteed that it can be finished with the budgetary financial resources and developed in compliance with the Brazilian environmental regulations.

ANNEX III
IMPLEMENTATION OF THE ACTIVITIES ON INTEGRATION OF THE ALREADY DELIVERED EQUIPMENT, BELENE NPP, BULGARIA

III-1. INTRODUCTION

The discussions on constructing a second nuclear power plant started in the early 1970's. After performing the necessary investigations, studies and analyses, the Belene site was approved by the Bulgarian Government in 1981 for the construction of a second nuclear power plant on the Danube River. In the same year, engineering site preparation commenced with:

- construction of anti-filtration walls
- erection of external communications, civil and installations facilities

To avoid the risk of site flooding the terrain was built up with eight meters and leveled.

The technical design for the Belene Nuclear Power Plant construction was completed in 1987, thus initiating the large-scale construction of the first two units. According to the then-intended design, four units of 1000 MW each had to be built with a possibility to increase their number up to six. By 1989 the following erection works were completed:

- circulation pipelines
- Units 1&2 ballast mats,
- Unit 1 foundation plate,
- Unit 1 reactor building up to elevation 13.20 m,
- diesel generators' cubicles,
- foundation and support structure of the turbine hall, etc.

In 1990, the Bulgarian Government decided to suspend the project execution due to financial difficulties. Since then, measures have been continuously undertaken to preserve the supplied equipment, the construction site and the buildings. Various investigations and assessments have been carried out with respect to the site suitability and the equipment status, all of which yielded positive conclusions. New investigations have been performed in relation to site safety and its compliance with international requirements. There has been particularly extensive research on the seismic safety of the chosen site. A number of missions were carried out by the International Atomic Energy Agency (IAEA) and other bodies of authority. All these came up with positive conclusions and confirmations that the Belene site is suitable for the construction of new nuclear power plant.

In June 2002 the Bulgarian Parliament enacted the new Act for the Safe Use of Nuclear Energy. The updating Nuclear Regulatory Authority (NRA) regulations on implementing the Act for the Safe Use of Atomic Energy continued until 2004. These new normative documents have been harmonized with the current standards and safety manuals of the International Atomic Energy Agency.

These circumstances required that various steps be taken in accordance with the new legislation resulting inter alia in the development of two basic documents:

— Environmental Impact Assessment

The assessment was carried out in the period from October 2003 to November 2004, and the report was brought to public discussions in both Bulgaria and Romania. The procedure ended successfully, resulting in Decision No.18-8 of the Ministry of Environment and Waters, dated November 22, 2004, thus approving the investment proposal for the construction of a Nuclear Power Plant at Belene site.

— Feasibility Study Report substantiating the construction of Belene NPP

Eight types of nuclear installations were analyzed, on the basis of the technical and economic data provided by the installation suppliers. The summarized technical and economic results of the Feasibility Study showed that an optimal choice, based on the levelized electricity cost, would be the construction of two Units with Pressurised Water Reactors at Belene site. The Feasibility Study Report was made public in November 2004, and a public hearing was held in January 2005 according to the requirements of the Act for the Safe Use of Nuclear Energy.

Fulfilment of all legislative requirements allowed the Government to enact Decision No.260 of the Council of Ministers dated April 8, 2005, thus approving the construction of a nuclear power plant on the Belene site with total rated electric capacity of 2000 MWe. Pursuant to the above-mentioned decision, on May 10, 2005, the National Electric Company (NEK) launched a procedure for selection of a Contractor for the engineering, procurement, and commissioning of Belene Nuclear Power Plant, Units 1&2.

Two companies submitted proposals by the announced deadline — the Russian company Atomstroyexport and the Czech Skoda Alliance. Nine months later the Board of Directors of NEK officially announced that the Russian Atomstroyexport is the company which had been rated first for the construction of two 1000-MWe light water reactors in so called A-92 design at Belene site.

The agreement with the selected Contractor was signed on 29 November 2006. This agreement is the first part of the Main Contract, which will specify all details of the plant construction works, will determine the conditions for successful project completion, the overall construction schedule and the main parameters of the equipment.

III-2. GENERAL DATA OF BELENE NPP

Being a Light Water Reactor of new generation, the WWER-1000/V-466 Evolutionary Design (A92 Design) has improved safety as well as technical and economic features. The main advantages of the WWER-1000/V-466 Evolutionary Design (A92 Design) against the existing nuclear power plants of previous generation VVER-1000/V 320 serial design are achieved by:

- ensuring fast termination of the nuclear reaction in the reactor core, thanks to the action of two individual completely independent reactivity control systems;
- redundancy for all safety functions provided by the use of both active and passive safety systems (including Passive Residual Heat Removal System and Passive Filtering System), which require neither operator's intervention nor electric power supply;
- use of a special structure of the protection enclosure to contain the accident products.

This structure is composed of a primary containment of pre-stressed reinforced concrete and leak tight metal liner, secondary reinforced concrete containment and cast concrete external structure designed for a large range of internal and external events.

A specific feature of the third generation reactor presented in the WWER-1000/V-466 Evolutionary Design (A92 Design) is the provision of an ex vessel corium retention area (core catcher) for severe accident cases. This prevents the occurrence of containment integrity violation and release of highly radioactive substances in the environment.

The comparison between the general data of WWER-1000/V-466 Evolutionary Design (A92 Design) and VVER-1000/V 320 serial design is presented in table 1.

TABLE 1. MAIN GENERAL DATA OF WWER-1000/V-466 EVOLUTIONARY DESIGN (A92 DESIGN) VS. WWER-1000/V 320 SERIAL DESIGN

Parameter	WWER-1000/V-466 Evolutionary Design	VVER-1000/V 320 Serial Design
Service life, years	60	40
Thermal power, MWth	3012	3000
Electric output, MWe	1049	980
Capacity factor, %	90	80
Safety Systems Capacity:		
Reactor Protection System	1x200%	1x100%
Fast Boron Injection System	4x25%	-
Safety Protection Systems including DG+UPS+I&C+HVAC+SW	4x100%	3x100%
Passive ECCS	4x50%+4x33%	4x50%
Passive Heat Removal System	4x33%	-
Melted Core Retention and Cooling System	1x100%	-
Core Damage Frequency, reactor-year	1.5E-07	<1E-05
Early Large Release Frequency, reactor-year	5.5E-10	<1E-06

III-3. GENERAL PROVISIONS

The purpose of the integration Procedure is to establish the order for implementation of the activities on integration of the already delivered equipment under WWER-1000/V-320 Serial Design on Belene NPP Site, for its utilization in WWER-1000/V-466 Evolutionary Design (A92 Design). As result of implementation of the activities under the Procedure, it is required to indicate that the utilization of the existing equipment is appropriate, economically feasible, that it is accompanied by the relevant documentation, spare and completing parts, and satisfies the current regulatory requirements and those of the design for construction of Belene NPP. The purpose of the activities under the procedure is utilizing of the delivered equipment to the maximum extent. The equipment delivered under WWER-1000/V-320 Serial Design, which would prove unsuitable for use in WWER-1000/V-466 Evolutionary Design (A92 Design), will be evaluated technically and financially, in order to be put on sale by the Owner.

III-4. SCOPE AND SEQUENCE OF WORK PERFORMANCE

The Procedure covers the implementation of all activities required to determine the equipment, which can be integrated in WWER-1000/V-466 Evolutionary Design (A92 Design), as well as the activities on evaluation of the technical status of the equipment, which is to be put on sale/purchase. The main activities envisaged in the Procedure are divided into three phases:

First phase:

- Review, updating and addition of the preliminary list of the equipment, which cannot be integrated in WWER-1000/V-466 Evolutionary Design (A92 Design), with the appropriate substantiation;
- Inspection of the remaining equipment (which is object of eventual integration) following the requirements of the Procedure.

This stage of activities will result in the development of a list of the integrated equipment. The results of this stage are recorded in Equipment Data Base and documented in the protocols.

Second phase:

- Evaluation of the costs for the integration (with account of CM: Compensatory Measures, and RRA: Repeat and Reconstruction Activities);
- Determining the price of the equipment, which may be used (with account of needed scope of examination, CM and RRA fulfilled).

Third phase:

- Organization and performance of survey of the non-integrateable equipment (according to the program and requirements of the prospective buyer of the equipment) intended for sale/purchase, with further division into the following categories:
    - Category 1. List of the equipment, which can be utilized in the construction of Units with Nuclear Steam Supply System WWER-1000/V-320
    - Category 2. List of the equipment, which can be utilized as spare parts for Units with Nuclear Steam Supply System WWER-1000/V-320
    - Category 3 List of the remaining industrial equipment of general purpose
- Determining of the price of the equipment, which is intended for sale/ purchase.

The process of determining of the equipment suitable for use or rejection will be reflected in Equipment Data Base. The Owner’s list of the equipment, sub-divided by groups, will serve as a basis for establishment of the data base. Check-up of the equipment will be performed by Code GP (Goods Position) Number, down to Level 3 of the data base (positions of equipment, which can function independently).

Implementation of the integration Procedure

A Joint Evaluation Committee between the Employer NEK and the Contractor was established for the purposed of determining the possible integration of existing Belene plant equipment into the A 92 Plant Design with VVER-1000/V 466 reactor type proposed for implementation under the project.

Once equipment had been determined as acceptable for integration into the project, it was necessary to determine a value of this equipment at which it could be transferred to the Contractor. Both the Contractor and the Employer agreed that the starting point for these discussions was to be the current market price of similar equipment in the country of origin taking into account its current condition.

In the period January – April 2007 the Joint Evaluation Committee prepared of following:

- List of Common-Station Equipment for Integration into A-92 Design (Technological equipment)
- List of Common-Station Equipment for Integration into A-92 Design to be used in the construction and civil works and for construction and civil works base)

Similar lists of equipment that would not be integrated into the A-92 Design were also prepared during this period.

The balance value of the equipment included in these lists was extracted from reports provided by the Employer. A review of this price information indicated that the existing balance values were significantly lower than current market prices for similar equipment. In order to provide the Employer with price information with which to begin the pricing discussions with Contractor, the Architect Engineer has prepared an estimate of the current market price for the equipment to be integrated into the A-92 Design.

This market price information has come from a variety of sources:

- From suppliers, still available on the market;
- From cost engineers working in the industry;
- From internal databases of cost information developed for other Architect Engineer projects worldwide.

The survey of the existing buildings and structures of the construction and erection base at Belene NPP, including analysis of executive documentation, visual inspection, instrumentation survey, including geodetic/field measurements, analysis of the results and making the reports and submission of the reports, was implemented in the period April–June 2007.

At the end of 2007 the Employer and the Contractor signed a separate contract for sale of the equipment that would not be integrated into the A-92 Design.

III-5. SEQUENCE OF ACTIVITIES ON INTEGRATION OF THE EQUIPMENT

The main activities on integration of the equipment are divided into six stages:

First stage — Visual Inspection

Visual inspection means an examination conducted without special means of control (USC — Ultrasonic control, RGD — Radiographic defectoscopy, MPD — Magnetic powder defectoscopy, etc.) and special measurement means.

The visual inspection is conducted based on the Work Programs developed for each type of equipment, describing in detail the scope of examination and means of control of the individual assembly units and elements, as well as the scope of the necessary equipment dismantling works.

The visual inspection is performed to resolve the following tasks:

- determining the completeness of the equipment;
- assessment of the technical condition of the equipment and compilation of a list of defects;
- determining the scope of the required instrumental examination and testing;
- preliminary conclusion/findings on the possibility of using the equipment according to its technical condition.

By results of this stage, the following certificate of visual inspection is drafted, with the following documents to be attached thereto:

- list of the equipment, which cannot be used in the project;
- list of the equipment completeness;
- list of the defects/damages;
- list of equipment to be subject to instrumental examination.

Sub-stage — Inspection of the equipment documentation

Inspection of the equipment documentation includes: inspection of the design, engineering development, manufacturer's, as-built (for installed equipment) and repair documents.

This sub-stage shall be performed:

- to define the completeness of documentation in accordance with the regulatory requirements by the time of equipment manufacture and delivery;
- to establish the guarantee storage terms of the equipment, its components and accessories;
- to make a list of the missing documentation;
- to check the as-built documentation for the conformance with the design;
- to evaluate the sufficiency of the documentation scope to perform the analysis of the equipment conformance with the requirements of the design and regulatory documentation.

By results of this sub-stage, a certificate on equipment documentation completeness shall be drawn up as an attachment to a visual inspection certificate. The results of the documentation review are reflected in the Equipment Data Base and are documented in the protocols. The equipment, for which the documentation is not available in the scope sufficient to prove the possibility of its utilization in project A-92, is not to be further considered for the purpose of integration (if the missing documents cannot be found). It is subject to evaluations for technical fitness and evaluation of its value for the purpose of purchase/sale.

Second stage — Instrumentation examination survey

Instrumentation examination is performed by using special means of control (USC — Ultrasonic control, RGD — Radiographic defectoscopy, MPD – Magnetic powder defectoscopy, etc.) and special measuring devices. If testing is required, the tests are performed by using of test stands or special equipment. Necessity to perform the instrumental examination and tests is determined upon the results of the visual inspection of equipment and documentation inspection.

The instrumental examination and tests are performed on the basis of the Work programs of instrumental examination and tests developed for each type of equipment, which describe in detail the scope, techniques and means of control, as well as the scope and methods required for the equipment tests.

Purpose of the instrumentation examination is as follows:

- Check of the quality of welds and base metal with nondestructive and destructive methods;
- Check of the working characteristics of the equipment, which requires special measurement devices;
- Assessment of the technical condition and preparation of a list of defects;
- Definition of the scope for repair-and-recovery activities.

By results of the above sub-stage, an instrumentation examination certificate is drafted, with enclosure of the following documents:

- Protocols of control and testing;
- List of defects;
- List of repair-and-recovery activities.

The instrumental examination certificates shall provide for the final conclusion on the possibility to bring the equipment to the requirements of the design and current regulatory documentation, with the list of measures necessary therefore. The results of the instrumentation examination shall be recorded in the Equipment Data Base and documented in the protocols.

Third stage — Analysis on compliance of equipment with the current regulatory and technical requirements and those of the design

The activities shall start after provision of the technical requirements for the plant design. Verifications shall be performed for analysis on compliance with the Technical requirements and with the current regulatory requirements. The results of the documentation review shall be recorded in the Equipment Data Base and documented in the protocols. The protocol includes a list of equipment that cannot be integrated, and a substantiation for every item from the list.

Equipment, for which the requirements of the plant design are not satisfied, shall not be further considered for the purpose of integration. It is subject to evaluation for technical fitness, and evaluation of its value for the purpose of purchase/sale.

Fourth stage — Determination of residual life of equipment

Residual life of equipment is defined on the basis of the results of all types of examinations and tests and checking calculations (if required). Based on the work experience on examinations and results of the performed researches, the methods to forecast the change of the material properties under the influence of aggressive environmental factors, including biological impact, shall be developed.

Fifth stage — Development of compensatory measures required for equipment integration into the design and of the documentation for repair-and-renewal activities, cost estimating of these actions

Based of the results of analysis on compliance, the compensatory measures shall be developed to bring the equipment to the requirements of the design and the accepted regulatory base. For each revealed non-compliance, a measure on its elimination or compensation shall be developed, including:

- Engineering solutions on admittance of non-conformances, which do not affect safety;
- Engineering solutions on additional measures to compensate the non-conformances (additional monitoring, testing, design justifications, etc.), providing confirmation of the required safety and reliability parameters of equipment;
- Engineering solutions on modernization (reconstruction) of equipment for the purpose of its bringing to the requirements of the plant design and regulatory base.

In accordance with the accepted engineering solutions the following documents shall be developed:

- Program for additional monitoring and tests;
- Engineering design documentation on modernization of equipment;
- Additional calculation activities to confirm the required safety and reliability parameters of equipment.

Based on the activities performed for all above stages, the cost estimation is made for repair work, compensative measures, and equipment modernization. The cost estimation is made on the basis of quantitative and qualitative criteria. Decision on integration or replacement of any equipment is taken based on the comparison between the cost of new equipment and that of the repair work, compensative measures, and equipment modernization.

Sixth stage - Performance of compensative measures, repair activities and modernizations, issue of specifications for equipment

After final decision on integration of equipment based on fulfillment of the previous stages, the compensatory measures, repair activities, and modernizations shall be carried out, including:

- Development of design-and-process documentation;
- Replenishment of the technical documentation and initial data required for integration;

- Fulfillment of the necessary calculations;
- Fulfillment of the compensative measures, repair activities, and modernizations.

Upon the results of the compensatory measures, repair activities, modernizations, the reporting documentation shall be drawn up to confirm the completeness and quality of performed activities, including the documents for manufacture and as-built documents.

On the basis of the performance of the entire work complex at the previous stages, the specifications shall be issued, which confirm that equipment is in compliance with all the established requirements and is allowed for integration into the plant design. After fulfillment of commissioning activities and testing of the systems and equipment at the stage of putting into operation of the power unit, the certificates of availability/serviceability shall be issued to confirm that equipment operates in accordance with the design requirements.

The activities on integration of the already delivered equipment under WWER-1000/V-320 Serial Design on Belene NPP Site, for its utilization in WWER-1000/V-466 Evolutionary Design (A92 Design) are presented on Figure 1.

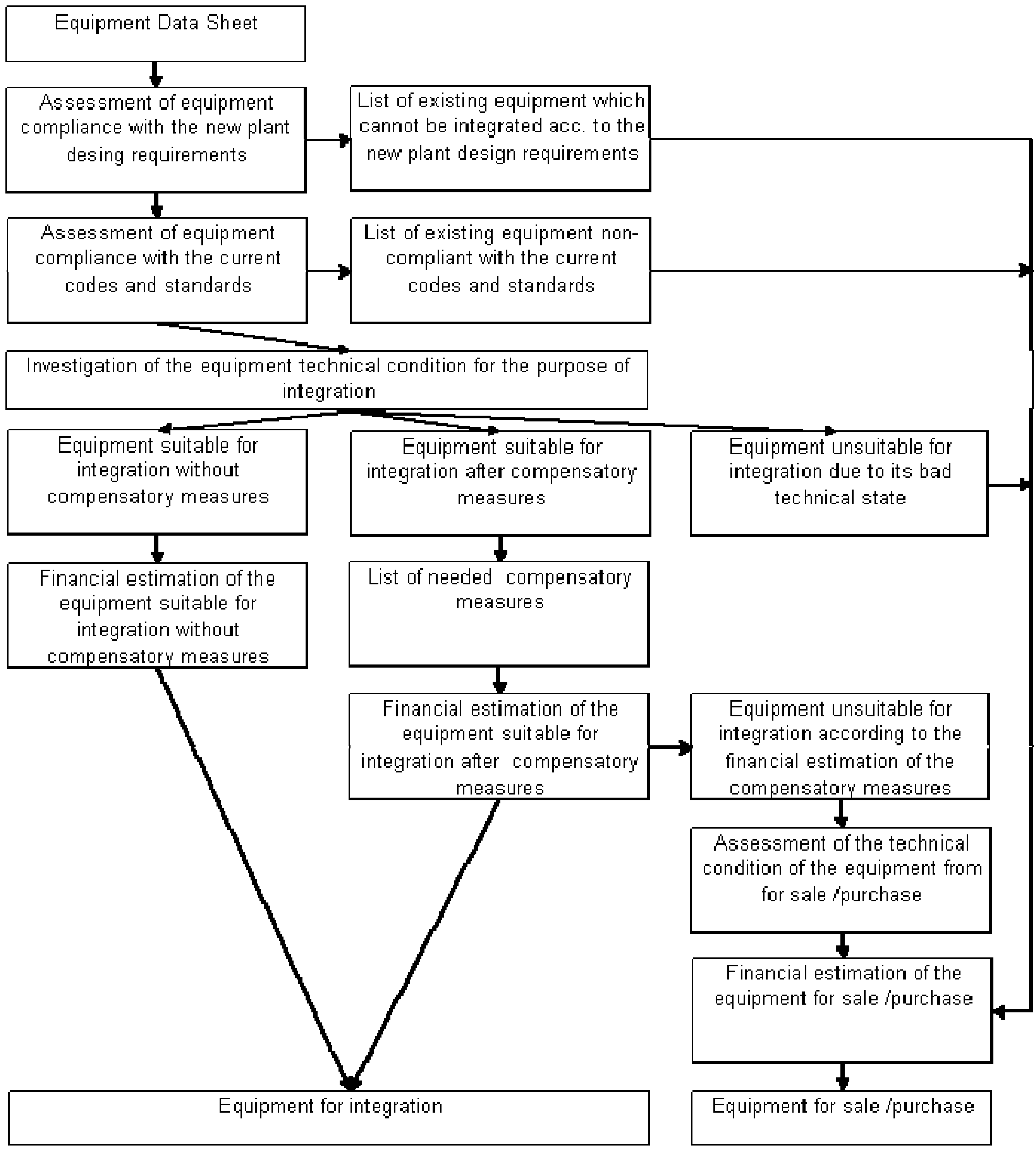


FIG. 1. Activities on integration of the already delivered equipment under WWER-1000/V-320 Serial Design on Belene NPP Site, for its utilization in WWER-1000/V-466 Evolutionary Design (A92 Design).

ANNEX IV
DELAYED NUCLEAR POWER PLANT PROJECT MANAGEMENT EXPERIENCE
CERNAVODA 2 NPP, ROMANIA

IV-1. Summary

The Cernavoda Unit 2 NPP work was originally started in 1982 with work coming to a halt in 1989, and a preservation program implemented in 1991 while work continued on Unit 1. In 1995 attention turned to the completion of Unit 2 and status verification reports were commissioned. Work proceeded, as funds were available, up until 2002 when an interim contract was signed. Subsequently a Contract Completion Effective Date (CCED) was signed in March 2003 with completion duration of 48 months.

A project schedule is a necessity for any project whether it is a new build or a restart to a delayed project. There are 5 major elements that are included in all CANDU project schedules, Engineering, Procurement, Construction, Commissioning and the conversion from Construction to Commissioning.

The Engineering schedule of deliverables was not fully defined at CCED. Design changes defined prior to CCED were not fully defined and the scope of work associated with these only became known during the actual construction program. A significant number of new design changes were introduced after CCED, which compounded the impact to the construction program.

All projects require their budgets to be built up within a defined structure. Delayed projects are no different from other projects in that respect. The standard Work Brakout Structure (WBS), which is applicable to most CANDU projects, is equally applicable for a delayed project. On Cernavoda Unit 2 we used a Budget Breakdown Structure, which was a combination of a traditional WBS and an Organization Structure. This structure was adopted in order to have consistency with the structure, which had been used prior to the delay on the project and also it was a requirement of the three party agreements with funding from different sources and in different currencies.

All major construction projects normally carry a contingency allowance for undefined work and a risk allowance for the possibility of major changes. Delayed projects require greater contingency due to the uncertainty of the legacy equipment inventory, the possible effect of code changes during the legacy period, and the possibility of schedule extensions.

One of the critical success factors for the construction restart of Cernavoda NPP Unit 2 was the condition and assessment of existing material and equipment stored in the warehouses or installed in the field. A preservation program was implemented separately for site-installed materials and managed through the construction division. Subsequently, a refurbishment program was also implemented on identified equipment, which including checking and testing of equipment and changing materials defined as obsolete or undesirable for further use in operation of equipment.

For the most part, the extent of testing of equipment is the same as for a new build project. However, some major components require additional testing which should be performed early

enough in the program to take corrective action if required. A good example of this is the Main Output Transformers T01, and T02, which were manufactured 20 years ago by Electroputere in Romania. These transformers have been preserved on site and recently refurbished.

The Cernavoda 2 Project provided many opportunities to better define the correct approach to a successful completion of a delayed project. Most significant is the need to have a full assessment and definition of the remaining scope of work before the beginning of the Completion Contract.

In conclusion, MT Project Management team adapted their work processes and procedures to suit the specificity and challenges of the Cernavoda 2 project. Interfaces with internal groups and external organizations were optimized through efficient communication processes. This allowed timely identification of issues through to the Engineering, Procurement, Construction, Planning, and Commissioning organizations. It was clearly demonstrated that teamwork, creativity and dedication to quality and productivity have been keys to the successful completion of many critical activities.

IV-2. General Information

Work on Cernavoda Unit 1 started in 1981 and work on Units 2-5 started in 1982 at this time progress was slow and all work stopped in late 1989.

AECL Ansaldo Consortium (AAC) was formed in 1991, with completion work starting on Unit 1, along with a preservation program for Units 2 to 5. In 1995 attention turned to the completion of Unit 2 and some Status Verification Reports were commissioned. In December 1996 Unit 1 was declared in service and after July 1997 AAC work became involved in Unit 2 only. In 1998 expatriate staff was reduced to 8, and a buildup of expatriate staff started again in 2000. A Completion Contract (CC) was signed in May 2001 but was not put into effect. An interim contract was signed in July 2002 to allow work to commence until a new CC effective date was determined. Concrete structures were surveyed and repaired, embedded equipment supports surveyed, assessed and repaired, delivered equipment evaluated for condition and inventory and remedial action initiated. Regular inspection of Steam Generators and other large vessels plus inventory and assessment of Turbine Generator components was completed.

Subsequently a Contract Completion Effective Date (CCED) was signed in March 2003 with completion duration of 48 months.

IV-2.1. Assessed Project Status at CCED

- Overall Project = 51.75%
- Engineering = 50%
    - Procurement = 67%
    - Civil Construction = 75%
    - Mechanical/Piping/HVAC Construction = 25%
    - Electrical & C&I = 10%

IV-3. Problems Encountered and Measures Implemented

The following reports address Problems Encountered and Measures Implemented from the perspective of the project knowledge areas of Planning & Control, Budget, Engineering, Materials & Procurement, Construction, Commissioning and Quality Assurance.

IV-4. Planning and Scheduling

A project schedule is a necessity for any project whether it is a new build or a restart to a delayed project. There are 5 major elements that are included in all CANDU project schedules, Engineering, Procurement, Construction, Commissioning and the conversion from Construction to Commissioning.

IV-4.1. Engineering Schedule

For Delayed projects an assessment must be made to establish what engineering deliverables are already available and those that remain. Included in the assessment will be a complete listing of all refurbishment work (Civil, mechanical, electrical/C&I) that must be performed.

When the scope of work is defined and the engineering deliverables established equipment and material lists should be available. This will allow the preparation of Purchase Requisitions (PR), Request for Quotations (RFQ) and eventually Purchase Orders (P.O.) for all permanent plant materials. For delayed projects this will define procurement requirements for material not already on site plus the material requirements for any refurbishing to be done. Activities for each of these will be included in the schedule with achievable dates for completion. Durations for the engineering portion of the procurement cycle will be based on current laws applicable to the project and past experience.

IV-4.2. Procurement Schedule

The development of the procurement schedule for a Delayed project is no different than the process used for a new build project.

IV-4.3. Construction Schedule

Using the Engineering deliverables and procurement deliverables established by the engineering schedule clear links to the construction portion of the schedule should be established.

Included in the construction schedule for Delayed Projects will be a special section devoted to refurbishing material and equipment as defined by the engineering schedule.

Other than the refurbishment activities, the development of the construction portion of the schedule for delayed projects is no different to new build projects.

IV-4.4. Commissioning Schedule

The commissioning schedule should be resource loaded and leveled prior to defining the system turnover profile that construction must work to achieve.

Therefore, for delayed projects there is no difference in the development of the Commissioning schedule.

IV-4.5. Conversion Schedule

Because construction builds the plant by area and commissioning commissions the plant by system it is necessary to include in the schedule activities that convert the construction schedule to a system based schedule.

This portion of the schedule contains system completion and verification activities for each system turnover package defined in the Commissioning schedule. For CANDU plants an allowance of 3 months is included to complete pressure testing, electrical check and tests, pipe painting and insulation as well as compiling all necessary documentation (as-constructed drawings, pressure test documents, etc) to allow the system to be turned over to commissioning. All construction work required to support the system turnover is tied to the appropriate system completion activity.

For delayed projects there is no difference in the development of this portion of the schedule.

IV-4.6. Level 2 Control and Coordination Schedule

When the 5 elements of the schedule are fully developed the entire schedule will be linked from Engineering to Procurement to Construction to Commissioning. Analysis of the overall schedule will be done to correct any logic problems and to ensure that the project critical paths are well defined. Resource considerations for Construction, Engineering and Procurement will be analyzed at this stage to determine the feasibility of achieving the preliminary schedule.

Once the schedule has been thoroughly reviewed and all activities have been coded to agree with the Work Breakdown Structure it should be presented to senior management for agreement. At this stage the appropriate contingency for the project should be introduced at the end of the project or against specific activities. With the inclusion of the contingency the project early dates will be established and included with the approved revision 0 of the Level 2 Coordination and Control Schedule (C&C Schedule).

The C&C Schedule defines early and late dates for all activities on the Project. Of particular importance are the Engineering and Procurement deliverable dates which interface with construction, the System Turnover dates which define the construction deliverables and the Project Milestone dates. Also defined are the major critical paths for the project.

The C&C Schedule is coded in such a way that extracts of various combinations of data can be retrieved and presented. One such extract will be the Level 1 Summary schedule.

For a New Build CANDU Project a contingency of approximately 8% should be applied to the overall project duration. Because of the greater unknowns associated with Delayed projects this contingency should be increased to 10 to 12% depending on the degree of scope definition and time of lay-up.

IV-4.7. Scheduling Problems Encountered at Cernavoda Unit 2

The Engineering schedule of deliverables was not fully defined at CCED. Design changes defined prior to CCED were not fully defined and the scope of work associated with these only became known during the actual construction program. A significant number of new design changes were introduced after CCED, which compounded the impact to the construction program.

When the refurbishment program was initiated after CCED a significant number of problems surfaced which required Engineering and Procurement actions again impacting on construction. Definition of new requirements due to Design Change Notices (DCN), Refurbishment, and incomplete Engineering continued throughout the construction phase, which inevitably impacted on the ability to meet the system turnover requirements.

The Cernavoda 2 project schedule was established as 48 months for the completion contract. This was defined prior to CCED and did not include contingency and was based on information know at that time. The project was in its 33rd month when it was forecasted to be 3 months late to the 48-month requirement. A contingency of 10% would have covered this delay.

IV-4.8. Budget Breakdown Structure

All projects require their budgets to be built up within a defined structure. Delayed projects are no different from other projects in that respect. The standard WBS, which is applicable to most CANDU projects, is equally applicable for a delayed project. On Cernavoda Unit 2 we used a Budget Breakdown Structure, which was a combination of a traditional WBS and an Organization Structure. This structure was adopted in order to have consistency with the structure, which had been used prior to the delay on the project and also it was a requirement of the three party agreements with funding from different sources and in different currencies.

IV-4.9. Project Budget

In preparing the project budget it is necessary to have a complete scope definition as well as an agreed upon project schedule. On a delayed project, the scope definition requires to have a clear status of work prior to restarting the project. The Management and Commissioning Team have to be established and budgeted taking into account the overall project schedule and scope of work. The Services required over the life of the project must also be estimated. For a delayed project there are sometimes additional Services costs covering items such as staff remobilization and preservation of legacy equipment. As with traditional construction projects the overall budgeted must be cash flowed in order to clearly identify the resources (personnel and cash flow) required for the life of the project.

IV-4.10. Construction Budget

The Construction budget is established by first having a clear scope of work and a status of the work prior to restarting the project. On Cernavoda Unit 2 the status of work was established through the preparation of a “Status Verification Report” or Assessment Report. Due to the amount of time between preparation of this report and the signing of the Completion Contract, it was necessary to update the report to account for work done until the CCED. When preparing the budget for a delayed project, it is necessary to update the rate structure to account for the current rates at CCED and to allow for escalation throughout the project. There should also be an allowance for the possibility of bonuses or overtime for construction contractors required in case the project falls behind schedule. The Construction budget on a delayed project must also include an allowance for legacy equipment refurbishment.

IV-4.11. Permanent Material Budget

The Permanent Material budget has to be prepared first looking at what the total inventory is available at the re-start of the project. Any purchase orders that were issued prior to interrupting the project will have to be reviewed to see what increases are required to complete the procurement. Prior to the CCED it is necessary to determine that the existing inventory listings are accurate. During the time between stopping and restarting the project, equipment is sometimes damaged or lost or transferred or sold to other units. All legacy equipment must be inspected to see if it is still fit for use as is or if refurbishment is required. If the delay in the project is lengthy, it is necessary to procure replacement of elastomers and gaskets. Depending on the preservation program put in place during the delay period there may be extensive refurbishment required.

As there may be many design and code changes during the delay period, the legacy inventory list must also be reviewed to see what equipment has to be replaced. Any equipment that is required to be replaced due to obsolescence must be reviewed to see if this results in design changes requiring other equipment replacements. Any items that require replacement will have to be estimated separately. Design should be well enough advanced prior to restart so that all equipment not identified in inventory can be estimated. On all projects, it is necessary for the equipment budget to include an allowance for spare parts for construction, commissioning and the start of operations. On a delayed project this allowance should be greater as sometimes there is a greater possibility that legacy equipment may fail and require replacement during commissioning.

IV-4.12. Contingency

All major construction projects normally carry a contingency allowance for undefined work and a risk allowance for the possibility of major changes. Delayed projects require greater contingency due to the uncertainty of the legacy equipment inventory, the possible effect of code changes during the legacy period, and the possibility of schedule extensions. While it was stated at the start that the project schedule must be agreed to prior to the CCED, a delayed project carries a greater risk of schedule extension due to some of the uncertainties stated above. Schedule extensions require increase not only for the management and commissioning teams but also for the support services that are required over a longer period of time. The amount of contingency on a delayed project depends on the extent of inspections and reviews done prior to the CCED.

IV-5. Engineering

The know-how applied to the design and construction of new CANDU stations cannot be directly applied to the completion of the Cernavoda 2 project without major adaptation to suit specificities of a delayed project restart. This is valid for all aspects of the project and has had great influence on work processes associated with all engineering disciplines. Since Engineering has a role in all phases of the project and interfaces with all the other divisions in the organization, the effort invested in adapting to a delayed project environment was significant.

IV-5.1. Engineering Estimate

Given the delayed nature of the Cernavoda 2 project, the total scope of engineering work was not accurately defined at project restart and many unknowns that unfolded during the execution of the project affected significantly the scope definition and estimates. Some of these unknowns included the status of installed equipment and structures, the legacy documentation, the jurisdictional authority approach to registering old and new equipment, the applicability of old and new versions of Codes and Standards, equipment vendor data, the impact of the application of new engineering and document control tools to old design documentation and the additional design changes identified after project restart.

The Completion Contract for Cernavoda 2 assumes that the design documentation of the reference project, Cernavoda NPP Unit 1, as of June 1997, is ready for use to implement contractual design changes for Unit 2. While performing design documentation updating for Unit 2 it was found that many old drawings had to be redrawn or fixed, and many had to be renumbered to be accepted by the new document control software.

IV-5.2. Challenges

In order to meet the challenges of a very demanding schedule, engineering activities were restarted at the same time as other site activities; therefore, many engineering tasks were carried out simultaneously to support the inspection and refurbishment of legacy equipment, the procurement of new equipment, equipment registration with jurisdictional authorities and construction work. The design documentation was revised several times in order to reflect the results of the above activities. Consequently, the actual engineering effort required to complete the project exceeded the original estimate by approximately 50%.

Qualified specialists in areas such as Control and Instrumentation and Stress Analysis were not available in adequate numbers in the local market. This problem was somewhat compounded by constraints in hiring new staff by the local engineering subcontractor. As a result, site engineering provided a great deal of “on-the-job” training and this also challenged the ability to finish deliverables in time.

IV-5.3. Refurbishment Program

The project management team implemented an assessment and refurbishment program involving all installed and stored legacy equipment and their associated documentation. The scope of the program was tailored to each discipline and each application to ensure, for example, that components belonging to safety systems or that are difficult to maintain during plant operation would be adequately inspected and refurbished. For non-safety bulk components, representative samples of equipment classes were inspected while the remaining items were adequately inspected under normal site procedures just before installation. The refurbishment program also included the replacement of obsolete parts, aged polymeric materials, damaged or missing parts and the replacement of items in compliance with Environmental Qualification requirements. Detailed databases were developed and kept up to date to provide the status of each item in the program at all times. The results of the inspection revealed a much larger scope of refurbishment and replacement than expected. Also, the equipment design and manufacturing documentation was often found inadequate. This demanded significant effort in discussions with manufacturers and/or in the performance of engineering evaluations and re-testing, in order to save time and avoid having to procure additional equipment.

IV-5.4. Equipment

Additional engineering scope resulted from having to deal with the authorization and design registration of imported equipment and materials since there were no mutual agreements between the Romanian jurisdictional authority and foreign (mainly Canadian and Italian) jurisdictional authorities. Also, for the existing inventory there was on-going discussion with the Romanian jurisdictional authority to clarify the level of detail required for the history documentation and life limits of shelf components.

When existing equipment or materials were identified as to be replaced, Engineering assisted the procurement team to re-evaluate the old supplier or to qualify the new supplier. Very often, associated documents were revised and deviations from specifications by suppliers evaluated in order to ensure compliance with design intent.

Due to lack of orders from nuclear power plants for many years, many of the local suppliers no longer had adequate engineering capability to support the manufacturing of equipment and materials commensurate with Cernavoda 2 project requirements. They looked to the project engineering team for technical support or to provide detailed manufacturing drawings.

There were over 80 design changes identified after project restart. Some of these are new design changes that dealt with plant improvements; Spent Fuel Bay stainless steel liner, Closed Circuit TV for Primary Heat Transport pumps, VESDA fire protection for Secondary Control Area, Raw Cooling Water maintainability/availability enhancement. Or, for adaptation to newly procured equipment (Flux detectors replacement, modification of heavy water detection system, fire detection system, etc), some were related to scope modifications of contractual design changes (replacement of RSW back up cooling for additional chilled water loads, replacement of pneumatic control panels with DCS, etc), and others are the reversal of contractual design changes (F/H design improvement, modification of charcoal filter, etc).

The extent of engineering work can be accurately established only after there is a clear definition of the impact that vendors information will have on detail design. A large amount of the above information was not available when the engineering scope of work was estimated. Moreover, completion of major design changes such as the implementation of DCS for BOP systems, the D2O Upgrader performance improvement, Standby Diesel Generator replacement, changes to the ventilation system in major buildings and ECC enhancements were pending availability of vendor's data.

Also, as a result of lack of vendors' data, work processes were developed or changed and considerable effort invested in obtaining advance information from suppliers in order to avoid delays to the project while maintaining quality and design configuration control requirements. Procedures were revised and time invested to ensure adherence.

IV-5.5. Measures taken to meet the challenges

First of all, in an effort to define the state of the reference design documentation, a program was put in place to bring the state of the documentation to the Cernavoda 1 as-built condition of June 1997 minus all changes not applicable to C2 and then introduce the 320 contractual DCNs plus the additional 80 DCNs approved after project restart.

Each design change is given a DCN number and assigned to a lead engineer for detail planning and coordination. The lead engineer defines, with inputs from all applicable engineering disciplines, the deliverables, the interfaces and the target dates for the implementation of the above design changes. Lead engineers are also responsible for the coordination and follow up to completion of detail design by all applicable engineering disciplines. Coordinators from each engineering discipline and an overall DCN coordinator for the Division meet on a regular basis with the General Manager to report on the DCN implementation status.

A detailed process was put in place to follow up on all activities related to ISCIR as applicable to legacy and new equipment, material and services. A log and a follow-up of all submissions to ISCIR and to the authorized Design Organizations to allow the manufacturing and delivery of pressure retaining components was put in place and updated regularly. A project coordinator was assigned to follow up, expedite activities and to ensure that documentation is complete and actions carried out on time. Also, monthly meetings with ISCIR were organized to deal with critical issues.

In order to deal with late delivery of equipment and materials, the engineering team were involved in activities such as material substitution and issuing drawings/documents to the field, marked up to flag pending information and including instructions to allow Construction to make full use of their work force and thus allow timely turnovers to Commissioning. An aggressive vendor data follow up system was instituted to expedite the suppliers in delivering pending design information to also expedite installation and turnover completion.

IV-6. Material Management

At the suspension of any large power project materials will continue to flow well after the order to stop has been given. At the restart of suspended power plant there will be an existing inventory available for the restart. These uninstalled materials will remain in a preserved condition and will usually form part of the Demand and Supply of the resurrected Project. Material Control plays a significant role in upgrading the inventory data and computerizing of Engineering information and Procurement information and assist Engineering with analysis of additional procurement requirements.

A task Team was instructed to perform a physical Condition, Completeness, and Obsolescence Assessment with Engineering and Material Control specialists prior to Contract Negotiations. Inventory records were mostly paper oriented and sketchy on details. Old project inventory data and descriptions required major upgrading and a large effort to improve the information. Many cases of “equivalent” materials could not be recognized due to hazy old descriptions and history.

Inventory records were reasonably accurate but required verification and expansion of information. Inventory verification was completed at same time as the identification and assessment process. Procurement and Technical information mostly archived in paper form required significant effort to locate and to update.

QA requirements of the time were applicable and sometimes no longer adequate for use during current restart construction phase due to code or regulatory changes. On restart projects a Procurement Quality Assurance Manual is produced and Material Supply secures supply offers to current specification or QA level. QA records and history dockets can be difficult to find and it takes time to thoroughly review these and match up to existing inventory. Due to the high cost of nuclear components verification of and mating of descriptions to demand and supply is necessary.

Incomplete and old Bill of Material computerization leads to significant efforts in conjunction with Engineering to finalize Bills Of Materials (BOM) and input to Data Bases so that proper demand and supply reviews can be completed. Bills of Material on reference plants are sometimes not suitable to load to databases in raw form due to many changes and due to newer technology being merged with existing older equipment and systems. Use of a central materials database allows the production of many customized and ad hoc reports to assist all site departments with their responsibilities. Comprehensive shortage and delivery reports can be created with data including delivery and inventory information.

Resources should be made available prior to CCED to ensure that this effort is captured and is the key to lessen the amount of late discovery work.

IV-6.1. Material Supply

ENG is responsible to match demand with available and suitable inventories and produce Procurement Requests (PR) Specifications and QA requirements for the balance of equipment and material to finish the project.

Evolving Engineering Work Packages, because of need to make hybrid of older equipment and systems with newer technology, sometimes, can lead to significant delays in PR and Specification issue and the offer review for the Procurement Group. This means many clarifications for vendor offers taking longer than normal time.

Many systems are subject to design changes and the design can be slow to complete. The design must be finished for procurement to advance to a stage were all requirements were known and manufacturing can commence. This can lead to later than anticipated deliveries and further schedule impacts in Construction Turnovers to Commissioning requiring schedule adjustments to turnover dates.

Consulting with Planning, Engineering and Material Supply early as possible is key to define sequence of Procurement.

Localization of manufacture and supply can often be very difficult due to ever changing and evolving licensing requirements imposed on manufacturers or suppliers by regulatory bodies. Instances can occur where qualified manufacturers are unable to use their existing inventories of perfectly suitable materials and be forced to procure new source materials under complex regulatory and licensing scenarios leading to manufacturing delays, impacting project schedule and increasing costs to the project.

A complete vendor qualification program of manufacturers and suppliers in the nuclear component supply must be implemented early in the Project. This review should include a complete financial viability review of the selected supplier.

Supply Chain management on delayed projects are more complex as procurement quantities are usually smaller however more expensive. In the nuclear component field a longer than usual lead-time is required for equipment fabricators. Prevailing world conditions and market demand for certain commodities also affect pricing if volumes are low.

Late discovery of missing components or parts of equipment place a strain on Engineering, Procurement and Construction groups to quickly acquire and install to allow for system turnovers on time. Due to evolving design, obsolescence and discovery work a sizable portion of the Completion Contract can become out of scope. Better analysis or definition of procurement scope early is very important.

In many countries there are rules and regulations that govern the work process of placing purchase supply contracts internally and externally. These methods should be studied very closely at CCED as the interfaces can add significant time to placement and ultimately affect delivery to site.

IV-6.2. Warehousing

Resources should be optimized in to centralizing a facility and making it the most modern building on the site. The receiving, storage and issuing of correct material in a timely manner can save the Project a lot of money and time. There are resources to gain with this approach. The facilities can be re shaped after the construction period to storage of material and equipment to support plant operations. The correct storage levels of equipment and materials will be maintained and be protected from harsh environments.

Again there are monetary long-range gains to equipping the warehouse with the most modern material handling equipment. With efficient material handling equipment there are gains in employee safety and quality handling of materials

IV-6.3. Preservation

The Preservation team that is engaged or tasked to perform preservation activities during the years of no construction normally stays with the equipment until issue to construction. Computerized records are used to schedule prescribed inspection and maintenance activities and work carried out continuously as required. All future supply contracts for equipment require the supplier and manufacturer to provide worst case preservation preparation and identify requirements for storage and preservation much earlier in the deliverables schedule.

IV-7. Construction

One of the critical success factors for the construction restart of Cernavoda NPP Unit 2 was the condition and assessment of existing material and equipment stored in the warehouses or installed in the field. A preservation program was implemented separately for site-installed materials and managed through the construction division. Subsequently, a refurbishment program was also implemented on identified equipment, which including checking and testing of equipment and changing materials defined as obsolete or undesirable for further use in operation of equipment.

Considering that most civil work was complete at CCED, changes had to be made to structures in meeting the design requirement for newly purchased equipment. Further discoveries of failures in valve seals and flange gaskets on older installed equipment have caused delays to testing and completion of systems. Resources for this type of work are not accounted for in planning and execution of the project.

IV-7.1. Preservation

A preservation program for Equipment and Materials was in place during the period of Construction and Commissioning of Unit 1; the program included any materials and equipment for Unit 2 and was under the management of the "Unit 1 project team". During the interim period between Unit 1 completion and the CCED for Unit 2 the program was under the management of the client and continued the same practices as established during the U1 construction period.

Since CCED, Equipment (including previously installed and newly installed) in Unit 2 is under a Preservation Program managed by Construction Site Services Department with small core Management Team (MT) staff and carried out by Contractors for equipment in their responsibility areas. This program has been very successful in preventing deterioration of equipment. Program is managed by approved MT Preservation, Cleaning and Housekeeping Procedure and is based on Engineering and Manufacturers defined requirements

Contractors are required to have internal (MT approved) procedures and perform required Preservation actions for equipment under their care and custody from time of removal from MT Warehouses up to Commissioning turnover. Each equipment has it's own record card, prescribed inspection and maintenance requirements and instructions specified by Engineering.

Contractors were required to issue a Preservation schedule for approval by MT. And all activities subject to verification by Engineering and QS groups. Both groups participated in a collaborative way with Site Services/Contractors and gave quick responses to new or unusual situations.

Engineering and Quality Surveillance (QS) groups raised and approved appropriate corrective actions through Non Conformance Reports (NCR) or Site Dispositions (SD) when deficiencies were found

It proved essential to work closely with Engineering and QS, and this collaboration ensured a very successful program for equipment installed and stored in Unit 2. Further, close collaboration with and monitoring of Contractor's activities was key to ensuring a successful prevention of deterioration to equipment and materials.

The Site Construction Contractors provided dedicate skilled trades people to such a program. In case of Cernavoda this also proved to be a key contributor to success.

IV-7.2. Inspection & Refurbishment Program

After CCED, an Inspection & Refurbishment program was implemented under the Construction Mechanical and Piping Department's management to inspect, test and refurbish selected equipment that had been installed in Unit 2 or remained in MT warehouses to verify/ensure that the equipment was ready for installation. This included major and minor pumps, motors, valves, valve operators, vessels, exchangers, electrical and control panels, and other equipment. The initial list was based on the "Status Verification Report" produced prior to CCED and this was added to during the project's evolution.

Additional refurbishment work has been necessary to replace elastomers and other components due to increased code requirements (i.e. EQ) and a program to replace gasket or packing materials containing asbestos.

A comprehensive procedure was prepared to manage the process and ensure results of inspections, testing, and refurbishment was properly documented for History Docket and future maintenance purposes. Engineering department had the responsibility to identify the equipment to be checked, establish the scope of inspection and refurbishment, issue required instructions, procure required parts, make final evaluation/decision after refurbishment, maintaining databases and ensuring documentation retained in permanent records.

Actual physical inspection and refurbishment work was the responsibility of Site Construction Contractors who were responsible to provide required tooling (except defined “special tooling”), provide trained trades people, qualified supervision, internal QS staff services, preparing Inspection and Test Plans and internal procedures/instructions as required.

Mechanical/Piping Department provided direct supervision of all Contractor activities related to the program, technical expertise, assurance that the contractor adhered to QA requirements, followed inspections &refurbishment in accordance to ENG requirements and ensured that all documentation properly prepared and collected for forwarding to ENG.

A large portion of the program was devoted to valve testing in a valve test/inspection facility. Wherever possible valves were moved from Unit 2 or from Warehouses to the test facility for testing/inspection and refurbishment if required. Some installed “legacy” valves were inspected/refurbished at site in Unit 2. A number of valves, upon inspection, required more thorough refurbishment than originally planned, requiring additional parts and work.

All NSP valves were inspected and tested. Support systems valves only a percentage was inspected/tested due to sheer volume and constraints due to installation schedule.

IV-7.3. Measures Taken

It was realized at the onset of the program that workers doing this kind of work must be a different skill set than normally required for construction and installation work. Training was provided to the subcontractor’s staff to ensure proper skill sets were available for all types of equipment refurbishment. Tooling requirements for this work was supplemented by the project, as the construction contractor did not carry some of the tooling required that they would normally use in the installation program.

IV-7.4. Civil Construction Program

Most of the main concrete and steel civil works for Unit 2 were made during the 1980s at same time as Units 1, and partially 3, 4 and 5. Structural steel beams for main buildings were maintained as part of the main preservation program during those years, which prevented significant deterioration of these elements.

An inspection program was implemented including a substantial amount of weld verifications on internal structural steel, supports and platforms etc. resulting in the need to change all old installed anchors to Hilti anchors to meet seismic requirements.

After CCED, changes were required to meet the design requirements for newly purchased equipment due to evolving Engineering of mechanical and piping systems. Some rework was required for support and alignment issues encountered due to the hybrid situation where older or already installed equipment was to be merged with newly specified and procured equipment

The restarted program also developed opportunities, which included the architectural finish portion of the project such as floors, wall, ceiling and room completions, installation of remaining underground services, painting of process equipment, structures, as well as roof rehabilitation.

Work was required to rehabilitate building roofs and cladding. A number of plugged embedded pipes and conduits were found as piping and electrical work progressed and often meant extra work to resolve. For some of these, high-pressure water jet technology was used to unblock, for others, retrenching and replacement was the only option.

New architectural materials (such as the surfacing materials for the dousing tank) were introduced due to changes in materials technology over the intervening years since Unit 1 was finished. More modern wall and ceiling systems were installed using imported materials, which improved finishes and shortened installation times.

IV-8. Commissioning

With Cernavoda Unit 2 Commissioning Program there are both similarities and differences to Commissioning of a new build plant.

The following are the areas that will be discussed: A new process of design basis review by commissioning engineers was undertaken for each system to review the Design Basis documentation, to establish the basis for the testing program; an operations assessment process of plant differences from Unit 1 was undertaken to document equipment and system differences, from an operations perspective, as training material for operations staff undergoing licensing training was required do address these differences; Technology upgrades in E, I&C equipment has required implementing new processes and additional training of commissioning staff; Some important major refurbished components undergo more exhaustive testing including repeating of factory acceptance tests; An enhanced process for managing discovery work during testing was implemented to minimize schedule delays from unexpected equipment or system problems.

The commissioning processes and organization structure are largely the same as commissioning a new build plant with the exception of increased staff in maintenance in anticipation of a higher level of discovery work, and a larger contingent of staff working on spare parts review and ordering for old equipment.

Ultimately the in-depth quality assurance process of Commissioning Completion Assurance (CCA) assures that all systems, structures and components meet their design intent and are available for service for both new and old equipment and for both safety and non-safety related system. The only difference is a higher risk of schedule delay because of unanticipated problem discoveries.

IV-8.1. A New Process of Design Basis Review

As is the case with any Nuclear Power Plant the primary objective of Commissioning is to develop and implement a testing program of the systems, structures and components to assure that the design requirements as specified have been met. Early in the commissioning process a technical benchmark is prepared by systematically reviewing all available design information and is performed by each commissioning engineer, prior to the preparation of Commissioning Specifications, Test Procedures and other documentation.

At Cernavoda Unit 2 a formal process of Design Basis Review was set up in the Commissioning Technical Department in order to establish what information was available, what information was missing and to identify issues for resolution with Site Engineering. The review included tabulating information from Conceptual Design Manuals, Design Modification Evaluation Reports prepared prior to CCED, Design Manuals as available, contract design changes (DCNs), and Site Dispositions. For Cernavoda 2 many sources of design information had to be thoroughly reviewed to get a clear understanding of the design. A quality record named Commissioning Clarification Request (CCR) is presented to engineering for issues resolution as part of this process and often to clarify the acceptance criteria for a proposed test.

IV-8.2. A New Process of Operational Differences Assessment

At Cernavoda 2, because the reference plant design is Cernavoda U1, previously in-service for seven years prior to CCED, a new process called Operational Differences Assessment provided the development of training material. This involved a systematic review process that provided a documented analysis of the U1/U2 design differences from an operational perspective. The starting point was the Design Basis Review process described above.

A team of Control Room Operators in training was assembled to prepare 37 summary packages. The main focus was to identify changes to Operating Manuals as a consequence of design or equipment differences. As a secondary step draft operating manuals for unit 2 were also produced.

In the case of Cernavoda Unit 2, the delayed NPP project was an advantage and opportunity to the authorized staff licensing program because the mature U1 operating program was an excellent starting point for Unit 2 only, taking into account the operational differences, which overall are not that significant. It is a much bigger task for a new build involving development of the licensing program from first principles.

IV-8.3. Technology Upgrades requiring new processes and training

Implementation of the approximately 300 design changes in the contract has resulted in the supply of newer technology solutions especially in the electrical, instrumentation and control area. This is also caused by obsolescence of older equipment no longer available. One of the most significant changes, which are due to obsolescence of the Control equipment used on unit 1, is the implementation of an ABB Symphony Harmony Distributed Control System (DCS) in the balance of plant. This is the first application of a DCS in a CANDU Nuclear Plant, requiring substantial focus in the following areas:

- Manufacturers training given to fifteen staff in hardware and software maintenance including both technical and maintenance personnel.
- New Software configuration management processes have been developed and implemented, modeled after similar processes which have been used in CANDU stations on their Digital Control Computers for more than 20 years. The major difference is the open architecture of the ABB system for which strict access requirements had to be established, and the programming methods where there are no Program Specifications but instead the program logic is described in Flow Control Diagrams (FCDs). To date, approximately 60 approved software design changes have been implemented through these processes.
- A new operation interface for local monitoring and control at “Operator Workstations” had to be implemented including hands on training to develop new skills sets.
- The design includes 14,000 Input/ Output loops as compared to 3000 on the Unit 1 equivalent system. This major difference has required adjustments to resources required to commission the additional loops.

Similarly for Mark VI vs. Mark II Turbine control system for Unit #1, training and new processes are required. Overall, the impact of the delay in design and construction of the plant has meant an improvement through the technology upgrade, similar to what would occur in a new build project undertaken today.

IV-8.4. Major refurbished components requiring additional testing

For the most part, the extent of testing of equipment is the same as for a new build project. However, some major components require additional testing which should be performed early enough in the program to take corrective action if required. A good example of this is the Main Output Transformers T01, and T02, which were manufactured 20 years ago by Electroputere in Romania. These transformers have been preserved on site and recently refurbished. A new comprehensive re-test program was established, which includes repeating the majority of the original factory acceptance tests and in compliance with Romanian norms. Five tests will be performed for early detection of problems and the balance will be performed after Turnover. A significant test will be to back feed the transformer from the Standby Diesel Generators and raise the primary voltage to 110% of rated voltage, which is 400KV.

IV-8.5. An Enhanced Process for Managing Discovery Work

In order to manage discovery work, which is anticipated to be higher for a plant delayed in its design and construction, an enhanced process for review of critical emerging issues has been implemented. Field problems, which arise, that have an immediate impact on work progress are identified to the planning department and are reviewed three times per week. Single points of contact (SPOC’s) from Engineering, Material Management and Construction Divisions attend the Wednesday meeting. This process gives the necessary Project focus to supporting new issues discovered after system turnovers. Similar processes are necessary for new build processes as well. The enhanced process for Cernavoda lies in the frequency of review at three times per week.

The warehouse preservation program, field preservation program, and refurbishment program have been described and the effectiveness of these programs will be realized as equipment is turned over to commissioning and tested. A general expectation is to find more problems in the BOP than NSP because technical requirements and quality levels are lower for non-safety related systems. Another expectation is that equipment not installed in the field at CCED will be in better condition than equipment previously installed. Some examples of equipment condition follow:

The Turbine Building inactive drainage system has been partially in service for many years. The preservation program called for periodic shaft rotation of the 26 vertical sump pumps but seven pumps were found seized after turnover and required extra maintenance to free them up.

The RSW pumps and motors, were delivered between 1992 and 2002 and installed in 2001/2002. The preservation included motor heaters, Insulation Resistance checks, and monthly shaft rotation. The sets are identical to Unit 1 and although problems are not expected, they will be addressed through maintenance if required.

The PHT pump motors have undergone extensive refurbishment including dismantling to verify the upper thrust bearings, restoring electrical isolation of upper brackets, pressure testing oil & air coolers, confirmation of winding resistances and insulation values and testing of RTDs.

The fuelling machines which are used for on line fuelling in all CANDU stations were shipped to Romania in 1989 under strict preservation requirements including 24 hour coverage for logging of environmental conditions and monitoring cover gas pressure. In 1994 they were un-crated for full inspection and a de-oxygenation unit was hooked up to each FM periodically to recirculate the water and to take samples and remove oxygen. In 2002 a clean room was established to start the refurbishment work, which was completed by TEN Bucharest. This involved draining the FM Heads and removing and dismantling the rams. All elastomers were replaced in the ram assemblies. Each ram assembly was then subjected to 300 ram cycles on the test facility. In 2003 the FM Heads underwent pre-acceptance and acceptance testing under cold and hot loop conditions. In 2005 the equipment has been delivered to site and has undergone some minor design changes and is in pristine condition.

The valve program is extensive. There are more than 20 000 valves in the station including small instrument valves. For small piping valves less than 2 inch, about 9200 are new and go directly to the field after warehouse preservation while the approximate 2500 old valves in the warehouse are routed to a clean room and a percentage are tested, pressure tested, visually inspected, and packing changed if required. A small percentage of non-nuclear valves were previously installed in the field and will likely require additional maintenance. For NSP older valves, the refurbishment strategy varies and depends on the type of valve. For large valves a rigorous program is in place for nuclear valves like the Motor Operated Valves and Containment isolation valves. The air-operated valves also have had extensive refurbishment. Some valves were originally excluded from program because they were in service, like the firewater ring header valves and are now undergoing replacement.

IV-8.6. Commissioning Organization and QA Processes

Training and qualification of commissioning staff has been largely carried out by SNN in the years prior to CCED. In this respect, a delay in construction of U2 has been an advantage in order to hire and train staff using mature Unit 1 training programs, and including on average one year of “on the job training”.

The only difference in staffing, as compared to a new build project, is an increased number of maintenance personnel in anticipation of a higher level of discovery work as discussed previously. In addition there is a larger contingent of maintenance staff working on spares part review and ordering for old equipment

IV-8.7. Commissioning Completion Assurance

For a project delayed in its design and construction, where more discovery work is likely to occur due to the many factors discussed in other disciplines, it is ultimately the in-depth quality assurance process of "Commissioning Completion Assurance" that gives the assurance that all systems, structures and components meet their design intent and are available for service for both new and old equipment and for both safety and non safety related systems. The only major difference is a higher risk of schedule delay because of unanticipated problem discoveries and resolution time.

IV-9. Quality Assurance

The basic principle on any Project is that in order to have a successful QA Program you need to have clearly defined processes (which ensure that the requirements of the QA Program are correctly implemented) and a sufficient number of trained personnel in place to carry out these processes. The challenge for any company working on a nuclear Project is to develop, and maintain an up to date QA Program and to have available a sufficient number of qualified personnel to implement the program, and to complete the work meeting the requirements of both the quality program and the schedule.

Although construction has been ongoing for over 22 years on Cernavoda Unit 2 NPP, Quality was never forgotten. There have been revisions to the Site QA Program (which was based on both the applicable Romanian and Canadian Nuclear Standards), and the Site QA Program has always been in line with the Owner's QA Program.

After the signing of the Completion Contract in December 2000, Project Staff started the process of revising procedures to make them specific to the requirements of the Cernavoda 2 QA Program.

In addition to meeting the relevant Standards and the Owners QA Program, the Project QA Manual was revised (at revision 4) to incorporate the requirements of the procurement phase together with the design and construction phase. This ensured that the Project had one integrated QAM without duplication, overlap and inconsistencies.

The Completion Contract specified the organizational structure, necessary to complete the commissioning phase using operating personnel authorized by the Romanian Regulator (CNCAN). The organizational structure that supports this Contractual requirement is the reason that a separate Commissioning QA Manual (CQAM) was issued. The CQAM meets the requirements of the Canadian Standard CSA N286.4 M86 as well as the CNCAN Norms AQ-01 and AQ-06.

In looking back over the Project history and in examining the number of QA Program revisions that were required to be implemented in order to keep the program documentation up to date it is clearly evident that these many revisions required a lot of effort and manpower. Under the 'ideal' circumstances of a continuous project this effort would have been spent on the implementation and monitoring of the QA Program, rather than in the effort spent revising the Program documentation. Additionally in a project that is not being completed in a continuous manner, the fundamental question becomes “is everyone aware of the final target or are they only working piece by piece without any overall picture of how it will all fit together at the end?”

When the decision is made to rejuvenate a Project then allowance needs to be made for the effort required to bring all applicable QA Programs up to speed and to be fully implemented (documentation and trained personnel). Depending on the Contract model there may be many QA programs involved which of course can require a huge effort.

Even more of a concern has to be the QA Programs for material and equipment Suppliers. The Nuclear industry imposes a number of stringent (additional) requirements over and above the requirements of other industries. These additional requirements are expensive to maintain, and if there is not a steady stream of demand for these services the Suppliers will naturally turn to a the more profitable areas of business. It is a long process to get Suppliers to “ramp up” for renewed business in the nuclear field (and they may choose not to participate if the volume of business is too low). Additional Project technical and QA effort is also required to evaluate and reconfirm that Suppliers can meet not only Project technical and quality requirements, but also that they have valid authorizations from the Regulators of the host country.

Without a doubt, the biggest issue on any interrupted Project is the loss of the key qualified line personnel. These are the leaders who direct others in the implementation of the procedures and processes. The lack of, or the loss of key qualified personnel causes three (3) main problems; firstly the increased time to document procedures due to limited resources; secondly the number of errors in work performed, and thirdly the increase in the amount of time needed to complete the tasks (and still meet program requirements).

The key message is that all companies involved in such a project needs to (somehow) maintain a core group of project personnel with the necessary level of qualifications especially in the nuclear industry. When Projects are suspended, workers naturally migrate to other work sites and projects and they are not always willing to return to the first Project.

Once the project has restarted, and once all the project programs and documentation are in place (together with qualified personnel) then (depending on how the project was closed-out\suspended) there can be many issues in the activities related to the verification of work completion status, and the collection\assembly of quality records.

The status of work completion needs to be clear (i.e. are there open documents which authorized field modifications to the design? where are all the Supplier History Dockets for the materials and equipment that have already been received?). How complete is the information in the document control system, (in place at the time of project suspension)?

If the status of Supplier or Construction Records is difficult to ascertain due to any reason then this becomes a high priority issue at the beginning of project restart. The record status needs to be confirmed and all results need to be made known to, and confirmed by the engineering group. Additionally the Regulators may also need to be advised and consulted if there have been changes in the Laws, Codes and Standards, which now apply to the Project.

In summary, this comprehensive set of records needs to address the status of design, procurement construction (and installed equipment). If complete:

(1) These records allow Engineering to efficiently evaluate completion status and the acceptability of completed work (especially installed equipment) to meet the (new?) design standards and requirements.
(2) These records also allow Material Management to know accurately the status of equipment and materials in stock and to provide accurate inventory information to the engineering department.

Note that the Completion Assurance records are not expected to be Completion Assurance Certificates, but they need to be the sub records which are used to support the final Completion assurance Records (by project phase).

Taking advantage of hindsight, the following processes would have made life much easier on Cernavoda 2 and I believe that they are sufficiently generic that they should be considered for implementation on all delayed project suspensions in order to ensure an efficient Project restart.

(1) Implement a process to collect completion assurance statements and lists of incomplete items, and ensure that this process is as complete as if these records were being turned over to the Client at the closeout of the Project.
(2) The Project Team and the Client need to review all completion assurance status documentation and ensure that it is correct before all (the site knowledgeable) staff have left the Project.

If these measures are put in place then the process to re-start any Project is much easier, and the probability of a successful Project completion will be greatly enhanced.

IV-10. Additional Information

IV-10.1. Planning Control & Budget Recommendations

A higher contingency for schedule and budget must be allowed for Delayed Nuclear Power Projects in light of unknowns in regards to equipment, suppliers, documentation and discovery.

The scope of work must be fully defined before a project schedule is finalized.

All material/equipment deliverables defined and scheduled before CCED (Completion Contract Effective Date).

All engineering deliverables defined and scheduled before CCED.

Refurbishment schedule defined before CCED.

An integrated Level 2 Coordination and Control schedule to be approved at CCED (Including contingency)

In order to avoid surprises and late discovery of unplanned activities leading to the increase of engineering work scope and exposing the project to risks of schedule delays and or budget overruns, it is recommended that some budget and time be allocated to carry out a thorough investigation of the engineering work in advance of project restart.

IV-10.2. Engineering Recommendations

Setting up engineering and Document Control tools such as CMMS, (CANDU Material Management System) IntEC, (Integrated Electrical and Control design tool) CADD (Computer Assisted Design Drafting) and TRAK (Document Tracking and Management System) at the very beginning, before the start of design documentation preparation.

Advance review of available engineering resources and qualification of engineering partners in order to ensure that numbers and expertise are commensurate with the effort and the time required for the completion of engineering activities.

Adequate identification of the status of legacy design documentation and estimates of the effort required to-fix deficiencies.

Consultations with suppliers of new equipment to obtain the required vendor data and allow detail design to proceed with minimum re-work.

Detailed inspection of existing “legacy” equipment, structures, materials and associated documentation to identify in advance all necessary refurbishment and replacement.

Early discussions with jurisdictional authorities to better understand their expectations and agree on the interpretation of rules, regulation requirements and required documentation.

Preparation of detail engineering estimates and planning based on the results of the above tasks.

IV-10.3. Construction Recommendations

Refurbishment trade staff should be part of the Project group rather than depending on Contractors to attract and train skilled workers.

Use of manufacturer’s tech representatives to provide appropriate supervision & training of inspection/refurbishment for their specific equipment will further enhance the refurbishment program.

Refurbishment tooling should be specified and procured by the Project rather than depending on Contractor to provide. Experience showed that contractors did not always provide tooling in acceptable quality or quantity.

Inspection/testing of all “legacy” valves is recommended. Higher than expected leak/failure rates were found at pressure test just prior to system turnover. This caused delays to schedule and strained resources further.

It would be a recommendation that on any future Delayed Nuclear Power Project, the internal civil works be engineered to suit variable types of equipment installation. Engineering and Construction can collaborate on a design of multi-fit base slabs so that various types of equipment mounting could be accommodated using a “standard” set of bases to eliminate/reduce rework.

The inspection of all early concrete civil works is to be performed with inspection technology such as ultrasonic detection. Specifications for architectural materials should be reviewed against new products on the market (with assistance from supplier technical reps) prior to project commencement as significant benefits for installation time and durability could be realized.

Use of manufacturers' tech reps to supervise/train contractors on the installation of new architectural systems and materials can be encouraged.

It would be recommended that the "project" directly procure modern concrete cutting tooling (high pressure water jet, diamond wire cutter machinery, etc. as a prerequisite to the project restart as significant time and schedule savings would accrue.

IV-11. Conclusion

The Cernavoda 2 Project provided many opportunities to better define the correct approach to a successful completion of a delayed project. Most significant is the need to have a full assessment and definition of the remaining scope of work before the beginning of the Completion Contract.

In conclusion, MT Project Management team adapted their work processes and procedures to suit the specificity and challenges of the Cernavoda 2 project. Interfaces with internal groups and external organizations were optimized through efficient communication processes. This allowed timely identification of issues through to the Engineering, Procurement, Construction, Planning, and Commissioning organizations. It was clearly demonstrated that teamwork, creativity and dedication to quality and productivity have been keys to the successful completion of many critical activities.

ANNEX V
PROJECT RE-START MANAGEMENT EXPERIENCE
MOCHOVCE UNIT 3 & 4 NPP, SLOVAK REPUBLIC

The description of the re-start activity for the completion of Mochovce Unit 3 & 4 (MO 34) of MO 34, documented in the present annex, has been carried out in the framework of an IAEA program dealing with the “Restarting Delayed Nuclear Power Plant Projects”.

The IAEA–TECDOC-1110 [1] is the reference guide for the present document; it provides information and practical examples about necessary management actions to preserve and develop the capability to restart and complete DNPP Projects.

This annex reports the experiences from MO 34 as a lesson learned for the nuclear utilities. It highlights the key management activities to solve typical problems encountered during the restarting activities (e.g. preservation and maintenance of equipments, updating to technological and regulatory requirements, human resources, protection of design documentation, etc).

V-1. SUMMARY

The purpose of this report is to describe the re-starting phase of DNPP MO 34 Project, mainly focusing on management issues.

The report consists of three main parts dealing with the Project management organization during the three different periods of the of DNPP re-starting process. The first part (Chapter 2) begins with the general background information about the NPP and then focuses on the pre-feasibility and feasibility study ([2]). The second part (chapter 3) deals with the current status of the plant and it stresses the main steps of the DNPP Project resuming after completion of the feasibility study. The third part (Chapter 4) outlines the main issues related to the criticality of a typical DNPP Project (e.g. preservation and maintenance of equipments, updating to technological and regulatory requirements, human resources, protection of design documentation, etc.) and the measures implemented in MO 34.

The hereby presented content reflects the experience and good practices concerning the following main management issues:

- project control measures;
- human resources;
- preservation and maintenance of site installations, structures and equipment;
- updating of the whole Project to meet licensing requirements and technology upgrades;
- preservation of Project documentation.

V-2. INTRODUCTION

The Mochovce site (see Figures. 1 and 2) is located on the upland plain of a valley on the western slope of the Kozmálovské hills, in the part of the Pohronská highlands called the Mochovecká highlands and in front of the southern foothill of Pohronský Inovec.

The height of Mochovecká highlands (varying from 109 m to 227 m a.s.l.) decreases at north into the valley between the rivers Žitava and Hron. This lower region forms a transfer corridor for road and railway road into the Hron gorge.

The Mochovce site is characterized by compact rocky subsoil, suitable for the safe foundation of the buildings; geologic analyses have also shown that, in the building site, there is no relevant flow of underground water.

The NPP site is also located at the borderline of the basins of the rivers Nitra and Hron. In particular, the Hron river and its water dam (built in Veľké Kozmálovce) is the main water source for Mochovce NPP.

The Slovak Power Enterprise (SEP): Government owned Company started in 1984 the construction of the Nuclear Power Plant of Mochovce with four VVER-440 Units. In 1992 the Mochovce construction was suspended due to lack of financial resources.

The Slovenské Elektrárne, (SE – Slovak Electric): Board of Directors and Supervisory Board decided to carry out a comprehensive review of MO 34 construction status by December 31st, 1996 and, after that, to start the completion work of EMO 12.

In April 2006, SE privatization process was completed through the finalization of sale of 66% of Company's shares to Enel Spa.

The present annex deals with the description of the management and technical activities conducted within the re-start phase of the MO34 NPP Project. It is not a simple description of a completion strategy, but it is to be intended as an example of Project management action to solve issues concerning the resuming and finalization of a DNPP Projects.

The report shows the main outcomes (from a management point of view) characterizing the most important steps of restarting process, which ran through the pre-feasibility and feasibility studies up to the present situation.

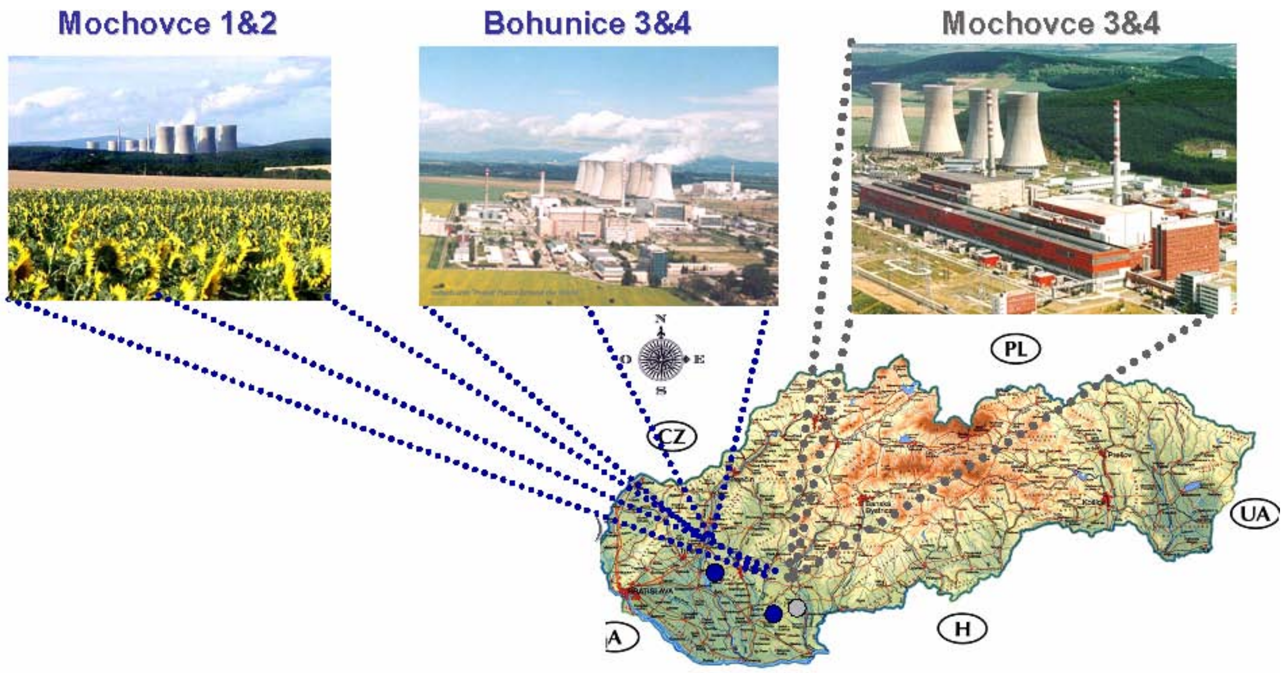


FIG. 1. NPPs in the Slovak Republic.

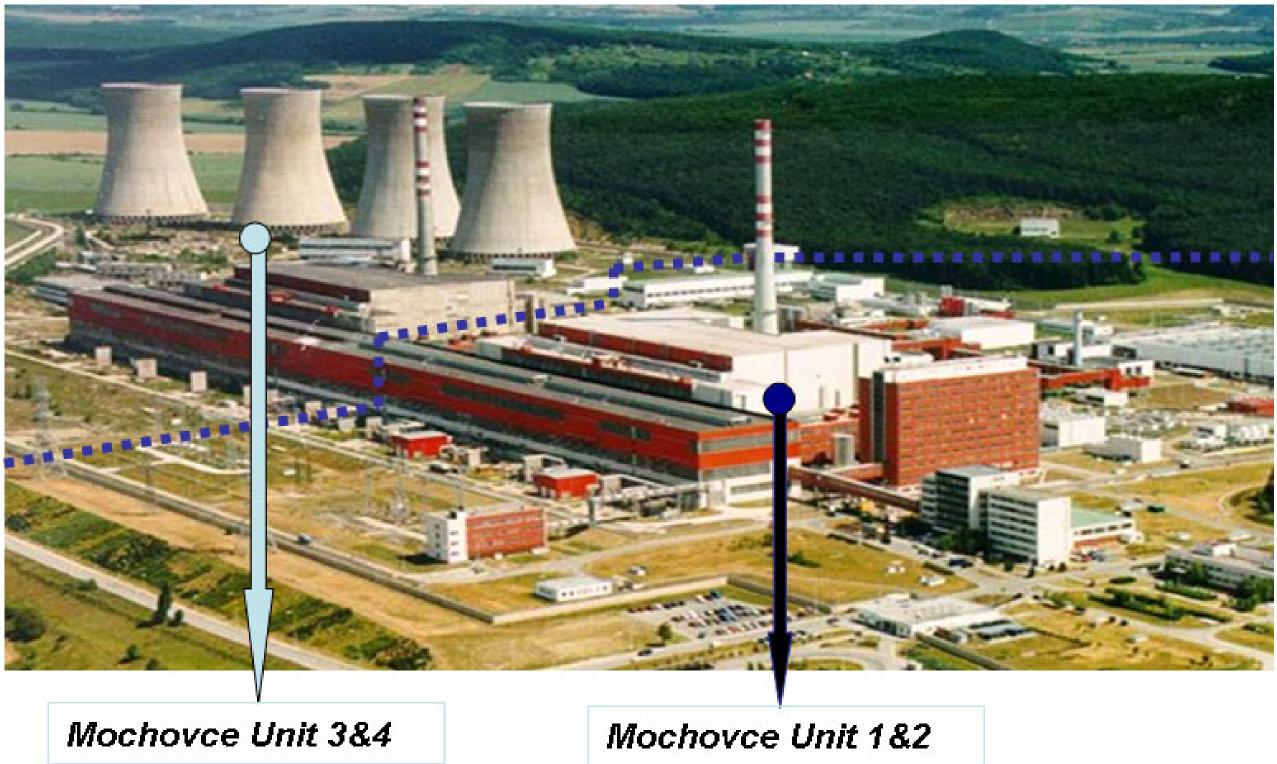


FIG. 2. Mochovce NPP: Units 1 & 2 and 3 & 4.

V-3. GENERAL INFORMATION

V-3.1. Background

The Mochovce NPP project started in 1981 when SEP set the preparatory activities on the construction of the Mochovce NPP with four VVER-440/213 units.

In 1984, the construction of the units began. According to original intentions, Mochovce Units 3 and 4 should have been commissioned with yearly intervals after Units 1 and 2.

In the pre-design and design preparations, the construction process was split into three phases:

- construction phase 1 – rough preparation of the construction site, supply of drinking water, installation of electric lines and water pipelines, back-up roads, clearing out of the forest, earthwork, etc;
- construction phase 2 – completion of Units 1 and 2, including the major parts of auxiliary objects needed for their operation;
- construction phase 3 – completion of Units 3 and 4, including the objects needed for their operation and links to the construction phase 2.

The original main suppliers:

- Hydrostav, a.s. Bratislava, as the largest supplier of the civil works;
- Škoda Praha, a.s., as the general contractor of the process part.

Works for Units 3 & 4 (design by AtomEnergoExport (Russia) / and Energoproekt Praha (Czech Rep.) started in 1986 with the construction of some buildings (reactor building, lengthwise electrical building, transformer basements, cooling tower, vent stack) and continued up to 1992, when the lack of financial resources put everything on hold.

In 1996 the construction of the EMO 12 was resumed and they were gradually completed and put into operation in 1998 and 2000 respectively.

Below are reported the main milestone of the construction:

- 1981 Start of the site levelling works;
- 1984 Start of NPP Unit 1&2 construction;
- 1986 Start of NPP Unit 3&4 construction;
- 1989 Decision about replacement of the original instrumentation and control system;
- 1990-1991 I&C replacement;
- 1991-1995 Halt of civil works (reviews and audits of international organizations);
- 1995 Completion model confirmed by the Slovak Government;
- 1996 Signing of contracts and loan agreements;
- 1996 Start of the Unit 1&2 completion works with the nuclear safety improvement program implementation;
- 1998 Unit 1 commissioning;
- 2000 Unit 2 commissioning.

Several international audits, focused on the review of the safety level of EMO 12, were carried out with the attendance of about 2000 experts. After its commissioning, the following missions were organized:

- RISKAUDIT mission, within the frame of PHARE Project (1999);
- WENRA (Western European Nuclear Regulators' Association) mission (2000);
- IAEA IPSART mission (2001);
- WANO Peer Review mission (2002);
- WANO Follow Up Review mission (2004);
- IAEA OSART mission (2006).

WANO team and IAEA OSART identified several strengths which have been brought to the attention of other utilities as a benchmark (e.g. implementation of a monitoring program for corrosion and aging of plant equipment) and, at the same time, areas where minor improvements are suggested (e.g. the optimization of the maintenance schedule and procedures).

V-3.2. Status of Mochovce Unit 3& 4 NPP before the feasibility study

Since 1992, when the construction was suspended, maintenance and preservation/protection activities on equipment and civil structures were carried out by the original main suppliers and contractors. For this purpose a tailored maintenance and preservation plan was developed and the IAEA recommendations (see Ref. [1]) were fully adopted.

The planning of the activity for the preservation and maintenance process aiming at re-starting DNPP was performed by means of the following outsourced activities:

- Assessment of the available equipment;
- Assessment of the civil part of the DNPP;
- Assessment of the "up-to-date" status of the DNPP site.

To ensure these maintenance and preservation works, contracts with suppliers were signed and the works were implemented in line with Protection and Preservation Work (P&PW) programs (Refs [3–6])" approved by the Nuclear Regulatory Authority – ÙJD SR.

As a conclusion of the above mentioned assessments, it was estimated that construction of MO 34 reached approximately 30% completion in terms of mechanical equipment, approximately 70% completion in terms of civil works, minimal electrical work completion, and virtually zero completion on instrumentation and control (I&C).

Basic process equipment such as RPV, SG, PRZ, ECCS tanks, TG, and the like have been delivered on site, stored and partially installed. Measures for preventing equipment damage and degradation have been implemented.

The evaluation of the status of individual components/systems and parts of buildings was accomplished setting up a suitable methodology (ref. [5]) according to the ÙJD SR (ref. [7]) and international practices requirements.

These outcomes were also used in the feasibility study of the DNPP Project activity.

V-3.3. Feasibility study

In the present paragraph the feasibility study overview of the DNPP re-starting activity is reported, underlining which were the main management steps. The main outcomes (see [2]) of the study are not reported because beyond the purpose of this annex.

The study helps the Project planning activities providing a road-map of the main management and technical solutions that have to be addressed for the DNPP Project.

Before the feasibility study a pre-feasibility study (see [8]) had been carried out. The scope of that work was to prepare the activity for the next step and to identify the weakest point of the planned activities. It can be considered as an assessment of the methodology and strategy used for the feasibility study.

The pre-feasibility study included the following tasks:

- technical analysis of the current status of DNPP MO 34;
- safety and licensing evaluation;
- plans for completion of construction;
- time schedule evaluation;
- preliminary cost evaluation.

MO34 feasibility study set a basis for the re-starting activity. It began in January 2006 and SE had the commitment to complete it within 12 months from closing of SE acquisition [2].

Purpose of the feasibility study was to define in detail all technical, economic, financial, legal and authorization aspects of MO 34 completion in order to provide the Utility management with all the necessary information for a final decision.

The feasibility study structure is composed of three main objects:

(1) *Investment decision*, to provide final analysis of the technical, economic, financial, legal and permits aspects. It includes the following activities:

- revision of Basic Design documents;
- technical verifications of assets;
- detailed cost estimation;
- detailed time scheduling;
- definition of contracting strategy (see paragraph 3.3);
- structure of Owner's Company;
- definition of financing sources;
- permitting framework;
- Project risk analysis;
- Public opinion poll and public acceptance.

(2) *Approval of Design Changes* to be submitted to ÙJD SR and other authorities. It includes:

- design Safety Concepts;
- revised Basic Design documents;
- revised PRESAR;
- revised QA program.

(3) *Preparatory works* for tenders to define the contracting strategy, the beginning of pre-qualification process and to prepare tender documents. It includes:

- definition and finalization of contracting strategy;
- preparation of technical documents;
- preparation of contractual documents.

It has to be intended also as a tool of the Project management to have a complete overview of the DNPP Project situation. In MO 34 during the feasibility study a series of improvements on the original basic design were performed in order to:

- comply with the IAEA recommendations and safety standards;
- meet the requirements of ÙJD SR to bring MO 34 to a level of safety higher than that of EMO 12;
- take into account the recent technological developments in nuclear reactor operation and design, especially in the area of instrumentation and control;
- reduce the production of radioactive waste.

The two major areas of design modification are:

- implementation of systems, instrumentation and procedures to manage Severe Accidents scenarios;
- employment of the latest commercially available digital technology for plant control system in order to increase plant operability and reliability while reducing maintenance demand. A modern Human Machine Interface (HMI) shall enhance operator response at any plant condition.

In order to fulfill the aforementioned main areas of the Project activity, the following contracts were awarded.

- *Safety Board.* It is an independent body appointed by SE/Enel with the purpose of providing Nuclear Safety oversight on technical issues. It is composed of six leading independent experts in the area of safety, coming from: Austria, France, Germany, Italy, Russia and Slovak Republic. It provides guidance to SE / Enel on safety related issues of activities to be performed, overviews results of safety analyses, studies and detailed safety concepts before submittal to ÙJD SR. Safety Board evaluation and recommendations are provided as inputs / feedbacks for the Engineering works.

— *Engineering contract.* The contract was awarded to a Consortium (DOSMO) formed by the original General Designer of Mochovce NPP (EGP-Praha) and a Slovak engineering company, which had been previously involved in safety analyses of Mochovce and Bohunice. The engineering works started in June 06.

The purpose of engineering services is to define technical solutions for the additional safety requirements applicable to VVER-440/V213 to improve the general safety of MO34 to a level acceptable to ÙJD SR and in line with the international recommendations and standards for this type of reactors.

Result of the contract is the Basic Design Review, the PSA and PRESAR for MO 34.

— *Consultancy Contract.* This contract is aimed to support the Owner's Engineering work for verification of design and assistance to contractual, economic and planning assessment of the Project. The contract was awarded to WorleyParsons (AUS-USA).

— *Technical consultancy support.* Support on different technical areas was given by several high qualified nuclear-related companies:

- support on nuclear safety issues and safety board assistance and coordination;
- support activity on Environmental Impact Assessment (EIA);
- equipment evaluation ;
- safety evaluation of the Loss Of Offsite Power (LOOP) scenario and of the improvements on the 6 kV bus-bar level to be consider in the PSA L1 analysis ;
- load flow and short circuit analysis of the high voltage network.

— *Legal advice.* Support of MO 34 Project management through the authorisation, licensing and financing processes;

— *Data management System.* Development of a life cycle data management aiming at creating man-operated acquisition tool, user friendly design tools, automation of routine work, data consistency check & reporting, quality assured change management, etc.

In the framework of the investment decision (item 1 of the above list) the main technical activities are briefly reported below and also in paragraph 3.3.

Revision of Basic Design documents

This activity is performed by the Engineering Consortium (DOSMO). Review and approval of engineering documents produced by DOSMO is performed by Slovenske Elektrarne engineering team, created within the Mochovce 3-4 Project Team. In particular SE has to review the technical and engineering reports dealing not only with the Basic Design but also with the Detail Safety concepts, Design Revision Concepts, Safety Documentation (PRESAR), General Program of Quality Assurance, PSA.

Support to Slovenske Elektrarne for part of the review process is provided by in the framework of the consultancy contract.

Technical verifications of assets

Purpose of this activity was to define and perform activities necessary to carry out the condition assessment of existing structures and equipment of MO 34. The specific objectives of the "Condition Assessment of Existing Structures and Equipment" were as follows:

(a) to review and provide advice on the Owner's requirements and sample basis for the structures and equipment included in the Condition Assessment;
(b) to provide the specific Inspections Plans necessary to assess the condition of the structures and equipment delivered to or installed at the MO34 site;
(c) to perform the required work including:
   - visual inspections of structures and equipment;
   - special inspection testing;
   - structural painting and coating inspections;

(d) to describe and estimate the cost of the refurbishment work required to bring the structure or equipment back to the original design life;
(e) to identify the structures and equipments that cannot be used in the Project for plant completion;
(f) to document the work in specific Condition Assessment Reports (CAR), required for each structure or equipment (or equipment group).

On the basis of the technical verification of existing equipment, components and structures performed by the Contractor, the Owner will perform a detailed cost estimate for additional supplies, works and services necessary for Plant completion.

The basic scope of work of the Contractor was to define the framework of activities fit to determine the status and usability, for plant completion, of the following existing structures and equipment (see ref [11]):

— *civil works*, encompassing buildings, foundations, underground concrete tunnels (channels), and steel structures (see tab. 3);
— *mechanical equipment*, i.e. process stationary equipment (including underground piping) and rotating machinery. This includes the reactor pressure vessel, steam generators and other vital equipment for the Plant;
— *electrical equipment,* generators, motors, switchgears, etc, including motor driven valve operators. In general there is a small amount of electrical equipment at the MO34 site.

However, major equipment provided with prefabricated skid equipment is included for Contractor inspections, for example the Emergency Diesel Generators and related sub systems.

In order to optimize the operative management of the contract, the relevant civil works and equipments have been grouped into five categories for which homogenous tests and activities are performed. The categories are the following:

(1) *Category Civil work*: composed of structures and buildings;

(2) *Category 5a1*: Critical equipment requiring detailed visual inspection and tests;

(3) *Category 5a2*: Critical equipment requiring a partial disassembly in order to perform the detailed inspections and tests;

(4) *Category 5b1*: Non-Critical equipment requiring detailed visual inspections and tests.

(5) *Category 5b2*: Non-Critical equipment requiring a general visual inspection by the Contractor to confirm if the equipment exists and that no significant damages have occurred. No detailed inspections or tests was required on this equipment.

The activity was planned, organized and executed following a methodology for the inspections and assessments, based on worldwide applied International Code and Standard for this type of work. As reference the following standards have been used:

— ASME B&PV Code Section V and XI;
— ASME NQA-1-1994 Edition, Subpart 2.16, Requirements for the Calibration and Control of Measuring and Test Equipment in Nuclear Facility;
— ISO 10012:2003, Measurement management systems — Requirements for measurement processes and equipment.

The Contractors performed, during the Inspection plan preparation, only non destructive — NDT type tests and inspections.

It is also necessary to highlight that some equipment are under a preservation program issued by ÙJD SR, so the tests and inspections activities on them were carried out taking into account these related specific conditions. In particular the Contractor took into account the requirements stated in the Quality Plans issued for this specific activity.

The Inspection Plans are described in Ref. [11], they typically considered visual inspection, strength evaluation, corrosion tests applying non-destructive method, ultrasonic thickness measurements, leakage pressure test for welding, fire resistance test, magnetic particle/liquid penetrant examination (for identification of pitting or corrosion cracks primarily of pressure boundary parts), eddy current (ET) functional testing (FT) (to verify absence of abnormal conditions e.g. rotor seizure), measurement of electrical insulation resistance and electrical resistance.

TABLE 3 EXAMPLE OF TESTS TYPE ON BUILDINGS AND STRUCTURES

Buildings/Parts (1)	Tests								
	Visual inspection	Mechanical sample	Core sample	Radar for concrete	Thickness measuring	Laboratory test	Functional	Corrosion measurement	Leak tightness by air pressure
Turbine Hall (N 3)	X	X	X	X	X	X			
Electrical Building Lengthwise side (N 2)	X	X	X		X	X			
Electrical Building Cross side	X	X			X	X			
Bridge between 1st and 2nd Power Blocks	X	X							
Diesel Generator Station	X	X	X		X	X			
Reactor Building	X	X	X	X	X	X	X	X	X
Nuclear Auxiliary Service Building	X	X	X	X	X		X	X	X
Bridge between 2nd Power Block and Nuckear Auxiliary Building	X	X	X						
Air Ducts to Stack	X	X							
Emergency Feed water System	X							X	
Conventional Island Cooling & Fire Fighting Water Pumping Station	X	X	X	X				X	
Nuclear Island Cooling Water Pumping Station	X	X	X	X				X	
High Pressure Air Compressor Station	X	X	X						
Forced Cooling Towers (N 3)	X		X	X				X	
Cooling Towers (N 4)	X		X	X				X	
Diesel Generator Station Lube Oil System	X	X	X	X				X	
Fuel Oil System - 2nd Power Block	X		X	X				X	
Underground Channels	X		X	X	X			X	

Detailed cost estimation

This activity was done in the framework of the consultancy contract. The purpose was to establish a budget price for the total completion of the Project with a high level of accuracy based.

In particular it has to:

- assist the Owner in the assessment of financial issues of the Project and investment decision;
- highlight any long lead component or labour issues that could result in critical path items to be considered into the overall Project schedule;
- assist the Owner in the development of the contract strategy for the Project (e.g. EPC contract, etc).

The Project costs were divided into a number of discrete categories or cost packages:

- civil work cost: total cost associated with completion of the civil works;
- installation labour cost: total labour cost associated with completion of the installation of equipment;
- bulk material: total cost of the supply of all bulk materials (e.g. steel, cable, etc) required to complete the Project;
- new components: total cost of new components required to complete the Project. All the sources related (e.g. suppliers, the availability, the delivery lead time, the price, etc) have been identified;
- refurbished components: total cost of refurbishing components which have been identified as refurbishable. All the sources related to that (e.g. suppliers, the availability, the delivery lead time, the price, etc) have been identified;

- Owner's cost: it includes the typical costs like site infrastructure (access road, segregation between operating units and construction area, additional security facility, etc), site electrical supply requirements for the Project, staff cost, equipment and structure preservation costs, regulatory and licensing costs and fee, training costs, insurance, etc;
- cost related to EPC and EPCM activities.

The methodology, reported in Ref. [13], is based, for all the costs above identified, on the information coming from the Engineering contract and CAR, on the estimation cost for completion of civil works and of installation, on the experience and knowledge of similar Project, etc.

Detailed time scheduling

Also this activity was performed in the framework of the consultancy contract. The purpose was to draw up a detailed completion schedule (CS) up to the end of the Project [14]. In particular it:

- formed part of the Owner's investment decision making process regarding the feasibility of completing the Project in a reasonable timescale;
- assisted the Owner in developing the overall planning process for the Project;
- allowed the Owner to plan and reduce, where possible, the overall timeframe and cost, by addressing long lead time issues and critical paths.

The activity started from the initial CS proposed by the Engineering Consortium and became a "whole-project" CS incorporating additional activities which were beyond the purpose of the Engineering Consortium; such as:

- EPC contract tendering process;
- timetable of refurbishment of existing components;
- procurement timetable for new goods and services;
- Owner's activities;
- regulatory and licensing approvals;
- commissioning activities.

Permitting framework

An activity concerning the permitting evaluation was done with the purpose to analyze:

- the Slovak legal regulatory framework in the field of construction law, nuclear law, environmental law, as well as international directives in those areas;

the permits and licences currently available.

Environmental Study

SE/ENEL performed a new Environmental Study.

The reasons for that were:

- Environmental and Corporate Social Responsibility Policies of SE/ENEL;
- Information to interested stakeholders as local communities and Slovak Authorities,
- Financing purposes.

The Environmental Study structure is in line with Annex 11 “Content and structure of the report…” of Act 24/2006 and with the table of contents contemplated in the “Equator Principles”. It has been accomplished evaluating the impact with the four operating units, taking as reference the existing status (operation of EMO 1-2). It was divided into three main sections for further information): programmatic framework, design framework and environmental framework.

Project risk analysis

The objective of the risk analysis was:

- to identify the events that have the potential to impact the Project time schedule and cost;
- to analyze these events, applying assessment of probability based on expert judgment and using standard risk analysis software;
- to provide SE management with analytically supported advice on the Project risks, assisting SE management in decision making on the Project completion alternatives, as well as identifying weak areas, where special attention had to be given in order to mitigate Project risks;
- to provide a platform for future evaluation of Project alternatives, sub-alternatives and Project risk during Project design and execution.

The applied methodology of risk analysis for MO 34 consists of the following general steps:

(1) elaboration of the list of Major Risk Issues;
(2) development of several questionnaires, designed to cover all the identified major risk issues and potential impacts;
(3) performance of a survey to obtain a representative number of experts’ opinion on the Major Risk Issues;
(4) processing of the results, using appropriate statistical methods;
(5) analysis of the results, including recommendations for risk mitigation.

The risks (issues) were divided into three major groups to facilitate the listing of the risks and survey responses. It does not necessarily represent the entire nature of the risk since interconnection occurs between many of them - and between their basic causes as well – so that some of the risks could show more than one first cause (see ref. [12]). The groups identified are:

- Project Execution and Management Issues;
- Licensing Issues;
- Technical Issues.

Public opinion poll and public acceptance

The main sources of information regarding the public level of knowledge and the perception of nuclear power, particularly for Mochovce NPP, are represented by:

- Country Nuclear Power Profile, by IAEA 2002;
- Perception of NPP Mochovce by inhabitants of I and II Protective zone, by Department of Geography and Regional Development of University of Constantin Philosopher in Nitra, 2004;

— Attitudes to perception of the company SE by inhabitants of Slovakia, survey conducted by Gfk, 2004 and 2007.

The above mentioned documents (below explained) provide information at various levels, starting from a single opinion on the use of nuclear energy to a poll on the perception of Mochovce NPP by inhabitants of I and II Protective zone, and even a poll on the perception of nuclear energy and NPPs in the whole Slovak Republic.

Country Nuclear Power profile 2002

The preparation of the Country Nuclear Power Profile was initiated within the framework of the IAEA's programme on assessment and feedback of NPP performance. It responded to a need for a database and a technical document containing a description of the energy and economic situation, the energy and the electricity sector and the primary organizations involved in nuclear power in IAEA Member States.

The main issues related to present nuclear power policy, like: moratorium, public acceptance, open market, privatisation, safety and waste management issues, role of the government in the nuclear R & D, human resources development, economic and financing issues, and impact of nuclear power in avoiding CO2 emissions, etc, are considered. Regarding social issues and public acceptance, it provides the results of a survey carried out in Slovakia of public opinion on the use of nuclear energy.

Perception of Mochovce NPP by inhabitants of the I and II Protective zone

In 2004 the Department of Geography and Regional Development of the University of Constantin Philosopher in Nitra carried out a survey of the perception of Mochovce NPP by inhabitants of the I and II Protective zone. The survey focused on:

— level of knowledge of Mochovce NPP;
— level of knowledge of monthly "SE News Mochovce";
— perception of threat;
— opinion on completion of MO34;
— opinion on the future of NPPs in the Slovak Republic;
— opinion on use of nuclear power;
— level of knowledge of environmental impact.

The survey was divided into 3 phases. The first one was a preliminary phase which included preparation of a questionnaire in close cooperation with the Mochovce Infocentrum and a tour of Mochovce NPP with the aim of obtaining feedback on the effectiveness of the given information.

A second phase of the survey involved 32 settlements, including the towns of Levice and Vrable in the I and II Protection area of Mochovce NPP. In this survey 10% of the working inhabitants were questioned, a total of 1770 people expressed an opinion in response to 25 questions related to Mochovce. Evaluation of the received information (statistical and graphical) was the scope of the final phase of the survey.

Attitudes to and perception of the company SE, a.s. by inhabitants of the SR

In 2004 the Gfk group, specialized in market and consumer research, carried out a survey on attitudes and perception concerning the company SE, a.s. by inhabitants of the Slovak Republic.

The poll focused on:

- implications of nuclear energy;
- opinions on pros and cons of nuclear energy;
- opinion on the extent of a threat from the NPPs in the Slovak Republic;
- perception of nuclear energy as a source of electric energy production;
- opinions on the amount of the electric energy produced by means of NPPs;
- respondents' opinions on the protests against nuclear energy;
- respondents' opinions on the safety of the Mochovce NPP;
- information about completion of the remaining parts of Mochovce NPP;
- opinions about completion of the remaining parts of Mochovce NPP.

The sample was made up of 1.000 persons with age intervals of 19÷69 (adults) and 14÷19 (students).

V-4. CURRENT STATUS

V-4.1. General Design Description of Mochovce Units 3&4 NPP

According to the original design, the plant consists of 4 units of VVER 440/213. Units 3 and 4 in Mochovce NPP site mirror the already operating units 1 and 2 and will use the auxiliary systems already built and operable which are common for all four units. The design is based on a twin units concept with common reactor building and common turbine hall. Each unit includes two main circuits (primary and secondary; see Fig. 3) and safety systems.

The primary circuit of each unit is formed by the RPV and six coolant loops (see Figs. 3 and 4); each loop consists of one hot leg with an isolation valve, the steam generator (horizontal design) and one cold leg with a main circulation pump and an isolation valve. Tables 1 and 2 summarize the main technical parameters of the primary and secondary circuit.

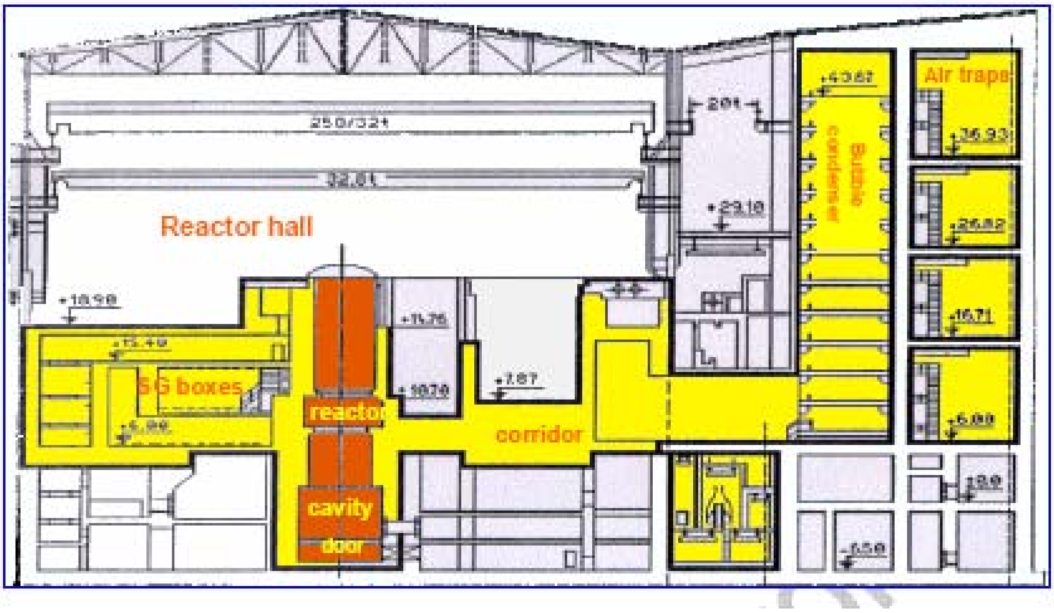


FIG. 3. Mochovce NPP Plant cut-off view.

TABLE 1 MAIN PARAMETERS OF PRIMARY CIRCUIT

Reactor Thermal Power	1375 MW
Total Coolant flow rate	42600 m^3/h
Outlet reactor temperature	297.3 °C
Inlet reactor temperature	267.9 °C
Heat-up in the core	29.4 °C
Pressure in the primary circuit	12.36 MPa
N_o of main coolant pumps	6
N_o of SG	6
N_o of main isolating valves	12

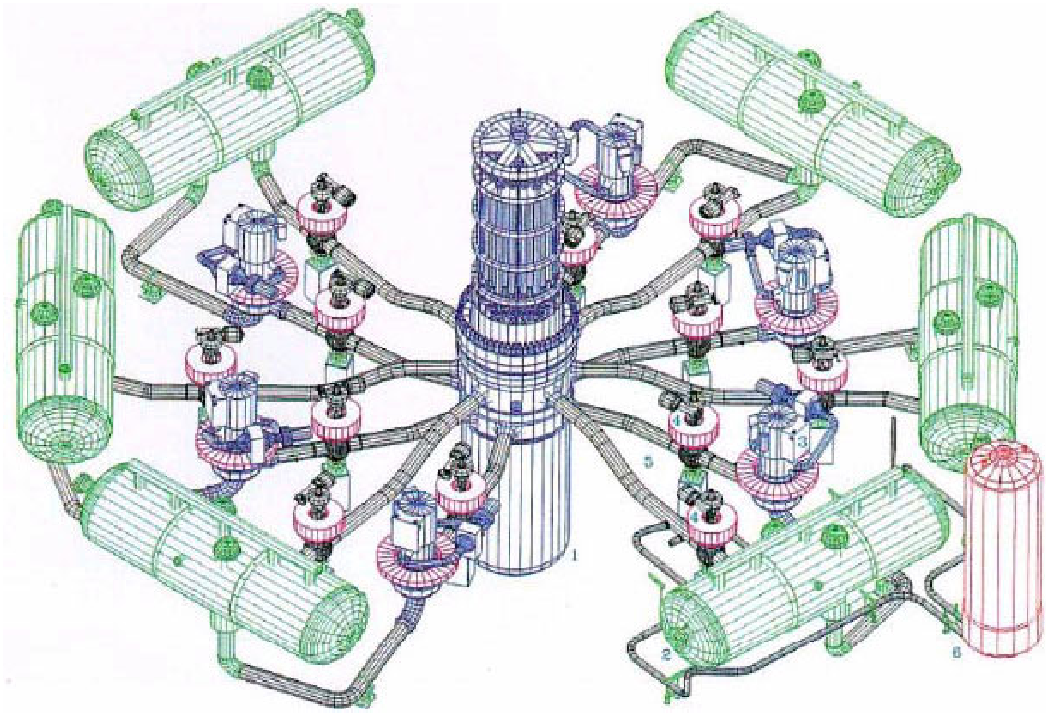


FIG. 4. Primary system.

TABLE 2 MAIN PARAMETERS OF SECONDARY CIRCUIT

N_o of Steam Turbine Generators sets for each unit	2
Pressure of SG	4.61 MPa
Saturation temperature	260 °C
Pressure at the inlet of HP turbine	4.12 MPa
Steam flow rate at inlet of each turbine generator	367.75 kg/s
N_o of cooling tower for two unit	4
Circulating cooling water flow from cooling towers for each unit	74200 m^3/h
Unit rough output power	440 MW
Unit net output power	405 MW

MO 34 is equipped with typical VVER 440/213 safety systems among which the main one are: Emergency Core Cooling System (ECCS), Containment Pressure Suppression System (Bubble condenser and spray system), hydrogen catalytic recombiners and burning system, emergency residual heat removal system, Steam Generator emergency feed water system, etc.

One of the main characteristic of the DNPP Project of MO 34 is the amount of work made for the safety improvements. They have been identified during the definition of the scope of work of the “Engineering contract for detailed safety concepts and revision of Basic Design” performed by SE in the framework of the feasibility study. At the same time safety improvements take into account the most recent international recommendations and technical solutions for nuclear safety in order to bring MO34 NPP to the highest level of nuclear safety.

The safety improvements considered in the design of MO34 can be grouped into the following categories:

- severe accident (SA) management;
- I&C and electrical equipment;
- seismic upgrade;
- fire protection & radiation monitoring systems.

Reference source for these tasks were the IAEA document [9] and feedback from the EMO12 operational experience.

V-4.2. Authorization, permits and licensing process overview for MO 34

An overview of the authorization, permits and licensing process related to MO 34 is briefly shown:

- The original Construction Permit for MO 34, still valid, is the Permit No 2010/86, issued on 12/11/1986 by District National Committee in Levice, according to building law No 50/1976.
- The deadline for completion has been shifted twice and the latest date was stated by the Decision No 2004/00402-007, issued on 15/07/2004 by the Civil Construction Authority in Nitra.

Due to the fact that the latest Decision No 2004/00402-007 requires some changes and modifications to the original Basic Design Documentation, such changes and modifications must be subjected to approval of ÙJD SR and of the Civil Construction Authority for Nuclear Power Facilities. The State and Local Authorities involved in the approval process are specified by ÙJD SR; at the moment they are: Public Health Office of SR, Environment Department Office in Levice, Regional Environment Office in Nitra, National Labour Inspectorate in Nitra, Regional Fire and Protection Headquarter in Nitra, Technical Inspection of SR. Furthermore, SE must submit to ÙJD SR, for approval, the documentation related to the safety changes, in order to meet the requirements of the new Atomic Act No. 541/2004 Coll. The whole approval process will be divided into the following parts:

- Submittal to ÙJD SR for approval of required “safety documentation”;
- Submittal to ÙJD SR for approval of Design Safety Concepts including modifications to Basic Design;
- Submittal to ÙJD SR for review of Preliminary Safety Analysis (PRESAR) report.

The complete description of all authorizations, permits is reported in Refs. [2] (Section 3.9) and [10].

V-4.3. Main steps of the DNPP Project re-start after feasibility study

In the following section the main steps of the re-starting activity after the feasibility study are briefly reported. The analysis of the DNPP Project criticalities that are typically encountered in such activities is addressed in chapter 4.

After the previous stages (pre-feasibility and feasibility) described in paragraphs 2.2 and 2.3, the Project management activities are focused on:

- planning and scheduling, financial and budget evaluation for DNPP completion, commissioning, operation and also decommissioning;
- Project engineering (starting from the results of the engineering contract activity above mentioned).

The DNPP Project management strategy is headed towards:

- construction;
- contractual agreements and negotiation;
- legal, institutional and permitting issues;
- construction all risk (CAR) insurance;
- human resources during construction and operation;
- communication program.

Each of the above mentioned themes is described below.

The construction strategy is focused on:

- Site preparation before the beginning of construction activities. The site area for MO34 is divided into two parts: Construction area and Logistics area. The latter is equipped with all the necessary infrastructures (roads, offices, warehouses, workshops) that were built in the 1980's but must be reconfigured for the new construction requirements and largely refurbished. As of the Construction area, the close contiguity with already operating EMO 12 requires physical separation and a security barrier in order to de-classify, from a security point of view, the Construction area.
- Use of existing components and civil structures. As part of the feasibility study (see section above), civil parts and mechanical/electrical components have been inspected to verify their suitability for employment in Mochovce completion. Owing to the large number of stored devices, the verification has been performed selectively, taking more care of expensive components important for safety. This analysis will be completed as part of the construction phase, when any component will be acknowledged as re-usable only if these conditions are met: suitability from a design point of view (considering the applicable codes and standards), equipped with the necessary fabrication information and related certifications, verification of correct preservation.
- Outside infrastructures. The Construction site is connected to the national highway system through a stretch of approximately 35 km of regional road. The site is also connected to a railway branch; SE is authorized to operate both the railway and the transport on the railway. No additional other infrastructure is required for the completion of MO 34.

The Contractual Agreements and Negotiating Strategies

The DNPP MO 34 strategy dealing with the "evaluation and assessment of the require work for DNPP completion" (which is in compliance with chapter 3 of the main report "Restarting Delayed Nuclear Power Plant Projects" and with ref. [1]) is reported below.

The completion of MO 34 has characteristics, specific to this Project, that are drivers for the definition of the contractual strategy. These characteristics are:

- pre-defined technology (VVER 440-213) for the NI;
- most of the critical NI components have been manufactured and are currently preserved as required by ÙJD SR;
- largely completed civil works.

Furthermore, it should be considered that the substantial reduction of new NPP construction over the past twenty years has determined a strong reduction in the number of qualified suppliers, especially for the most advanced technological parts. In some cases this peculiarity leads to a lack or absence of competition.

In order to avoid extending to the whole plant the market limitations driven by the specific nuclear technology, with the ensuing high risk of significant cost increase, it has been decided to separate the supply of the nuclear part of the plant from the conventional part in order to enhance the competition and to have an easier and more effective Project monitoring and controlling. Weak point is represented by the foreseen effort to manage contractual interfaces.

Moreover, a multi-contract approach has been selected for CI.

The resulting proposed Contractual strategy is listed below:

- the completion of MO 34 will be managed by SE through several Contracts that will be based on the different expertises required; SE will act as Owner and General Project Manager for the construction phase;
- the Contract for NI will be a Turn Key Lump Sum contract that will include the Project management, design, procurement, construction, commissioning and start-up of: primary system, relevant safety systems, radwaste systems, civil works of the containment zone, reactor building and nuclear auxiliary service building.

This Contract will be based on fixed schedule and fixed price and will include performance guarantees, completion schedule guarantees and warranties on the scope of supply:

- the completion of the CI will be performed through an Engineering Procurement Construction Management (EPCM) Contract plus: several supplies, construction, erection and service contracts that will be awarded directly by SE;
- the EPCM will be a Lump Sum contract that will include the following services: Project management, design, technical assistance for the procurement activities, inspections during supply fabrication, construction management and supervision, commissioning and start-up for the CI as a whole, i.e.: secondary system, main circulating water systems, auxiliary systems, power export and in general all civil works and systems not included in the NI. This contract is for services only and does not include supply or construction contracts;
- the detailed procurement plan for the CI, which will identify the planned number of contracts and the scope of each of them, will be defined at a later stage. At the moment, approximately 80 contracts are envisaged.
- the Contracts for the Engineering Consultants, that will assist SE during the whole phase of Plant completion, will include the following activities: support to Project management and control, technical verification of the detailed design performed by contractors and of the interfaces between NI and CI, technical support with the Nuclear Regulatory Authority and other National Authorities, support on preparation of Pre-

Operation Safety Analysis Report, preparation of commissioning documents and support for the commissioning activities.

Legal, institutional and permitting issues

Legal advice supports the Project planning for contract management and authorisation processes. It takes part in handling day-by-day issues, permitting and licensing processes, dealing with third parties (international bodies, etc). It also plays an important role in the financing activities.

Construction all risk insurance

It is the typical insurance that covers all risks during construction and commissioning phase of NPP.

Human resources during construction and during operation

The Human Resources (HR) necessities for the completion and operation of MO34 are determined on grounds such as the schedule date for starting commercial operation, the construction contract approach (Multi Package, Turn key, etc.), the subdivision of the 4 units in Mochovce in two Operation Departments, etc.

Risks related to resources migration to supplier companies have also been taken into account to define the amount and quality of SE HR for completion and operations. In particular, the HR department expects that the supplying companies will carry out a considerable recruitment activity among SE experts.

In order to avoid a negative impact on quality and number of the staff for MO 34 completion and operation, SE will implement a strategy aimed at:

- losing a minimum number of qualified resources by defining in the contracts with suppliers restrictions to migration of SE personnel;
- properly managing the resources already present in SE by motivating actions;
- activating recruitment operations involving the existing, both internal and external, sources of skilled personnel (EMO 12 employees, other SE departments, supplying companies which cooperated in EMO 12 completion, graduated students, etc).

Further information is reported in Section 4.3.

Communication program

In the early 1990's SE recognized the need for open communication with the public. In 1991, as a result of this need, it established the Information Centre in Mochovce NPP.

At the same time a Regional Interest Association of Towns and Villages Mochovce (ZRZM), initiated by mayors of the Vrable region, was established in order to gain legal and financial support for common solutions to environmental influences of Mochovce NPP operations, but also to guarantee protection of legal rights and interests of settlements, development of local government functions, and co-ordination of regional policy.

After the privatisation of 66 % of SE shares was completed in April 2006, Enel envisaged an ambitious plan of investment in Slovak Republic mainly devoted to the completion of the delayed MO 34.

Enel’s external communication strategy (see ref. [15]) was defined accordingly to reach the following goals:

- strengthening SE/Enel image as a socially responsible and environment-friendly company ;
- SE/Enel as a “company of value”, active and dynamic from a cultural point of view;
- maintaining constant and transparent media relations;
- keeping the public support to existing and future nuclear developments in Slovakia.

The vision of the company is to forward the message that SE/Enel is a long-term investor that is efficient, innovative, and sensible to the socio-cultural development.

The communication activities are split in four major areas: institutional (integration, citizenship, socio-cultural growth, trustworthiness), environmental (environmental compliance), economic (investments, quality, innovation), and social (sustainability, schools, universities, charity), where various tools are applied to approach the ultimate goals.

As of the acceptance of Nuclear energy in Slovakia, on the basis of the last public opinion poll by GfK (March 2007), no less than 87 % of the population in the 10-km area of Mochovce NPP agreed with completion of Units 3&4, while in the national scale it is more than 2/3 of the entire population. SE/Enel is committed to keep the high acceptance of nuclear in Slovakia.

V-5. CRITICAL ASPECTS OF A TYPICAL DNPP PROJECT AND MEASURES IMPLEMENTED FOR MO 34

The present chapter deals with the main critical aspects that usually are addressed in the DNPP Project and shows how for MO34 they were considered and which measures were implemented according with the management procedures (see also [3]).

V-5.1. Preservation and maintenance of equipment

Construction works of MO 34 started in 1986 by laying the foundations of main buildings (reactor building, lengthwise electrical building, transformers foundations, cooling towers, vent stack) and continued up to 1992, when construction works have been suspended. From 1992 to 2000 maintenance and conservation activities of equipment and components and of civil structures have been performed by the original main suppliers and constructors on behalf of SE [3].

Since 2000 up to date the preservation and protection works on buildings, structures and on selected safety and non safety related equipment have been performed by SE on the basis of programs approved by ÙJD SR and in accordance with IAEA-TECDOC-1110 [1].

The main objective of the program was to preserve and maintain facilities and equipment in order to protect the investment and also to be able to re-start and complete the MO 34 NPP.

The status of equipment (mainly of selected components) has been checked annually. ÙJD SR performed regular inspections to verify if the conditions specified in the programs for quality assurance and in technical specifications were fulfilled. Conservation and protection works are carried out by selected companies: ŠKODA Slovakia, EURO-BUILDING and maintenance team of EMO12. The following main measures, generally headed to avoid corrosion and condensation on the components, have been considered together with quality control:

- enveloping of the already installed stainless steel pipes and fittings with plastic wrapping (e.g. primary circuit pipes);
- painting with protective varnish of components and introducing humidity absorbers (e.g. RPV);
- monitoring of temperature and humidity (e.g. SG, where humidity absorbers are used as well).

V-5.2. Updating to technological and regulatory requirements

This section presents the references of the main outcomes of the activities necessary to establish a set of improvements required to bring the plant into conformance with the current best nuclear practices and the nuclear regulatory requirements.

The update activity of MO 34, from a technical point of view (without going into details) is briefly reported in the paragraph 3.1 and complies with ÙJD SR (refs [6], [7]) and IAEA ([9]) requirements.

The MO 34 design is based on the experience gained during EMO 12 construction and operation according to IAEA-TECDOC-1110 [1] recommendation.

V-5.3. Human resources issue

The management considerations and activities aimed at preserving the manpower resources necessary for re-starting the plant in MO 34 are briefly reported. The nuclear utility, during the DNPP Project stages, maintained a “core group” mainly devoted to management issues.

Thanks to the construction and operation of EMO 12, stable and skilled human resources, together with the procedures and planning experience, are available to support activities linked with construction, pre-commissioning, and commissioning of MO 34. The recruitment and training of the MO 34 operating personnel are conducted among the existing EMO 12 operation staff.

It is foreseen that the plant staff for operating MO 34 will increase of about 200 units. The initial staffing of the organization will be made through the transfers of selected experienced people from the staffs of EMO 12 and EBO V2, plus the recruitment of external candidates. Some skilled staff will be available from the shutdown of EBO V1 as well, so that an optimal structure of experienced and newly employed personnel is assured.

V-5.4. Protection of design data

The management considerations and activities aimed at preserving the engineering data and other documentation necessary for re-starting the MO 34 are briefly reported (see also [4]).

The methodology of long-term protection of design data has been developed according to the IAEA recommendations [1] and within the quality system of SE-MO34. The objective of the design data protection is to ensure that all the necessary documentation and its related technical data are under conditions enabling to restore the suspended work on the Project and subsequent plant safe operation.

The concerned documentation is divided in: Documentation for quality assurance, design documentation and safety documentation.

(a) Documentation for quality assurance

All the activities related to quality assurance at MO34 are in compliance with the concepts of quality assurance "Quality guide of SE. - SE/PK-002" based on the requirements of international standards and legal regulations in STN EN ISO. The Nuclear Regulatory Authority by its Decision No. 35/2002 approved the "Specification program of quality assurance". The recommendations from [1] were implemented into the specification program. The quality system represents an integrated management system that contains tools for the control in the area of the safety, quality and environment.

(b) Design documentation

The design documentation was developed on the basis of the regulations No. 105/81 Zb. a No. 5/87 Zb. of the Federal Ministry of Technical and Investment Development (FMTIR) on the documentation of constructions.

(c) Safety documentation

The Safety Analysis Report for MO 34 was developed by the designer Energoprojekt Praha in 05/1980 considering the up to date legislation. Nowadays the Engineering Company is preparing the PRESAR.

V-6. CONCLUSIONS

The description of management experience in the re-starting of DNPP MO 34 has been carried out and reported in the present annex, pointing out the information and practical examples about necessary management actions to preserve and develop the capability to re-start and complete DNPP Projects.

After a brief description of the DNPP MO 34 Project status before and throughout the feasibility study, the document highlights the typical criticalities of the DNPP Project: preservation and maintenance of equipments, updating to technological and regulatory requirements, human resources, protection of design documentation, etc. It also shows how such problems are solved in MO34.

It is important to remark that the aim of this annex is not the accounting of study results used for economic purposes. It identifies the main steps of the activities needed to complete MO 34 and evidences the key management re-start experience applied to the solution of encountered criticalities.

As a conclusion it can be stated that, thanks to an accurate management strategy, the benefits cast on the Project re-starting are consistent. The experience of MO 34 can be accounting as outstanding. For instance the suitable coordination of preservation and maintenance activities led to save time and investments. Similarly the human resources issue has been properly solved, preventing the loss of knowledge and skilled personnel. Regarding the protection of design documentation, it is foreseen that the management strategy adopted so far will allow to easily retrieve every single part of the design whenever required.

ABBREVIATIONS

CAR	Condition Assessment Reports
CI	Conventional Island
COD	Commercial Operation Date
CS	Completion Schedule
DG	Diesel Generators
DNPP	Delayed Nuclear Power Plant
EBO V1-V2	Bohunice Unit 1&2 – 3&4 NPP
ECCS	Emergency Core Cooling System
EGP	ENERGOPROJEKT
EIA	Environmental Impact Assessment
EMO12	Mochovce Unit 1&2
EPCM	Engineering Procurement Construction Management
ER	Electrical Resistance
ET	Eddy Current
EUR	European Utility Requirements for LWR NPP
FT	Functional Testing
HA	Hydro-Accumulators
HR	Human Resources
HP	High Pressure
I&C	Instrumentation and Control
IPSART	International Probabilistic Safety Assessment Review Team
IR	Insulation Resistance
LOOP	Loss Of Offsite Power
MO 34	Mochovce Units 3&4
NDE	Non-Destructive Evaluation
NDT	Non Destructive Test
NI	Nuclear Island
NPP	Nuclear Power Plant
OSART	Operational Safety Review Team
P&PW	Protection and Preservation Work
PHARE	Poland and Hungary: Assistance for Restructuring their Economies
PRESAR	Preliminary Safety Analysis Report
PRZ	Pressurizer
PSAR	Probabilistic Safety Analysis Report
PSA L1	Probabilistic Safety Assessment Level 1
QA	Quality Assurance
R & D	Research and Development
RPV	Reactor Pressure Vessel
SA	Severe Accident
SE	Slovenské Elektrárne
SEP	Slovak Power Enterprise
SG	Steam Generators
TG	Turbine Generators
ÙJD SR	Úradu Jadrového Dozoru (Nuclear Regulatory Authority of the Slovak Republic)
VVER	Vodo Vodni Energeticeskj Reaktor
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association
ZRZM	Regional Interest Association of Towns and Villages Mochovce

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ANNEX VI
IAEA ASSISTANCE ON MANAGEMENT OF DELAYED NUCLEAR POWER PROJECTS

VI-1. What is the service provided?

Assistance to the management of organizations responsible for Nuclear Power Plant Projects with significant delays with respect to the originally scheduled commercial operation.

What are the issues?

- Several Member States have Nuclear Power Plant Projects with delays of five or more years with respect to the originally scheduled commercial operation. The degree of conformance with original construction schedules shows large variations due to several issues, including financial, economic and public opinion factors.
- Solving the special difficulties related with a delayed NPP project is problematic and dependent on the particular country situation. However is not regarded as an isolated country problem but as a significant subject with a number of difficulties shared by several Member States.
- The IAEA collects information and supports the management of delayed NPP projects by identifying main common issues, gathering available experience and addressing specific needs. On this background the IAEA is in the position to provide unique impartial assistance, based upon best international practices, and on a non-profit basis.

VI-2. What are the benefits?

- Maintaining readiness for resuming the project construction when the conditions permit.
- Strengthening management‘s abilities for the completion of the project.

VI-3. What specific assistance can be provided?

The service is tailored to the needs and requirements of the requesting organization, implemented on-site by international experts, addressing areas such as:

- Project control measures
  - Quality assurance/Quality Management/Management System
  - Safety culture
  - Peer reviews
  - Technical support
  - Communication with the public
  - Management of procurement

- Human resources
  - Human performance improvement

- Preservation and maintenance of equipment and facilities
  - Analysis of state of preservation of the assembled and stored components
  - Surveillance and inspection

- Providing information on updating to technological and regulatory requirements
  - Design analysis/review
  - Safety systems and engineered safety features
  - Cost-benefit analysis
  - I & C modernization
  - Cooperation with the regulatory body
  - Environmental issues

- Project data
  - Configuration Management

- Nuclear safety review
  - SAR evaluation
  - Emergency Planning and Emergency Preparedness

- Physical protection and nuclear security
  - Design basis threat
  - International guidance
  - Identification of vital areas
  - Physical protection system

- Preparation to resume project construction / operation
  - Assessment of project status
  - Feasibility, financial and public acceptance aspects
  - Project management organization and strategies for completion
  - Integrated management system
  - Risk management
  - Project planning, scheduling, controlling and budget
  - Feedback from restarted and completed delayed NPPs

VI-4. References

- Available national regulations and standards
- IAEA-TECDOC-1110: Management of delayed nuclear power plant projects
- IAEA Nuclear Energy Series-NP-T-3.4: Restarting Delayed Nuclear Power Plant Projects
- National practices provided by the experts

VI-5. Looking ahead

Increasing energy demand brings about reconsideration of delayed NPP projects. The IAEA can provide special expert advice and experience exchange in subjects relevant for the successful maintenance and restarting of these projects.

VI-6. How to benefit from this service?

Member States can benefit from this service in a number of ways, including: requesting an advisory/review mission, a national technical co-operation project, or joining a regional project.

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