IAEA-TECDOC-1656

Evaluation of Human Resource Needs for a New Nuclear Power Plant: Armenian Case Study

IAEA
International Atomic Energy Agency

EVALUATION OF HUMAN RESOURCE NEEDS FOR A NEW NUCLEAR POWER PLANT: ARMENIAN CASE STUDY

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYAN ARAB JAMAHIRIYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA
VIETNAM
YEMEN
ZAMBIA
ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA-TECDOC-1656

EVALUATION OF HUMAN RESOURCE NEEDS FOR A NEW NUCLEAR POWER PLANT: ARMENIAN CASE STUDY

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2011

For further information on this publication, please contact:

Nuclear Power Technology Development Section and
INIS & Nuclear Knowledge Management Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
email: official.mail@iaea.org

EVALUATION OF HUMAN RESOURCE NEEDS FOR A NEW NUCLEAR POWER PLANT: ARMENIAN CASE STUDY
IAEA, VIENNA, 2011
IAEA-TECDOC-1656
ISSN 978–92–0–113510–0

Printed by the IAEA in Austria
May 2011

FOREWORD

Rising expectations of an increased role for nuclear power in providing energy for future national and global sustainable development have become a reality in many Member States of the IAEA. Over the last several years, dozens of Member States have announced plans to embark on or expand nuclear power programmes. Reflecting on these developments, the IAEA has adjusted its priorities to focus more on the nuclear power programmes of newcomers. Specifically, the IAEA has produced publications providing guidance on the development of a national infrastructure for nuclear power (IAEA Nuclear Energy Series No. NG-G-3.1) and on managing human resources in the field of nuclear energy (IAEA Nuclear Energy Series No. NG-G-2.1). Additionally, assistance to eligible Member States through new technical cooperation (TC) projects has been increased, including direct support through on-site assist visits.

In 2007–2008, the IAEA carried out a TC project titled 'Feasibility study of nuclear energy development in Armenia: Evaluation of human resource needs in conjunction with new NPP build' (ARM-005). The project analysed the human resource demands required to support work at all stages of the life cycle of a new power unit planned for Armenia. This included drafting proposals for the means, conditions and requirements for development of human resource capabilities needed to carry out the work. This report is intended to complement the previous IAEA publications by providing an in-depth technical consideration into this critical area of human resource development. The report summarizes major findings of the TC project and details the tasks linked to management of the human resources that will be required by a country planning to build a new NPP. Additional guidance on the development of a national nuclear infrastructure can be found in the IAEA publication 'Milestones in the Development of a National Infrastructure for Nuclear Power', IAEA Nuclear Energy Series No. NG-G-3.1.

The objective of this publication is to identify and analyse the demand in human resources at all stages of construction of the new nuclear power unit, these stages being pre-preparation, preparation, mobilization of resources and readiness to adopt responsibility for staged introduction of equipment, buildings and facilities. Another objective is to draw up proposals for the means, conditions and requirements for the training of the specialists who will be needed to take forward and carry out work at all stages of the life cycle of a planned new nuclear power unit.

The report is intended for governmental officials and officers of ministries in Member States planning to embark upon or expand a nuclear power programme, as well as national utilities and regulators.

Using as an example the Armenian initiative to build a new nuclear unit, the report addresses in detail the issues of selection of an option for construction, standard processes associated with construction work, customer actions at various stages leading up to commissioning, means, conditions and requirements for the training of the specialists, and assessments of various projects being considered for implementation (from the standpoint of human resource mobilization at different project stages).

The IAEA officers responsible for this publication were V. Kuznetsov and A. Kosilov of the Division of Nuclear Power.

EDITORAL NOTE

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

CONTENTS

SUMMARY

(1) Evaluation of human resource needs in conjunction with new NPP build — Armenian Case Study

As a result of increasing interest expressed by Member States considering nuclear power for the first time, the International Atomic Energy Agency (IAEA) has adjusted its priorities to focus more on these newcomer countries. Specifically, the IAEA has produced documents providing guidance on the development of a national infrastructure for nuclear power and on managing human resources in the field of nuclear energy [1–4]. Technical Cooperation (TC) projects remain the primary means of delivering assistance to developing countries planning to embark on or expand nuclear power programmes. This report, utilizing the Armenian case study, is designed to complement this existing work.

In 2007–2008, the IAEA carried out a TC project titled 'Feasibility Study (FS) of Nuclear Energy Development in Armenia: Evaluation of Human Resource Needs in Conjunction with New NPP Build' (ARM-005). The project analysed human resource demands and developed proposals for the means, conditions and requirements for the training of the specialists who will be needed for such an undertaking. Activities at all stages of the life cycle of the new power unit planned for Armenia were considered:

— Pre-preparation;
— Preparation;
— Resources mobilization; and
— Readiness to adopt responsibility for staged introduction of equipment, buildings and facilities.

The ARM-005 project evaluated both programmes and activities associated with developing the human resource capabilities that would be required to build a new nuclear power unit. To carry out the project, the IAEA established a team of experts from Member States with established nuclear power programmes. An initial 'kick-off' meeting was held in October 2007 followed by an on-site mission to Yerevan, Armenia in November of that year. During the on-site visit, the team met with government officials, Armenian Nuclear Regulatory Authority (ANRA), university leaders and industry representatives to gather information and data related to human resource development. Two additional meetings were held in 2008 including a workshop in Yerevan on 'The experience of Member States in Human Resource Development'. The project also analysed human resource needs and issues, taking as examples the possible construction of WWER-1000 and AP-1000 nuclear power units. The ARM-005 report represents one of the chapters (human resources management issues) of the overall feasibility study conducted under the direction of the Armenian Ministry of Natural Resource and Energy (MoENR).

(2) Status of nuclear energy in Armenia

Currently Armenia relies on nuclear power for 40–45% of its base load electricity. In an effort to meet increasing demands for power and to enhance its energy independence, the government has taken steps to build a new nuclear power plant (NPP) by the end of 2016. This effort is part of a broad energy strategy which focuses on developing a diverse mix of power generation with nuclear power serving as the major source of baseline generation. Armenian existing nuclear power station is located at Metsamor about 40 km from the capital, Yerevan. The site originally operated two WWER-440 MW reactors that were designed, constructed and commissioned during the era of the former Soviet Union. Both units were shutdown in 1988 after a severe earthquake raised concerns about their seismic vulnerability.

While Unit 1 remains shutdown, Unit 2 was restarted in 1995 to meet critical power needs. The Unit 2 is scheduled for shutdown at the end of operational life in 2016.

To compensate for the loss of power when Unit 2 is shutdown, Armenia has initiated efforts to build a new nuclear unit at the existing Metsamor site. This decision was supported by an Energy and Nuclear Power Planning (ENPP) study for Armenia which was conducted under a TC Programme of the IAEA. The outcome of the study was supportive of the option to construct a new nuclear unit [5]. This option was recognized as preferable by Armenia. Currently, Armenia is moving forward with plans to construct and commission a new unit by the end of 2016.

Two options considered for the construction of a new NPP were:

— power unit construction using Armenian resources; or
— power unit construction on a turnkey basis.

Based on the analysis of the human resource requirements conducted as a part of this study, *the best option appears to be to build the new power unit on a turnkey basis*. This view is based on the existing levels of technical expertise available in construction, engineering, installation and research organizations. In addition, the short time frame planned to bring the unit on-line (end of 2016) was considered.

As noted above, the two existing units were built during the era of the former Soviet Union. Therefore, while nuclear power generation is not new to Armenia, the construction and commissioning of a new NPP will be a first for this government. Since this is a new experience for Armenia, other countries considering nuclear power for the first time can gain valuable insights.

(3) Links between Customer and General Contractor work processes

Based on the experiences of Member States caring out similar projects, as well as the current situation in Armenia, the following main stages (processes) involved in the building of a new NPP were identified. These stages or processes were categorized as follows:

— For the Customer:
  - A.1 — Pre-preparation;
  - A.2 — Preparation;
  - A.3 — Human resources mobilization;
  - A.4 — Readiness to adopt responsibility for staged introduction of equipment, buildings and facilities;
— For the General Contractor:
  - B.1 — Preparation for tender process announced by the customer;
  - B.2 — Work under contract for turnkey construction;
  - B.3 — Human resource mobilization;
  - B.4 — Full-scale work on site;
  - B.5 — Preparation for placing the site under the responsibility of the customer, and handover of responsibility to the customer.

The analysis covered all stages of construction of the new nuclear power unit and relates both to the Customer (stages A.1–A.4) and General Contractor (stages B.1–B.5). In addition, activities required by the regulatory body — ANRA were considered. The durations of each stage are also addressed. Sections of the report provide a sequential description of the processes and actions needed to support human resource development for the commencement and subsequent implementation of work to fit out (complete) the power unit. Consideration is

given to the links between processes to be carried out during the different stages of construction.

The responsibilities and actions for the four Customer stages are elaborated in detail. For stages A.1 most actions are expected to be carried out by the MoENR and the ANRA. Stage A.2 also involves actions for the on-site customer representative. For stages A.3 and A.4 actions are generally specified in A.1 and A.2 but include additional duties such as acceptance of installed equipment, structures and building, handover of documentation, drafting of operating instructing, etc. It should be borne in mind that the Customer's most important task, in all stages of the project, is to ensure effective coordination of work with that of the General Contractor.

(4) Comparison of two design options

Two design options were selected for evaluation of human resource needs during stages of the new-build project; the Russian Federation WWER-1000 and the Westinghouse AP-1000. This approach provided realistic examples to Armenia of human resource requirements for these options.

The WWER-1000 option considers the requirements of Russian normative documents for a standard 2-unit NPP project with WWER reactors. As the Westinghouse the AP-1000 is a new advanced design reactor currently only in the stages of construction (Sanmen site in China), staffing data was limited to projections based on the reactor design, improved construction technologies and past experience with existing NPPs.

(5) General observations

— In the event that the AP-1000 installation is selected, staff mobilization at the site during construction stages may be significantly reduced, since the plan is to use pre-assembled modular components and advanced construction technology. However, the question of the integral costs linked to the involvement of assembly workers (number, housing on site, training in special NPP construction processes, delivery of special installation equipment and other issues) remains open. There is currently inadequate data for the situation to be resolved.
— Further attention is needed on the question of whether it is possible to deliver pre-assembled modules to the power unit construction site using available means of transport. An assessment of the capital investment in the transportation infrastructure required to achieve such delivery is needed.
— Available information on the AP-1000 is limited because NPPs with this type of reactor are not yet in the operation stage and are only under construction. Consequently projections have been used, taken primarily from the US industry, including the duration of construction work and the required human resources. Nevertheless we can say that the estimated construction period for an AP-1000 unit is less than the equivalent for a WWER-1000. However, the time needed to create the infrastructure for such modular construction must be considered. This makes it difficult to draw a comparison between equivalent time and cost characteristics for the AP-1000 and WWER-1000.
— Both approaches are based on the premise that staff already available at the Armenian NPP (ANPP) site could be utilized on a permanent and temporary basis during the construction period. For either choice language issues should be taken into account. If an AP-1000 is built, local skilled workers will need to be taught English, or a fair quantity of working documentation will need to be translated into Armenian. As an alternative to this, it will be necessary to keep local staff involvement to a minimum,

which will in turn lead to an increase in the overall cost of construction. If a WWER-1000 design is chosen, potential language problems will also need to be borne in mind. While Russian is the language used in operations at the existing NPP[1], new workers may not be fluent in the language. It is not entirely clear at present what type of language problems should be considered in the event that the WWER-1000 design is chosen.

— For a WWER-1000 installation, the entire range of ancillary production processes is located on site and forms part of the cost of the turnkey project. A list of ancillary production processes is given in the document OTP-86[2], which the Armenian side has. In addition, ANPP staff has the relevant competence at working with WWER technologies. Because of this, extra study of the capital component will be needed (in view the return-on-investment requirements) with the selection of any project.
— Staff training will have its specific features, such as; measurement system (US vs. SI system), operator computer control systems, and man-machine interface solutions.

(6) Observations on differences in proposed technologies

WWER technology is familiar to ANPP staff (the existing power unit is a WWER-440). Experience in the re-training of staff has shown that little extra work is required to draw up and introduce training programmes and training hardware that take into account the specifics of the system and the equipment of a new power unit with WWER-1000 reactor. Such efforts should be comprehensive in nature, and should be applied primarily with a view to matters relating to the unit's computer control system and the power system.

The AP-1000 technology is new, and generally less known. This will give rise to extra demands in the drawing up and delivery of training programmes, including a large amount of training of the Customer's staff by the General Contractor and equipment suppliers. Corresponding efforts will also have to be made at the higher education level, to ensure that the relevant information is reflected in study plans and curricula at Armenian higher education institutions (currently all training in the nuclear sphere at higher education institutions is oriented towards WWER technology).

Comparison of staff numbers for operation, technical servicing and maintenance is difficult, as staffing projections for the AP-1000 are based on expected improvements in construction technology and advanced design features. For a WWER-1000, the average numbers are known.

(7) Main conclusions:

(a) Developing a skilled workforce, (engineers, skilled trades, project managers, etc.) to support construction and operations of a new NPP, requires many years. Strategic planning and initial actions to develop these human resource capabilities should be initiated as early as possible in the project (Pre-preparation and Preparation stages). Key stakeholders (universities, technical organization, trade unions, Ministry of Education,

[1] Experience in IAEA Member States shows the language of operation is also important; as a rule the language of operation is largely chosen on the basis of design data; in the event of an AP-1000, clearly this should be English. For the Tianwan NPP, for example, the language of operation is English (the same as the language of the contract); documentation is drawn up in English and Russian, and in the event of any discrepancy, the English version takes precedence.

[2] Technical rules for a construction of nuclear power plants with WWER-1000 reactors, OTP-86, Atomenergostroyproekt, Russian Federation.

etc.) should be involved in these initiatives. Such efforts are not dependent on the selection of a specific design.

(b) To ensure that construction work is conducted in an efficient and cost effective manner, recommendations that should be considered during key construction activities are provided in Appendix I. This approach is not dependent on the selected design technology.

(c) The assessments of labour outlay (cost and staffing numbers) should be carried out in a comprehensive way, taking into account matters relating to the development of infrastructure for the new construction work. Developments in the proposed technologies should be used in assessing the required labour cost and staff needs for each stage of NPP construction.

(d) On the basis of the data evaluated, it is difficult to draw conclusive comparisons between the known technology of the WWER-1000 and the new design of the AP-1000. Further study by the Customer and customer representatives is recommended, taking into account the information and observations presented in this report.

1. INTRODUCTION

1.1. BACKGROUND

This report provides a case study of ongoing efforts by Armenia to construct a new NPP. The report is based on work conducted in 2007–2008 under the IAEA Technical Cooperation (TC) Project ARM-005. The project focused on the analysing the human resources that would be needed for this new build project. As with similar efforts, an evaluation of the current workforce, educational system and training facilities was necessary to help identify gaps and develop proposed solutions.

Armenian existing nuclear power station is located at Metsamor about 40 km from the capital, Yerevan. The site originally had two WWER-440 MW reactors; however both units were shutdown after a severe earthquake in 1988 triggered concerns about their seismic vulnerability. Unit 1 is currently in decommissioning, but Unit 2 restarted operations in 1995 and currently provides about 40–45% of the country's base load electricity. Unit 2 is scheduled for shutdown at the end of operational life in 2016.

To compensate for the loss of power when Unit 2 is shutdown, Armenia has initiated efforts to build a new nuclear unit at the existing Metsamor site. This decision was supported by an Energy and Nuclear Power Planning (ENPP) study for Armenia which was conducted under the TC programme of the IAEA. The outcome of the study (see Ref. [5]) was supportive of the option to construct a new nuclear unit to replace Unit 2 after shutdown.

In view of the country's energy security and energy independence criteria, and also considering the socioeconomic aspects of the energy problem, this option was recognized as preferable by Armenia. In 2006, The Armenian Ministry of Energy and Natural Resources (MoENR) used this work as a basis for the drafting, of the following documents:

— Plan for lowest-cost energy generation;
— Overall strategy for the country's power generation;
— Action plan for upgrading of the energy sector.

This was in line with the 'Republic of Armenia National Security Strategy' and was ratified by a governmental decision, in November 2007, to build a new NPP in Armenia, to replace the existing unit following its shutdown. To put these principles into effect, in 2007 a 'Cooperation Agreement' was signed between Armenia and the US government which envisaged the drafting of a 'Feasibility study for the construction of a new NPP unit in Armenia', along with an 'Environmental impact study of new NPP unit'. This work under ARM-005 represents one of the chapters of the feasibility study, devoted to human resources management.

Currently, Armenia is moving forward with plans to construct and commission the new unit by the end of 2016. This effort is supported by the IAEA, USA, and the Russian Federation (RF).

1.2. PURPOSE AND SCOPE OF THE STUDY

The purpose of IAEA Project ARM-005 was to evaluate the human resource development needs to support the construction and commissioning of a new nuclear power plant in Armenia. The work under ARM-005 was used to support an overall feasibility study, related to the new-build, initiated by Armenia.

The scope of the study was to provide a comprehensive evaluation of human resource requirements for the construction and operation of the new unit and to link management

actions to each stage in the plant life cycle. The study is based on implementing a strategic and integrated approach to the management of human resources to ensure that adequate numbers of trained and qualified staff are available when needed.

This report utilizes the Armenian case study to complement existing IAEA documents in supporting Member States embarking on or expanding a nuclear power programme.

1.3. OBJECTIVES OF THE STUDY

The main objective of the ARM-005 study was to support the feasibility study (FS) for the construction of a new NPP in Armenia as a part of the overall energy strategy. The approach used was to identify and analyse the demand in human resources at all stages of construction of the new nuclear power unit:

— Pre-preparation;
— Preparation;
— Human resource mobilization; and
— Readiness to adopt responsibility for staged introduction of equipment, buildings and facilities.

This objective included developing proposals for the means, conditions and requirements for the training of specialist needed to implement the above stages.

Other objectives included, providing a sequential and detailed list of standard work process for the Customer, evaluating comparisons of potential design technologies and making recommendations based on study findings.

The report addresses the area of human resources management, developing proposals based on a strategic and integrated approach that will ensure a qualified staff is available when needed to carry out work at all stages of the life cycle of the new NPP. A sufficient level of detail is provided to enable a Customer to understand the full scope of actions necessary to build a new NPP and to evaluate the level of work that is necessary to prepare and subsequently mobilize and deploy the necessary human resources. The ARM-005 report represents one chapter in the feasibility study.

1.4. STRUCTURE OF THE REPORT

The project envisaged a study of the on-site situation in Armenia, analysing the needs and resources available for the commencement of work to construct and operate a new NPP. The report is organized to provide a sequential outline of actions to be followed through all stages of the project. Sufficient detail is included to ensure a thorough understanding of the actions required of the customer.

The report consists of a Summary, followed by seven sections and five appendices. Following the introduction, Section 2 addresses the prerequisites for the feasibility study, including government actions such as legislative framework, and information and data on the current workforce status. Section 3 covers the evaluation of options available to Armenia for construction of a new NPP. Section 4 describes standard process, for the Customer and General Contractor, associated with new build and the links between these work processes. Section 5 identifies Customer actions at each stage (main process and sub-processes) leading up to the commissioning of a new unit. Section 6 compares two potential design options available to Armenia; the Westinghouse AP-1000 and the RF WWER-1000. Section 7 contains observations and conclusions made by the IAEA team members drawn from the study and from various information sources.

2. PREREQUISITES FOR THE FEASIBILILTY STUDY

A major prerequisite for the study was the preparatory work by Armenia (government decisions, legislative action, responsibilities assigned, etc.). Armenia had already made the decision and initiated preliminary efforts to build a new nuclear unit at the existing Metsamor site. The MoENR had been assigned to act as the lead government organization. This decision to construct a new nuclear unit was supported by Energy and Nuclear Power Planning (ENPP) study for Armenia conducted under the TC Programme of the IAEA (see Ref. [5]).

As indicated above the ARM-005 project's main objective was to support Armenian feasibility study for construction of a new NPP. This was to be accomplished by evaluating the human resource demands associated with the proposed new build project. The IAEA team held a kick-off meeting in September 2007 to plan the overall approach to be taken. Another prerequisite for the success of the IAEA mission was the gathering of current workforce demographics in Armenia. This included data for the following organizations and key stakeholders:

— Existing Armenian Nuclear Power Plant (ANPP);
— Armenian Nuclear Regulatory Authority;
— Armenian universities;
— Engineering and technical support organizations;
— Labour organizations;
— Others.

To prepare for the first onsite meeting in Yerevan, plans were developed on the approach for the upcoming mission. In this meeting the IAEA team identified key data elements required to complete the needs analysis for the feasibility study. Questionnaires were developed and provided to the counterpart to support the timely gathering of the necessary data (numbers of staff, average age, years of services, time needed to prepare, etc.). Issues to be addressed by the team included:

— National policy and legislative framework;
— Nuclear regulations and the regulatory body;
— Management aspects;
— Status of current human resource development activities;
— Level of stakeholder involvement;
— Level of industry involvement.

During the first onsite visit to Yerevan, the team focused on meeting with each of the organizations and key stakeholders to gather information and discuss the challenges and possible solutions. The information and data obtained during the onsite visits and subsequent meetings was used as the basis for this report.

The roles of the main Armenian organizations in nuclear related activities are presented below (the information is taken from IAEA Country Nuclear Power Profile: http://www-pub.iaea.org/MTCD/publications/PDF/cnpp2009/countryprofiles/Armenia/Armenia2006.htm)

The Armenian Nuclear Regulatory Authority (ANRA) was established in 1993. The ANRA was authorized to be a regulation body in the area of nuclear and radiation safety, to perform inspection activity and issue the licenses for the appropriate applications.

During the period of preparation for the Armenian NPP (ANPP) restart (1993–1996), the 'Armatomenergo' was established under the Ministry of Energy and Natural Resources. The 'Armatomenergo' is authorized with the functions of Operator of the ANPP. On 4 April 1996, by the Government decree No. 98, the operation of the 'Armatomenergo' was ceased, and the CJSC 'Armenian NPP' was given the functions of Operator. At the same time the Department

of Atomic Energy was established at the Ministry of Energy and Natural Resources. The department participates in the elaboration of Armenian energy and nuclear energy development strategy, organizes the development of list of measures on the ANPP safety upgrading and decommissioning programme; collaborates with the IAEA and other international nuclear energy organizations.

The 'Armatom' Institute was created in 1973 to provide engineering support to the ANPP, the institute includes in its activity such works as: implementation of diagnostic systems; implementation of Safety Parameters Display System (SPDS), creation of a compact simulator, and then of a multi-functional one. 'Armatom' is involved in development of 'Deterministic Analysis of ANPP Unit 2' and 'Probabilistic Safety Analysis of ANPP Unit 2'.

CJSC 'Atomservice' was created in 1987. The company took active part in the plant systems adjusting and testing programmes implementation during the period of preparation for the ANPP Unit 2 restart. It continues to perform the same activity nowadays.

CJSC 'Atomenergoseismoproject' was created in 1983. During the period of preparation of Unit 2 of the ANPP for its restart in 1993–1995, a set of works on finishing investigations of the plant seismic conditions was performed by CJSC 'Atomenergoseismoproject' for final resolution of all the issues and approval of the possibility of the plant restart and further operation. The whole processes of work and final resolution were considered and discussed by the IAEA experts. One of the major results of conducted investigations was the proving that the ANPP has been erected on a whole (non-destructed) basalt block, i.e. absence of a tectonically active break under the ANPP site was proved.

There are several construction, repair, mounting and other organizations also related with the operation of the ANPP.

3. SELECTION OF OPTIONS FOR CONSTRUCTION OF NEW-BUILD NUCLEAR POWER UNIT

Several power unit designs are available for construction by Armenia. An effort is made in this report to analyse human resources needs, taking as examples the construction of WWER-1000 and AP-1000 nuclear power units. A comparison of these options is given in Section 6 of this report.

With regard to the approach to construction of the new NPP, the following options were discussed with MoENR and other involved organizations:

— Power unit construction using Armenian resources; or
— Power unit construction on a turnkey basis.

Based on the analysis of the human resource requirements, which were conducted as a part of this project, the best option for constructing the new unit was viewed to be a turnkey contract, (constructed by a general contractor and turned over to Armenia or designated operating organization when ready). This view is based on the existing levels of technical expertise available in construction, engineering, installation and research organizations and also considering the short time frame planned to bring the unit on-line (end of 2016). In general, staffing data provided by the MoENR indicated that the overall nuclear workforce was shrinking and aging.

Considering that a turnkey approach for construction will be used, it is anticipated that active efforts will be made to involve, to the extent practical, human resources from within Armenia.

To accomplish this, there is an urgent need for early planning for human resource development. This need is driven by such factors as:

— Ageing of operating staff at the existing Armenian NPP;
— Restrictions/challenges on recruitment of experienced staff at the ANPP to work at the new unit:
  - Lack of genuine motivation for staff to work at the new unit;
  - Timing of commissioning new unit and shutdown of Unit 2;
  - Need for staff for decommissioning of Unit 2;
— Insufficiently developed material and technical base at training institutions (inadequate equipment and resource allocation on the part of the state);
— Lack of highly-skilled national personnel in a range of specialist areas who might be brought in to work on the project (personnel emigration caused by poor economic conditions at home);
— Need to strengthen the system of standards, and particularly the national nuclear inspectorate, ANRA (need to ensure that a modern standards system is in place before new construction work begins);
— Other aspects and conditions impacting on quality and quantity of human resources available in Armenia.

Utilization of staff from the existing ANPP during the construction of the new unit will require advance training of replacement personnel. This is necessary to avoid any potential negative impact on the continued operations of Unit 2 due to a lack of experienced personnel.

The IAEA has issued several publications to assist Member States in addressing such challenges. Guidance is provided in the Nuclear Energy Series publications that address specific issues such as, managing human resources in the field (see Ref. [3]) and responsibilities and capabilities of owner/operators (see Ref. [2]). Broader issues related to the overall national infrastructure needed to support nuclear power programmes are address in INSAG-22 [6].

To provide a clear understanding of the human resource demands of a new build project, the working relationships (process, sub-processes and work links) of the Customer and General Contractor are detailed in Sections 4 and 5.

4. DESCRIPTION OF STANDARD PROCESSES ASSOCIATED WITH CONSTRUCTION WORK ON NEW-BUILD NUCLEAR POWER PLANT UNIT

Based on the experiences of Member States with similar projects, as well as the current situation with available human resources in Armenia, the following main stages (processes) involved in the building of a new NPP power unit have been identified. These stages/processes are categorized as follows:

— For the Customer:
  - A.1 — Pre-preparation — during this stage, which runs up to the point of drafting and approval of a feasibility study, a programme of work is carried out to prepare all organizations and people who will be called on once the project is initiated.
  - A.2 — Preparation — during this stage a programme of work is to be carried out to ensure full-scale development and preparation of the infrastructure for project implementation.

- A.3 — Human resources mobilization — during this stage work is to be carried out to recruit, select and train, and mobilize human resources and to create a system for staff training.
- A.4 — Ensuring that the customer is ready to take on responsibility for the equipment buildings and facilities to be introduced on a staged basis, and progressive handover of responsibility to the customer — during this stage, work is to be carried out to prepare for the progressive transfer of responsibility to the Customer prior to the pre-operational functional testing of equipment and facilities.

— For the General Contractor:

- B.1 — Preparation for tender process announced by the customer;
- B.2 — Work under contract for turnkey construction;
- B.3 — Human resource mobilization;
- B.4 — Full-scale work on site;
- B.5 — Preparation for placing the site under the responsibility of the Customer, and handover of responsibility to the customer.

The analysis covered all stages of construction of the new nuclear power unit and relates both to the Customer (stages A.1–A.4) and General Contractor (stages B.1–B.5). In addition the report considered activities required by the regulatory agency dealing with nuclear power in Armenia. Durations of each stage are also addresses. These work links are illustrated in Fig. 1.

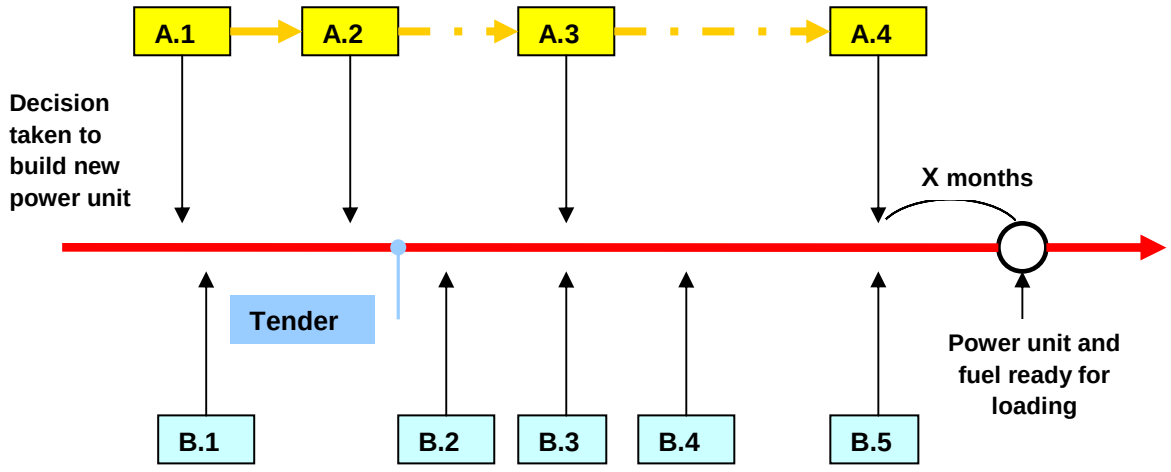

FIG. 1. Links between processes for Customer and General Contractor.

This report provides a sufficient level of detailed information to make it possible for the Customer to evaluate the levels of the work required and to prepare and subsequently deploy qualified staff in preparation for the construction of a new nuclear power unit. Consideration was given to the links between processes to be carried out during different stages of construction. The responsibilities and activities for the four Customer stages (A.1–A.4) are outlined in detail in Section 5. An example of how Customer processes, time and work are linked is given in Appendix II.

5. CUSTOMER ACTIONS AT VARIOUS STAGES LEADING UP TO COMMISSIONING OF THE NUCLEAR POWER PLANT UNIT

5.1 CUSTOMER ACTIONS FOR STAGES A.1 AND A.2

For the stage A.1 actions for the most part will be carried out by the MoENR and the ANRA. The actions are incorporated into the process and sub-processes outlined in Section 4. At all of the stages, active participation of the Customer's staff is assumed as, the party establishing the requirements for sub-processes and the party taking part in the implementation of such requirements.

For the stage A.2 responsibilities are divided into three areas, actions by the MoENR, actions by ANRA and actions by the on-site customer representative (CR). The CR may be a consulting firm selected to represent the government in various activities of the project. The level of involvement assigned to the CR may vary based on factors such as, available resources and level of expertise within the government. Appendix III shows the divisions of responsibilities for these sub-processes

Details (objectives, scope, indicators of readiness, etc.) for each of the Customer stages A.1 and A.2 are shown in the following sections. The Customer's main task during all stages is to ensure synchronization of its work with that of the General Contractor. In the case of Armenia the Customer is the government and the MoENR is the appointed lead organization for the new build project. In several IAEA publications the lead government organization is referred to as the 'Nuclear Energy Programme Implementing Organization' (NEPIO) [7] (see also Ref. [1]). While these publications provide guidance regarding activities of the NEPIO, the organization and level of activities are determined by the government based on needs and customs.

5.1.1. Sub-process details for the Customer in stage A.1 Pre-preparations

5.1.1.1. A.1.1 Sub-process

A.1.1 Sub-process — establishment of a strategic plan for human resources development in Armenia.

(1) Objectives:
Development of a single approach (plan, programme of work, budgeting) to the shaping of human resources in Armenia to support the entire programme of work to prepare for and build a new NPP.

(2) Scope:
Drafting of the following:
- — Programme for the development of nuclear power in Armenia;
- — Year-on-year plan (for 5–7 year period) for work to develop and support new construction;
- — Budget plan for funding of work in line with Armenia requirements.

(3) Indicators of Customer readiness:
The existence of decisions at the governmental level on the start (roll-out) of work to construct a new NPP.

(4) Customer actions:
A strategic plan is drafted for human resource (HR) development and management. A unified and comprehensive approach to HR development and management is drawn up, and a year-by-year budget for the work is set for all stages. Setting the budget for pre-design work is done item by item; for subsequent stages — by estimation.

(5) General Contractor actions:
No or limited participation at this stage. Technical assistance may be provided as outlined in the offer of expert services for drafting of plans and development programmes for power generation in Armenia.

(6) Indicators of success:
Plans, programmes, yearly budget plan for preparation and construction of new NPP power unit.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.1.2. A.1.2 Sub-process

A.1.2 Sub-process — planning of required HR and infrastructure for the performance of pre-preparation work (see Refs [1, 3]).

(1) Objectives:
- Recruitment, selection, training and shaping of expert, working and design groups for launch of entire work programme to prepare for the building of a new NPP unit;
- Shaping of a new (or conferral of new powers on existing) sub-section at the MoENR for planning and control of human resources to support the building of a new nuclear power unit.

(2) Scope:
- Drafting of schedule and ratification of funding of work by expert and working group drawing up strategic plan for the development of nuclear power;
- Recruitment and setting up of working group reporting to the Government of Armenia for drafting of strategic plan for the development of nuclear power;
- Recruitment and setting up of inter-authority expert group for analysis and production of recommendations for drafting of strategic plan for the development of nuclear power in Armenia;
- Recruitment and setting up of supervisory agency expert group for analysis and upgrading of current normative requirements;
- Drafting of programmes for preparation and training of working and expert groups through targeted courses: management of construction project for new NPP power unit; systematic approach to training; human resources management in power unit construction; normative requirements for NPP power unit construction, etc.;
- Recruitment, training and placing of staff in key posts to support launch of construction programme for new NPP power unit (Ministry of Energy and Natural Resources, NPP administration, regulatory agency);
- Allocation of new powers to personnel management, drafting of amendments, introduction and ratification of amended personnel management regulation at the Ministry of Energy and Natural Resources.

(3) Indicators of Customer readiness:
The existence of decisions at the governmental level on the start (roll-out) of work to construct a new NPP.

(4) Customer actions:
At the given stage, the main work of setting up a working and expert group to support the roll-out of Armenian nuclear power development plan is carried out. The working group does the preparatory work for the creation of a new (altered) structure (sub-section) at the Ministry; the expert group is a multi-authority structure and is there to consider and analyse all matters, including those that relate to contiguous spheres. The

functions of the working group include drafting of the necessary documents; the functions of the expert group include expert appraisal of such documents prior to their ratification. Training needs to be arranged over the whole range of required competences for the work of these groups.

(5) General Contractor actions:
No or limited participation at this stage. External technical assistance may be offered as follows:
- In drawing up new administrative procedures for new sub-section responsible for mobilization of staff for new construction work;
- In developing the required courses;
- In running the required training on 'Management of human resources for commencement of construction of new NPP power unit'.

(6) Indicators of success:
- Established working and expert groups to support performance of programme of work to construct new NPP power unit;
- Established sub-section at Ministry of Energy and Natural Resources to manage human resources, with corresponding powers.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.1.3. A.1.3 Sub-process

A.1.3 Sub-process — gathering, analysis, review and drafting of new requirements of supervisory agencies to take into account the new building requirements.

(1) Objectives:
Determination of scope of use of existing supervisory agency requirements (standards) and need to amend these and draft new. Ensure that regulatory agency is ready to oversee new building work.

(2) Scope:
- Analysis of current normative base, setting of requirements for construction of new NPP power unit taking into account IAEA recommendations and European Commission standards;
- Drafting of plan for adjustment and development of new requirements for construction of new NPP power unit (in the event of drafting of new (additional) requirements);
- Review of current and drafting of new normative documents (essential minimum requirements, 'starting package');
- Drafting of other normative documents in accordance with drafting schedule.

(3) Indicators of Customer readiness:
- Existence of working and expert groups;
- Completion of training of working and expert groups — drafting of programmes for preparation and training of working and expert groups through targeted courses: management of construction project for new NPP power unit; systematic approach to training; human resources management in power unit construction; normative requirements for NPP power unit construction, etc.

(4) Customer actions:
The existing requirements of normative documents are based on the normative system of the Russian Federation. An analysis needs to be made of the current normative documents and new requirements drafted taking into account IAEA recommendations and European Commission requirements. The Scientific and Technical Centre of the

State Inspectorate also needs to be provided with skilled staff to carry out the necessary calculation and analytical work associated with safety evaluation for the new project.

(5) General Contractor actions:
No or limited participation. External technical assistance may be offered in work to analyse existing normative documents and draft new normative documents on the basis of IAEA recommendations and EC requirements.

(6) Indicators of success:
— Plan for review of existing normative documents;
— 'Starting package' of normative requirements to support launch of work on new construction, drafted and put into effect.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.1.4. A.1.4 Sub-process

A.1.4 Sub-process — performance of the necessary organizational work to set up an infrastructure for subsequent preparation for tender, including development of tender procedures.

(1) Objectives:
Preparation of the baseline package of procedures that is required for the organization and implementation of the tender process for construction of new NPP power unit at stage A.2, as relates to the tender process organization. For technical evaluation procedures during implementation of tender process — see stage A.2.

(2) Scope:
Study and drafting of plan for preparation for tender process for construction of new NPP power unit. Drafting of baseline set of organizational and technical procedures enabling preparation for tender process to be carried out.

(3) Indicators of Customer readiness:
— Readiness of 'starting package' of normative requirements as in scope A.1.3 item 3;
— Existence of expert appraisal and ratified documents as in scope A.1.7 item 4;
— Allocation of powers to plan for and monitor the provision of skilled staff for the new construction work to MoENR personnel management.

(4) Customer actions:
For the tender preparation work to be carried out with the required quality, an analysis needs to be made of the experience of managing similar tender processes elsewhere in the world (or in Armenia). Drafting of the essential set of baseline organizational/technical and administrative documentation for the launch of the tender process must be carried out in stage A.2.

(5) General Contractor actions:
— Active participation;
— Participation in consultations, study trips to examine the organization and running of similar tender processes for construction of the new NPP power unit.

(6) Indicators of success:
Prepared tender documentation, corresponding technical assignment and Feasibility Study.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.1.5. A.1.5 Sub-process

A.1.5 Sub-process — regular assessment, control and upgrading of efforts at national level to achieve human resource development objectives [8].

(1) Objectives:
Organization of monitoring state personnel mobilization and work quality performance on human resource planning and development, setting and adjusting strategic and tactical work plans taking into account development of national skilled staff programmes.

(2) Scope:
Development and introduction of mechanism/procedure to ensure control and evaluation of state of human resources in Armenia to support launch and control of new construction work with a view to implementation of turnkey contract. Running of training in use of mechanisms to control and evaluate state of human resources at Ministry level in working group.

(3) Indicators of Customer Readiness:
Same as for A.1.3.

(4) Customer actions:
For long-term work in the human resources sphere, a set of procedures needs to be drawn up (a mechanism needs to be developed). A mechanism of continuing evaluation of existing human resources in Armenia should be launched, with establishment of short- and long-term demand, and establishment of the required funds to support this, independently of the new NPP project being implemented (planned).

(5) General Contractor actions:
External cooperation (technical assistance) in the drafting of procedures (mechanism) for monitoring and evaluating quality of work in the human resources sphere.

(6) Indicators of success:
Mechanism for monitoring and assessing personnel resources in Armenia to support programme of work for turnkey contract, drafted and put into effect.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.1.6. A.1.6 Sub-process

A.1.6 Sub-process — setting up the infrastructure to support the introduction of an integrated knowledge management (KM) system [9, 10].

(1) Objectives:
- — Analysis of state of development and introduction of integrated vertical system of nuclear knowledge management;
- — Rolling out knowledge management system for all stages of life cycle of new NPP power unit;
- — Establishing operator of knowledge management system at national level.

(2) Scope:
- — Performance of analysis of readiness of national infrastructure for development and introduction of a nuclear knowledge management system in accordance with IAEA recommendations;
- — Development of concept for creation of an employment management system and an infrastructure development plan for concept implementation;
- — Develop mechanism/procedure to support functioning of knowledge management system at national level.

(3) Indicators of Customer readiness:
Same as for A.1.3.

(4) Customer actions:
To support management of data associated with construction of a new NPP power unit, an analysis must be made of the readiness of the national infrastructure to produce a KM system. Funding must be envisaged for the work needed to introduce the KM system. For implementation of the construction project, provision must be made to integrate the knowledge management system and the NPP design system (data management for the design process).

(5) General Contractor actions:
— Active participation;
— Assistance in carrying out analysis of infrastructure, drafting and introducing nuclear knowledge management concept in Armenia, setting up and launching employment management system.

(6) Indicators of success:
Employment management system at national level drafted and put into effect.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.1.7. A.1.7 Sub-process

A.1.7 Sub-process — drafting of the technical documents establishing requirements for the new NPP.

(1) Objectives:
Carrying out drafting work on technical assignment and Feasibility Study for construction of new NPP power unit.

(2) Scope:
— Drafting of initial requirements for construction of new NPP power unit in Armenia;
— Drafting of Feasibility Study for construction of new NPP power unit in Armenia;
— Performance of independent expert appraisal of documents drafted;
— Ratification of technical assignment and Feasibility Study.

(3) Indicators of Customer readiness:
— Readiness of ‘starting package’ of normative requirements as in scope A.1.3 item 3;
— Completion of training of working and expert groups as in scope A.1.2 item 5;
— Existence of data as in scope A.1.4 item 2.

(4) Customer actions:
At the given stage, technical documents are drafted which support and specify the requirements for the construction of a new NPP power unit in Armenia. At this stage it is essential to take into account all existing requirements and conditions for the construction of a new NPP power unit. The documents will be used in preparing for the tender process for the construction of a new NPP power unit.

(5) General Contractor actions:
— No or limited participation;
— Technical cooperation in drafting of technical documents possible.

(6) Indicators of success:
— Technical assignment, drafted and ratified;
— Feasibility Study, drafted and ratified.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2. Sub-process details for the Customer in stage A.2 Preparations

5.1.2.1. A.2.1 Sub-process

A.2.1 Sub-process — creation of special sub-section (department) at MoENR with powers conferred on it by the Government of Armenia to perform the functions of Customer for building work on the new power unit or allocation of new powers to existing sub-section at MoENR and enlarging its resources for the organization of work in stage A.2 (see Refs [1, 7]).

(1) Objectives:
Implementation of function of state administration for building work on new nuclear installation.

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
- Existence of conceptual decision of the government of Armenia on increasing electricity generation capacity, including through the construction of a nuclear power unit;
- State agency assignment to draw up provisional case for construction of new NPP power unit.

(4) Customer actions:
The lead person at the MoENR launches an initiative with the Council of Ministers of Armenia to set up a multi-authority committee for construction of the new power unit in order to coordinate the efforts of all interested ministries and authorities in building the new power unit. The committee functions on a regular basis under the chairmanship of the President and Prime Minister (or Deputy Prime Minister for the relevant area). The objective of the committee's work is to reduce costs by involving national resources, to provide timely supplies of local materials and to deal effectively with management tasks.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
Nuclear Power Department (NPD) set up to:
- Perform Customer functions, including presentation of these functions on construction site;
- Planning and setting up (expansion) of operating organization for subsequent operation of new power unit following completion of construction.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.2. A.2.2 Sub-process

A.2.2 Sub-process — establishment of investment source for construction of new power unit.

(1) Objectives:
Financial support for new construction and setting method and terms of investment repayment.

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
Official decision of Government (President) of Armenia on construction (Cabinet of Ministers Resolution, State Council decision, other).

(4) Customer actions:
The MoENR makes a rough evaluation of the construction work on the new power unit (various types of nuclear steam-generating installation (NSGI) and construction options), and in conjunction with the Ministry of Finance of Armenia carries out a monitoring exercise on the investment options taking into account Armenia law and return on investment, and puts forward to the Government of Armenia options for the taking of a final decision.

(5) General Contractor actions:
General Contractor (may offer credit in event of direct talks with potential supplier or suggest other investment terms).

(6) Indicators of success:
Assessment of construction of new power unit (various types of NSGI and construction options) carried out and monitoring of investment options taking into account Armenian law and return on investment. Options for taking of final decision submitted to Government of Armenia.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.3. A.2.3 Sub-process

A.2.3 Sub-process — calculation of provisional costs of preparation period, establishment of special budget and financing mechanism for preparation work.

(1) Objectives:
Financial support for preliminary preparation work, including financing of structures set up by Customer, up to commencement of main building work and establishment of main budget for power unit construction work from detailed design results.

(2) Scope:
Included in indicators of Customer readiness

(3) Indicators of Customer readiness:
— Creation of special sub-section (department) at MoENR with powers conferred on it by the Government of Armenia to carry out the functions of the Customer for construction of new power unit;
— Functioning of economic planning and production and technical group.

(4) Customer actions:
The financial and economic group at the NPD makes a provisional evaluation of the costs of preparatory work and, in conjunction with the Ministry of Finance, sets up a special budget and a mechanism for it to be defrayed on preparatory work.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
Preliminary evaluation of costs of preparation work carried out. Special budget established and mechanism for its disbursement on preparation work.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.4. A.2.4 Sub-process

A.2.4 Sub-process — setting up of a multi-authority committee with the participation of:
— Ministry of Energy and Natural Resources;
— Ministry of Urban Planning;
— Ministry of Economics;

— Ministry of Transport and Communications;
— Ministry of Foreign Affairs;
— Ministry of Finance;
— Ministry of Internal Affairs (Ministry of Defense);
— Ministry for Environmental Protection;
— Ministry of Education;
— Academy of Sciences of Armenia;
— ANRA and other interested authorities.

(1) Objectives:
   — Coordination of actions of ministries and authorities to address tasks linked to building of new power unit;
   — Maximum involvement of human and material resources of Armenia in building of new power unit to reduce cost of construction and stimulate the activity of organizations and businesses within Armenia.

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
Official decision of Government (President) of Armenia on construction (Cabinet of Ministers Resolution, State Council decision, other).

(4) Customer actions:
The top person at the MoENR launches an initiative with the Council of Ministers of Armenia to set up a multi-authority committee for construction of the new power unit in order to coordinate the efforts of all interested ministries and authorities in building the new power unit. The committee functions on a regular basis under the chairmanship of the President and Prime Minister (or Deputy Prime Minister for the relevant area). The objective of the committee's work is to reduce costs by involving national resources, to provide timely supplies of local materials and to deal effectively with management tasks.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
   — Multi-authority committee set up for construction of new power unit in order to coordinate efforts of all interested ministries and authorities for new power unit construction;
   — Committee meets on a regular basis under the chairmanship of the President or Prime Minister (or Deputy Prime Minister responsible for relevant area).

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.5. A.2.5 Sub-process

A.2.5 Sub-process — gathering information, assessing quality and scope of production and systematization of data on production originating from businesses in Armenia which may be utilized at the various stages of construction (to be transferred to General Contractor at detailed design stage).

(1) Objectives:
Maximum utilization of own resources, reduction in cost of construction and stimulation of local industry.

(2) Scope:
Included in indicators of Customer readiness

(3) Indicators of Customer readiness:
Official decision of Government (President) of Armenia on construction (Cabinet of Ministers Resolution, State Council decision, other).

(4) Customer actions:
The NPD carries out monitoring of industry in Armenia and keeps catalogues of products, showing production volumes and product quality, which may be utilized in the construction of the power unit. The catalogues are then sent to the Supplier for use of these products during power unit construction. Utilization of local resources may be a mandatory condition of contract.

(5) General Contractor actions:
Supplier may ask about potential of industry in Armenia for supplies to meet needs of new power unit construction.

(6) Indicators of success:
Monitoring of Armenia industry carried out and product catalogues produced showing volumes and quality of products that could be used in power unit construction. Catalogues sent to General Contractor for these products to be used during power unit construction.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.6. A.2.6 Sub-process

A.2.6 Sub-process — gathering information, analysis and systematization of data on construction and assembly organizations that may be involved in building facilities while the new power unit is being constructed (to be transferred to General Contractor at detailed design stage).

(1) Objectives:
Involvement of local organizations, reduction of construction cost, stimulation of construction organizations, and acquisition of experience in constructing high-tech production processes.

(2) Scope:
Included in indicators of Customer readiness

(3) Indicators of Customer readiness:
Official decision of Government (President) of Armenia on construction (Cabinet of Ministers Resolution, State Council decision, other).

(4) Customer actions:
The NPD carries out monitoring of construction and assembly organizations in Armenia and produces catalogues showing construction volumes and specializations which may be utilized in power unit construction. The catalogues are then sent to the Supplier for use of these organizations during power unit construction. Utilization of local organizations may be a mandatory condition of contract.

(5) General Contractor actions:
Supplier may ask about potential of construction and installation businesses in Armenia for involvement in new power unit construction.

(6) Indicators of success:
- Monitoring of Armenia construction and installation organizations carried out and catalogues produced showing construction volumes and specializations that could be used in power unit construction;
- Catalogues sent to General Contractor for these organizations to be used during power unit construction (this may be a mandatory condition of contract).

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.7. A.2.7 Sub-process

A.2.7 Sub-process — gathering of information on human resources that will be needed during construction — all types of work, including ancillary work.

(1) Objectives:
Provision of employment to the people of Armenia.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Official decision of Government (President) of Armenia on construction (Cabinet of Ministers Resolution, State Council decision, other).
(4) Customer actions:
The NPD carries out monitoring of human resources in Armenia and the skill base that may be of use in constructing the power unit. Data are then sent to the Supplier in order for these resources to be used during construction of the power unit. Utilization of local human resources may be a mandatory condition of contract.
(5) General Contractor actions:
Supplier may ask for human resources data in Armenia for hiring during new power unit construction.
(6) Indicators of success:
— Monitoring of Armenian human resources that could be used in power unit construction and their specialist areas;
— Data sent to General Contractor for these resources to be used during power unit construction (this may be a mandatory condition of contract).
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.8. A.2.8 Sub-process

A.2.8 Sub-process — organization of preparation of initial data on site selection (organization of research and surveying work if required) for organization of tender procedures and tie-in of selected installation at the detailed design stage, including data on seismic risk, presence of water reserves for residual heat removal, method of residual heat removal, overhead power lines and their features, purification plants, etc.

(1) Objectives:
Gathering of evidence of suitability of site for nuclear installation construction, transfer of data to potential suppliers and then to winner of tender process for evaluation and tie-in of NSGI to existing conditions and evaluation of cost of construction.
(2) Scope:
Included in indicators of Customer readiness
(3) Indicators of Customer readiness:
Official decision of Government (President) of Armenia on construction (Cabinet of Ministers Resolution, State Council decision, other).
(4) Customer actions:
— The NPD, with the help of specialist organizations, carries out research and prepares initial data on the construction site, including the seismic risk, the existence of water reserves, approach details, etc.;

— Data on the site are sent to the Regulatory Agency for approval and then to the Supplier for tie-in with the NSGI.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
— Study carried out and initial data prepared for construction site, including seismic risk, existence of water reserves, approach details, etc;
— Site data sent to Regulatory Agency for approval and then to General Contractor for NSGI tie-in.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.9. A.2.9 Sub-process

A.2.9 Sub-process — making of the case for the type of nuclear installation and its main parameters (power, flexibility, fuel type, baseline technical and economic indicators, etc.)

(1) Objectives:
Selection of design of NSGI based on comparative analysis taking into account all individual features and existing conditions (presence of functioning power unit with WWER reactor, existence of stocks of uranium, Armenian low-capacity power system, etc.).

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
Budget for preparation work made available. Group of MoENR technical experts from special sub-section (nuclear power department, hereinafter referred to as NPD) has commenced work.

(4) Customer actions:
The NPD, with the help of specialist organizations, carries out an evaluation and makes a case for the type of nuclear installation and its main parameters (power, flexibility, fuel type) on the basis of existing local conditions.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
Assessment carried out and case made for type of nuclear installation and its main parameters (power, flexibility, fuel type) based on existing local conditions.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.10. A.2.10 Sub-process

A.2.10 Sub-process — drafting of requirements for nuclear installation for organization of open tender process (competition and selection with limited number of participants).

(1) Objectives:
Organization of tender process, receipt of submissions aimed at meeting the demand in Armenia, taking into account all individual country features.

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
— ANRA has established a set of requirements for the NSGI through harmonization and review of the norms, rules and standards in force in Armenia.

— Working group set up from specialists at the NPD.
— Engineering or design organization selected for drafting of (consultation on) tender documentation packages.

(4) Customer actions:
The MoENR (with the help of specialist organizations) draws up tender documentation and sends it to the Regulatory Agency for approval prior to announcement of the tender process (competition).

(5) General Contractor actions:
No participation.

(6) Indicators of success:
— Tender documentation drawn up;
— Tender documentation sent to Regulatory Agency for approval prior to announcement of tender process (competition).

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.11. A.2.11 Sub-process

A.2.11 Sub-process — organization and running of independent expert appraisal entitled 'Installation requirements' to establish compliance with generally accepted (in place or anticipated) international standards.

(1) Objectives:
Orientation towards acquisition of most up-to-date technology with maximum achievable level of safety meeting generally accepted international standards.

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
— Package of documents with NSGI requirements falling within the competence of Armenian regulatory agencies put together;
— Council of Armenian regulatory agencies set up for prompt and coordinated provision of expert appraisals on new power unit (see stage A.2.16).

(4) Customer actions:
The MoENR organizes the running of an expert appraisal (not to be confused with the check for compliance with norms and rules) of the NSGI requirements in order to check that they comply with international (in place or anticipated) safety standards.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
Independent expert appraisal of NSGI requirements carried out to check for compliance with international safety standards (in place and anticipated).

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.12. A.2.12 Sub-process

A.2.12 Sub-process —organization of tender process (competition) for selection of supplier of NPP or equipment for nuclear power unit'

(1) Objectives:
Receipt of most advantageous submission based on competition principle.

(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Package of tender documents for specific competition drafted and approved by all Armenian regulatory agencies.
(4) Customer actions:
The MoENR organizes and runs the tender procedures pursuant to Armenian law, on a competitive principle, or holds pre-contractual consultations and discussions in the event of a direct order.
(5) General Contractor actions:
No participation.
(6) Indicators of success:
Tender procedures organized and carried out in line with Armenian law based on competitive principles, or pre-contract consultations and talks held in the case of a direct order.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.13. A.2.13 Sub-process

A.2.13 Sub-process — creation of a working agency (customer representative) on site to manage the construction of the power unit and interact with the General Contractor (see Refs [1, 6]).

(1) Objectives:
— Implementation of Customer functions (rights and duties);
— Guaranteeing quality of power unit construction at all stages of construction process;
— Rational funds disbursement.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Budget for preparation work made available.
(4) Customer actions:
The MoENR sets up a Customer Office (CO) on site in the form of a capital construction administration or power unit construction directorate, with a certain structure based on the Customer's tasks at all stages of construction work and the Supplier's requests.
(5) General Contractor actions:
Supplier may suggest (request) that Customer performs a number of functions on site such as provision of security for facilities, transport, organization of on-site Customs post, etc.
(6) Indicators of success:
Customer Office set up on site in the form of a capital construction administration or power unit construction directorate, with a certain structure based on the Customer's tasks at all stages of construction work and the General Contractor's request.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.14. A.2.14 Sub-process

A.2.14 Sub-process — creation of resource to manage quality at stages of supplier selection, design, construction and commissioning of new power unit.

(1) Objectives:
Implementation of planned measures to confirm that all actions in the construction of the power unit are being carried out in line with the rules, norms and standards, that construction work is being performed in a safe manner and that no harm is being done to the environment.

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
Creation of special sub-section (department) at MoENR with powers conferred on it by the Government of Armenia to carry out the functions of the Customer for construction of new power unit.

(4) Customer actions:
Within its structure the CO has a sub-section for quality management, which, in conjunction with the relevant services of the Supplier, plans and takes measures aimed at confirming that all actions to construct the power unit are carried out in compliance with the rules, norms and standards, work is done in a manner that is safe for people and no harm is done to the environment.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
Within its structure the CO has a sub-section for quality management, which takes steps aimed at confirming that all actions to construct the power unit are carried out in compliance with the rules, norms and standards, and that work is done in a manner that is safe for people and protects the environment.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.15. A.2.15 Sub-process

A.2.15 Sub-process — expert appraisal of (report on) site selection data.

(1) Objectives:
Check on observance of existing rules, norms and standards in the sphere of nuclear power.

(2) Scope:
Included in indicators of Customer readiness.

(3) Indicators of Customer readiness:
Release of report on site selection.

(4) Customer actions:
ANRA carries out an expert appraisal of the site selection report for compliance with the rules, norms and standards in conjunction with other state regulatory agencies.

(5) General Contractor actions:
No participation.

(6) Indicators of success:
Expert appraisal of the site selection report for compliance with the rules, norms and standards is carried out.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.16. A.2.16 Sub-process

A.2.16 Sub-process — organization of council (working agency) of all regulatory agencies in Armenia (for the environment, construction, health, fire fighting, physical security, etc.) in order to coordinate work linked to the expert appraisal of documents and issue of approvals (licences) for relevant types of work.

(1) Objectives:
Coordination of work on expert appraisal of documents, oversight at all stages of construction, including design work, and also the issue of relevant approvals.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Budget for preparation work made available.
(4) Customer actions:
ANRA launches an initiative for the setting up of a working council of regulatory agencies in Armenia in order to coordinate efforts for construction of the new power unit. The council meets on a regular basis under the chairmanship of senior management at ANRA. The objective of the council's work is to provide timely expert appraisals of documents and effective resolution of tasks that arise.
(5) General Contractor actions:
No participation.
(6) Indicators of success:
Working council of Armenian regulatory agencies set up to coordinate efforts for new power unit construction.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.17. A.2.17 Sub-process

A.2.17 Sub-process — expert appraisal of Feasibility Study for various power unit options.

(1) Objectives:
Observance of rules, norms and standards in the sphere of nuclear power, and also consideration of adopted international requirements in selection of type of NSGI.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Feasibility Study or case for investment in construction of new power unit released.
(4) Customer actions:
ANRA considers the various Feasibility Study options for compliance with the rules, norms and standards.
(5) General Contractor actions:
No participation.
(6) Indicators of success:
Examination of various Feasibility Study options performed to check for compliance with the rules and norms and standards.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.18. A.2.18 Sub-process

A.2.18 Sub-process — approval of tender documentation for compliance with rules, norms and standards applicable in Armenia and accepted international requirements.

(1) Objectives:
Observance of rules, norms and standards in the sphere of nuclear power and also consideration of accepted international requirements when calling for tender submissions.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Tender documentation (or individual packages of it) drafted.
(4) Customer actions:
ANRA considers the tender documentation for compliance with the rules, norms and standards.
(5) General Contractor actions:
No participation.
(6) Indicators of success:
Tender documentation considered to check for compliance with the rules and norms and standards.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.19. A.2.19 Sub-process

A.2.19 Sub-process — participation in assessment of submissions from potential General Contractors.

(1) Objectives:
Observance of rules, norms and standards in the sphere of nuclear power and also consideration of accepted international requirements in the assessment of tender submissions.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Packages of proposals received from potential suppliers (one supplier), deadline for submission of proposals has passed.
(4) Customer actions:
ANRA participates in an evaluation committee and considers the documentation submitted by tender process participants for compliance with the rules, norms and standards.
(5) General Contractor actions:
No participation.
(6) Indicators of success:
Documentation of tender process participants examined to check for compliance with the rules and norms and standards.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.20. A.2.20 Sub-process

A.2.20 Sub-process — approval of designs at detailed design stage.

(1) Objectives:
Observance of rules, norms and standards in the sphere of nuclear power and also consideration of accepted international requirements in design.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Parts of project requiring approval have been carried out.
(4) Customer actions:
ANRA approves design decisions at the detailed design stage for compliance with the rules, norms and standards.
(5) General Contractor actions:
Close cooperation with Supplier. Customer firms up on initial data and approves design decisions. Supplier ties NSGI design in to site conditions.
(6) Indicators of success:
Design decisions approved at detailed design stage to check for compliance with the rules and norms and standards.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.21. A.2.21 Sub-process

A.2.21 Sub-process — issue of individual approvals for design, construction, equipment manufacture, etc.

(1) Objectives:
Observance of rules, norms and standards in the sphere of nuclear power in design, construction, equipment manufacture, etc.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Readiness to carry out work requiring special permits (licenses).
(4) Customer actions:
ANRA issues individual permits and licences for design and construction work, equipment manufacture, etc.
(5) General Contractor actions:
No participation.
(6) Indicators of success:
Individual permits and licences issued for design, construction, equipment manufacture, etc.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.22. A.2.22 Sub-process

A.2.22 Sub-process — planning and cost consideration for power unit construction.

(1) Objectives:
Rational utilization of funds. Observance of legislation on investment fund outlay.

(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
At all stages of construction work.
(4) Customer actions:
The CO appointed by a state administrative agency sees to the planning of costs both for facilities erected outside the main contract (Armenian responsibility) and for facilities under the main contract (Supplier's responsibility), and accounts for them. In conjunction with the MoENR, the CO takes responsibility for rational utilization of investments in construction in accordance with Armenian law.
(5) General Contractor actions:
Close cooperation with Supplier on management of and accounting for expenditure.
(6) Indicators of success:
Payments made according to construction progress. No major accounting/audit findings.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.23. A.2.23 Sub-process

A.2.23 Sub-process — organization and performance of preparation work for housing of General Contractor's staff and creation of infrastructure for operating staff at new power unit, including:

— Building of residential accommodation in Metsamor;
— Building of facilities with social significance (canteens, domestic service facilities, heat and water supplies, electricity supplies, purification plants, etc.);
— Transport communications.

(1) Objectives:
— Creation of the necessary conditions for the General Contractor to work;
— Involvement of local resources in construction (employment);
— Reduction in cost of main Contract.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Budget for preparation work made available.
(4) Customer actions:
The CO organizes and carries out preparatory work to provide accommodation for building and assembly workers. Erects facilities for social and domestic use, infrastructure facilities and housing for operating staff.
(5) General Contractor actions:
Cooperation with Supplier to meet Supplier's conditions for accommodation and servicing of Supplier's staff.
(6) Indicators of success:
Support organization and general infrastructure in place to support General Contractor and workforce (housing, utilities, transportation, etc.).
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.24. A.2.24 Sub-process

A.2.24 Sub-process — organization and performance of preparation work on site:

— Preparation of storage facilities;
— preparation of premises for preparatory production processes (section for production of precast reinforced concrete, section for pipe amalgamation, section for manufacture of ventilation ducts, chemical protection section, insulation section, etc.);
— Erection of temporary accommodation for building and installation workers;
— Preparation of approach roads and lifting facilities for loading and unloading work;
— Organization of Customs post for clearance of imported equipment and materials;
— Delivery to site of drinking and process water and electricity.

(1) Objectives:
   — Creation of necessary conditions for commencement of work by General Contractor's personnel and technical (construction) gear on site;
   — Involvement of local resources in construction (employment);
   — Reduction in cost of main Contract.
(2) Scope:
   Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
   Budget for preparation work made available.
(4) Customer actions:
   The CO organizes and carries out preparatory work on the site to put up stores, layout details, supply heat and water, set up preparatory production processes and construct premises for workers and tools. The Supplier may request (under the terms of the contract) the setting up of a Customs warehouse and Customs post and other facilities required for contract implementation.
(5) General Contractor actions:
   Close cooperation with Supplier to create construction site infrastructure.
(6) Indicators of success:
   Construction site facilities in place and operational to support work activities, warehousing, and warehousing equipment, access details, utilities, access control, inspection and Customs posts operational.
(7) Human resource assessment:
   An assessment of HR needs is shown in Appendix IV.

5.1.2.25. A.2.25 Sub-process

A.2.25 Sub-process — organization and performance of preparation work for provision of essential materials (sand, gravel, cement, building bars, etc.) machinery and mechanisms, transport.

(1) Objectives:
   — Creation of necessary conditions for commencement of work by General Contractor's personnel and technical (construction) gear;
   — Involvement of local resources in construction (employment);
   — Reduction in cost of main Contract.
(2) Scope:
   Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
   Budget for preparation work made available.

(4) Customer actions:
The CO carries out investigations to provide the Supplier with the main construction materials: sand, gravel, cement and building bars, and also provides construction machinery and mechanisms.
(5) General Contractor actions:
Cooperation with Supplier to meet Supplier's conditions for construction material supplies.

(6) Indicators of success:
Construction equipment and materials available to General Contractor. No delays experienced resulting from shortages.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.26. A.2.26 Sub-process

A.2.26 Sub-process — design management.

(1) Objectives:
— Carrying out duties of Customer;
— Monitoring observance of rules, norms and standards;
— Quality assurance in design work.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
For preparation work — budget made available. For main work — contract concluded for construction of new power unit.
(4) Customer actions:
The CO manages the design process in order to monitor observance of the requirements of the technical assignment, approves amendments and sees to observance of the rules, norms and standards.
(5) General Contractor actions:
Close cooperation with Supplier on project management.
(6) Indicators of success:
No delays experienced based on Customer actions in support of design process.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.27. A.2.27 Sub-process

A.2.27 Sub-process — control of drafting and oversight of agreements.

(1) Objectives:
Carrying out duties of Customer.
(2) Scope:
Included in indicators of Customer readiness
(3) Indicators of Customer readiness:
For preparation work — budget made available. For main work — contract concluded for construction of new power unit.
(4) Customer actions:
The CO manages activities relating to agreements, sees that terms are adhered to, approves amendments and keeps track of expenditure on them.

(5) General Contractor actions:
Close cooperation with Supplier on management of agreements.
(6) Indicators of success:
Agreements in place between Customer and various support organizations, vendors and contractors to support new build activities.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.28. A.2.28 Sub-process

A.2.28 Sub-process — control of supplies.

(1) Objectives:
— Carrying out duties of Customer;
— Monitoring observance of rules, norms and standards;
— Quality assurance in supplies.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Contract concluded for construction of new power unit.
(4) Customer actions:
The CO manages supplies, in conjunction with the Supplier, in order to monitor the supply schedule, transportation and their preparation (incoming control) for installation or utilization in construction.
(5) General Contractor actions:
Close cooperation with Supplier on supplies management.
(6) Indicators of success:
Effective processes established and functioning to receive, inspect, store, etc. materials and supplies for utilizations during construction.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.29. A.2.29 Sub-process

A.2.29 Sub-process — control of equipment manufacture.

(1) Objectives:
— Carrying out duties of Customer;
— Monitoring observance of rules, norms and standards;
— Quality assurance in manufacture.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
Contract concluded for construction of new power unit.
(4) Customer actions:
The CO monitors the process of equipment manufacture and supply, in conjunction with the Supplier, in order to monitor manufacturing quality and ensure compliance with the norms and rules, and to monitor training.
(5) General Contractor actions:
Close cooperation with Supplier on monitoring of equipment manufacture.

(6) Indicators of success:
Capabilities in place to conduct on site inspections and monitoring of manufacturing process ensuring observance of quality standards and norms.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.30. A.2.30 Sub-process

A.2.30 Sub-process — managing the construction, assembly and fine-tuning of facilities that fall within Armenian area of responsibility in the preparation stage.

(1) Objectives:
— Carrying out duties of Customer;
— Involvement of local resources in construction (employment);
— Reduction in cost of main Contract;
— Quality assurance in construction work.
(2) Scope:
Included in indicators of Customer readiness
(3) Indicators of Customer readiness:
Budget for preparation work made available.
(4) Customer actions:
The CO manages the entire package of work that falls within the scope of responsibility under the terms and requirements of the main contract. These facilities are constructed at the same time as the power unit and should not get in the way of the staged commissioning of equipment and facilities under the main contract.
(5) General Contractor actions:
Close cooperation with Supplier on performance of work lying within the sphere of responsibility (in line with agreement on division of responsibility).
(6) Indicators of success:
Resources allocated and processes established and functioning to ensure cost and quality controls are effective. Functioning of Armenia as an Intelligent Customer.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.31. A.2.31 Sub-process

A.2.31 Sub-process — management of finance, expenditure and accounts.

(1) Objectives:
— Rational utilization of funds;
— Observance of law on expenditure of and accounting for investment funds.
(2) Scope:
Included in indicators of Customer readiness
(3) Indicators of Customer readiness:
At all stages of construction work.
(4) Customer actions:
The CO manages finance, expenditure and accounts by a stage-by-stage evaluation of costs, in conjunction with the Supplier, and keeps track of them through cumulative accounts for the various activities in line with accountancy requirements.
(5) General Contractor actions:
No participation.

(6) Indicators of success:
— Project on budget;
— Standard accounting practices in place and utilized;
— No major audit findings.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.32. A.2.32 Sub-process

A.2.32 Sub-process — coordination of General Contractor's work and work of other organizations.

(1) Objectives:
Carrying out duties of Customer.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
At all stages of construction work.
(4) Customer actions:
The CO organizes and runs the required meetings involving various participants in the construction work in order to coordinate work and solve problems that arise, and also to keep track of progress with construction work.
(5) General Contractor actions:
Close cooperation with Supplier on coordination of work of all participants in new power unit construction.
(6) Indicators of success:
— Construction on schedule;
— General Contractor, vendors, suppliers, etc. working effectively;
— Armenia functioning effectively as Intelligent Customer.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.33. A.2.33 Sub-process

A.2.33 Sub-process — acceptance of concealed and completed work.

(1) Objectives:
— Carrying out duties of Customer;
— Quality assurance in construction work.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
At all stages of construction work.
(4) Customer actions:
The CO carries out acceptance of concealed work and completed work, receives documentation on such work and makes payments for it.
(5) General Contractor actions:
Close cooperation with Supplier on acceptance of completed work.
(6) Indicators of success:
Approval process in place with documentation of quality inspections and acceptance maintained.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.1.2.34. A.2.34 Sub-process

A.2.34 Sub-process — geodesic work and running of General layout.

(1) Objectives:
Carrying out duties of Customer.
(2) Scope:
Included in indicators of Customer readiness.
(3) Indicators of Customer readiness:
At all stages of construction work.

(4) Customer actions:
The CO carries out all geodesic work under the general layout, takes surveys before concealed work is carried out, accepts completed work (as regards surveying), and keeps records of such work.
(5) General Contractor actions:
Close cooperation with Supplier on geodesic work.
(6) Indicators of success:
— Inspection processes established for concealed work acceptance;
— Documentation maintained and retrievable.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2 CUSTOMER ACTIONS FOR STAGES A.3 AND A.4

For stage A.3 actions are normally carried out by a customer designated on-site management organization, the MoENR and ANRA. For stage A.4 Customer actions are governed by the need to begin the progressive handover of buildings, installed equipment, structures, and documentation as well as completing all steps in preparation for start-up.

Details (objectives, scope, indicators of readiness, etc.) for each of the Customer stages A.3 and A.4 are shown below (see Sections 5.2.1 and 5.2.2). Again, the Customer's main task is to ensure synchronization of its work with that of the General Contractor.

5.2.1. Sub-process details for the Customer in stage A.3 Human resource mobilization

5.2.1.1. A.3.1 Sub-process

A.3.1 Sub-process — setting up production-shop-based or non-production-shop-based structure at the New Power Unit Directorate.

(1) Objectives:
— Establish future power unit management structure;
— Set up staff schedule and plan for NPP personnel mobilization.
(2) Scope:
— Establishment of principles for management of new power unit;
— Drafting and approval of structure (production-shop-based or non-production-shop-based);
— Drafting of regulations for sub-departments and instructions for officials at new power unit.

(3) Indicators of Customer readiness:
Decisions taken on selection of power unit management structure.

(4) Customer actions:
At this stage an approach is developed to how operation is to be conducted (production-shop-based or not); the management structure is established, which should envisage independence of operating personnel seeing to the safe running of production processes from administrative personnel who do not bear direct responsibility for safety of operation of the power unit; the management structure takes into account the level of automation of production processes, management and monitoring of quality, and planning and performance of maintenance, including the involvement of specialist businesses on a service basis. The structure envisages administrative/technical, operations, operations and maintenance, operations and fine-tuning and other personnel (ancillary sub-section personnel) of the following categories: managers, specialists, clerks, workers. The calculation of operations staff numbers should take into account:
— three shift work pattern;
— sliding work rotation, rest days, leave and sick leave;
— maintenance of skill levels at training centre.

(5) General Contractor actions:
Active involvement in development of new power unit management structure, close liaison with operating organization and Ministry of Energy and Natural Resources of Armenia.

(6) Indicators of success:
— Ratified management structure for new power unit;
— Ratified personnel chart for new power unit;
— Requirements applying to officials and occupations. Ratified job instructions for personnel at new power unit;
— 'Road map' for staff make-up year by year.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.1.2. A.3.2 Sub-process

A.3.2 Sub-process — development (creation) of new power unit operating organization.

(1) Objectives:
— Preparation for performance of functions of operating organization directorate;
— Ensuring a manageable transition of management from the new power unit directorate to the operating organization directorate.

(2) Scope:
— Establishment/distribution of functions between existing operating organization and new power unit construction directorate (formation of unified operating organization);
— Establishment of functions and tasks of sub-divisions of newly-created operating organization;
— Drafting of regulations for sub-departments and instructions for officials at newly-created operating organization.

(3) Indicators of Customer readiness:
Decisions taken on development of existing (creation of new) operating organization.

(4) Customer actions:
This stage is put into effect jointly with A.3.1.
At this stage new (altered) functions of the operating organization are established, and the way it is set up (developed). New (altered) functions are established for its sub-

sections, and interactions with the objects of management — power units and ancillary sub-sections. The management structure and agencies of the operating organization are established, along with vertical subordination of powers and liaison with the Ministry of Energy and Natural Resources of Armenia.

(5) General Contractor actions:
Active involvement in development of operating organization management structure within the scope of his powers, close liaison with new power unit directorate and Ministry of Energy and Natural Resources of Armenia.

(6) Indicators of success:
- Ratified management structure for operating organization;
- Ratified personnel chart for new (altered) operating organization;
- Requirements applying to officials and occupations;
- Ratified regulations concerning operating organization sub-sections;
- Ratified regulations concerning sub-sections of and administrative instructions for new power unit (relating to new (altered) functions of operating organization);
- Ratified job instructions for operating organization personnel;
- 'Road map' for staff make-up year by year.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.1.3. A.3.3 Sub-process

A.3.3 Sub-process — implementation and completion of establishment of necessary engineering infrastructure.

(1) Objectives:
Presenting the General Contractor with the necessary infrastructure for commencement of full-scale construction of the new power unit.

(2) Scope:
- Completion of construction (fitting out) of engineered infrastructure facilities on new power unit construction site;
- Acceptance of facilities on site where power unit is being built.

(3) Indicators of Customer readiness:
Start of work on A.2.24, A.2.25.

(4) Customer actions:
This stage sees completion of creation of the required engineered infrastructure that is necessary and adequate for commencement of full-scale construction of the new power unit:
- Construction of start-up complex facilities in line with schedule;
- Acceptance of start-up complex facilities from installation and from fine-tuning;
- Construction of main power unit facilities;
- Completion of construction of power unit facilities and ancillary structures;
- Acceptance of facilities from installation;
- Preparation of power unit equipment and systems for commissioning work.

(5) General Contractor actions:
Close liaison with sub-contractors on engineered infrastructure facilities to support functioning of new power unit.

(6) Indicators of success:
Infrastructure facilities accepted for operation in line with ratified acceptance list and schedules.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.1.4. A.3.4 Sub-process

A.3.4 Sub-process — completion of establishment of necessary infrastructure for future power unit operating staff.

(1) Objectives:
Presenting the General Contractor with the necessary infrastructure for housing future new power unit operating staff in line with A.2.23.

(2) Scope:
— Completion of construction (fitting out) of infrastructure facilities for future operating staff of new power unit;
— Acceptance of social infrastructure facilities on site where power unit is being built.

(3) Indicators of Customer readiness:
Start of work on A.2.23.

(4) Customer actions:
This stage sees completion of creation of the infrastructure for the housing and subsequent dwelling of operations staff operating the new power unit. The entire range of social and domestic conditions is in place:
— Acceptance of residential accommodation, social and domestic facilities and transport is carried out;
— Staff is housed, including accommodation for members of their families.

(5) General Contractor actions:
Close liaison with sub-contractors on social infrastructure facilities to support functioning of new power unit.

(6) Indicators of success:
— Social infrastructure facilities accepted for operation in line with ratified acceptance list and schedules;
— Accommodation of new intake staff at new power unit in housing accepted by State Commission.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.1.5. A.3.5 Sub-process

A.3.5 Sub-process — management of construction, installation and fine-tuning of facilities falling within the responsibility of Armenia at the resource mobilization stage.

(1) Objectives:
— Execution of Customer duties;
— Use of local resources for construction (provision of employment);
— Reduction in cost of main Contract;
— Construction and installation quality assurance.

(2) Scope:
— Completion of start-up construction and installation work to support commencement of commissioning;
— Acceptance of start-up construction and installation work.

(3) Indicators of Customer readiness:
Start of work on A.2.30.

(4) Customer actions:
— Put into effect along with A.3.3, A.3.6;

— During this stage the whole range of work on management of construction, installation and fine-tuning of facilities that fall within the area of responsibility of the General Contractor is carried out;
— Work management is carried out to provide a single start-to-finish schedule of work to construct and commission the new power unit;
— Provision is made for employment of home-grown (Armenia) labour at all stages of power unit construction;
— Quality control of work carried out on site is provided in line with requirements of the Quality Assurance Programme for the construction stage (QAP(Con)) and for the commissioning stage (QAP(Com)).

(5) General Contractor actions:
Close liaison with sub-contractors on facilities forming part of new power unit, liaison with ANRA and other authorities' inspectorates.

(6) Indicators of success:
— Equipment accepted and passed for installation on new power unit site;
— Equipment accepted and passed for commissioning work.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.1.6. A.3.6 Sub-process

A.3.6 Sub-process — supervision of production, purchasing and supply of equipment to new power unit site and acceptance of it.

(1) Objectives:
— Providing quality control for equipment supplied and services rendered, control of start-to-finish schedule for new power unit construction;
— Providing control of suppliers and management of risks to the construction schedule of the new power unit.

(2) Scope:
— Supervision of performance of work at equipment supply businesses;
— Supervision of performance of construction and installation work on site where new power unit is being built;
— Supervision of acceptance of equipment supplied and services rendered on site where new power unit is being built.

(3) Indicators of Customer readiness:
Start of work on A.2.26, A.2.27, A.2.28, A.2.29.

(4) Customer actions:
— Put into effect along with A.3.3, A.3.5;
— During this stage comprehensive quality control work is put into effect on equipment manufactured and supplied, at the equipment suppliers' works, through participation in the multi-authority commission;
— Acceptance and control of equipment supplies to the new power unit construction site is carried out; as well as control of implementation of the start-to-finish schedule for work and services rendered;
— Control of sub-contractor skills is carried out;
— Audits of equipment and service manufacturers and suppliers are planned and carried out in line with the requirements of sections of the Quality Assurance Programmes.

(5) General Contractor actions:
Close liaison with equipment suppliers for new power unit, liaison with ANRA and other authorities' inspectorates.
(6) Indicators of success:
— Equipment manufactured at manufacturer's works, accepted and passed for despatch;
— Results of audits of equipment manufacture quality at manufacturer's works, system suppliers and organizations providing services;
— Current list of ratified suppliers;
— Risk analysis reports on adherence to schedule for power unit construction.
(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.1.7. A.3.7 Sub-process

A.3.7 Sub-process — training of new power unit staff.

(1) Objectives:
— Management of operating staff mobilization;
— Organization of conditions for new power unit staff training;
— Provision of staff training in line with personnel chart and training schedule.
(2) Scope:
— Drafting of concept for new power unit staff training;
— Drafting and ratification of project for training centre in accordance with concept for new personnel staff training;
— Selection of suppliers of educational services and training hardware;
— Conclusion of agreements on staff training in accordance with training schedules;
— Conclusion of agreement on development and supply of full-scale simulator;
— Conclusion of agreements for equipping staff training system/training centre for new power unit;
— Training of staff in line with training schedules.
(3) Indicators of Customer readiness:
Existence of ratified requirements for:
— Staff training system, including use of external educational services suppliers;
— training hardware;
— training centre staff (instructors and service staff;
— training methodology;
— Mental functioning examination;
— Evaluation of effectiveness of staff training system.
(4) Customer actions:
Put into effect throughout stage A.3. During this stage the entire programme of Customer staff training is put into effect, as well as the establishment of a personnel training system, including the commencement of work to develop a full-scale simulator.
(5) General Contractor actions:
— Provision of conditions for development of elements of the staff training system on the new power unit site;
— Provision of funds for work on staff training on the new power unit site;
— Offer of own staff (training centre, NPP) to take part in work to set up the staff training system and obtain technologies and know-how in the sphere of development of training hardware and setting up staff training systems.
(6) Indicators of success:
— Ratified Concept for new power unit staff training system;

— Ratified training centre project;
— List of selected suppliers of educational services;
— Agreements concluded for staff training for new operation;
— Agreement concluded for supply of full-scale simulator;
— Agreements concluded for equipment of staff training system and training centre for new power unit;
— Implementation of training schedules in line with ratified training schedules;
— Drafted and ratified administrative procedures for staff training system;
— Trained instruction personnel to provide skilled involvement in work to set up staff training system for new power unit;
— Set of training centre buildings constructed in line with ratified design; ensuring readiness of start-up buildings complex for launch of staff training system and accommodation of full-scale simulator.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2. Sub-process details for the Customer in stage A.4 'Ensuring Customer readiness to take responsibility for staged commissioning of equipment, building and structures and progressive handover of responsibility to Customer'

5.2.2.1. A.4.1 Sub-process

A.4.1 Sub-process — setting up working commissions for acceptance of equipment, buildings and structures, and also a State Acceptance Commission, and organization of their work.

(1) Objectives:
— Execution of customer duties for acceptance of power unit;
— Check on readiness of buildings, structures and equipment, check on documentation and trial and test results;
— Check on overall compliance of power unit with design specifications.

(2) Scope:
— Appointment of owners of equipment in production shops;
— Creation of working commissions;
— Organization of State Acceptance Commission work.

(3) Indicators of Customer readiness:
Well before voltage is fed to internal needs busbars.

(4) Customer actions:
Customer along with other interested organizations sets up working commissions in a variety of spheres (specialist areas), for example electrical equipment, etc. The commissions look at handover documentation, examine equipment on site, compare the results of trials and tests with design characteristics, receive exhaustive information from custodians and take decisions on system readiness. They pass their decisions on to the State Acceptance Commission. The State Acceptance Commission is set up on the basis of Armenian law and takes the final decision on acceptance of the power unit for staged build-up to full power and acceptance for commercial operation on the basis of decisions of working commissions.

(5) General Contractor actions:
Close liaison with General Contractor to consider documentation and scope and quality of work.

(6) Indicators of success:
— Procedure established by Armenian law for acceptance of power unit put into effect;

— Compliance of power unit specification with design values as a result of attainment of full power in line with programme ensured.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2.2. A.4.2 Sub-process

A.4.2 Sub-process — expert appraisal and ratification of operating instructions and drafting of other documentation for the trials and testing stage.

(1) Objectives:
Execution of duties of operating organization as regards preparation to introduce operating mode at power unit with drafting of full set of documentation including logs of authorizations under orders, logs of technical and administrative dispositions, equipment function reports, fault logs, etc.

(2) Scope:
— Organization of work in production shops to study works equipment operation requirements and expert appraisal of operating instructions drafted by General Contractor, and their ratification;
— Drawing up lists of operating documentation for all power unit workplaces in line with technical operating rules;
— Making sure power unit workplaces are equipped with operating documentation.

(3) Indicators of Customer readiness:
Twelve months prior to commencement of hot and cold running in.

(4) Customer actions:
Prior to commencement of equipment operation, the Customer must study all factory requirements for the equipment, the power unit design, protections and interlocks, as well as all restrictions and safety measures. The operating instructions made available by the General Contractor should be checked by the Customer for compliance with these requirements and restrictions, and should include all safety measures. The Customer must establish a full list of operating documentation for all workplaces in line with the technical operating rules and make these documents into a set.

(5) General Contractor actions:
Liaison between Customer and General Contractor to examine and refine operating instructions.

(6) Indicators of success:
All workplaces at power unit, engineering sub-sections and maintenance services fitted out with documentation, instructions and procedures for safe operation, maintenance and technical servicing of power unit equipment.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2.3. A.4.3 Sub-process

A.4.3 Sub-process — attestation (certification) of staff and authorization to perform independent work.

(1) Objectives:
Check on skills and readiness of staff to carry out duties relating to the operation, maintenance and technical servicing of equipment with authorization to perform independent work.

(2) Scope:
- — Examinations by commissions with a representative of Armenian regulatory agency to check staff knowledge of norms, rules and standards;
- — Holding of targeted instruction (training) sessions on performance of work at stages of equipment commissioning, trials and tests, including special safety measures.

(3) Indicators of Customer readiness:
One month prior to hot-and-cold running-in.

(4) Customer actions:
A minimum of one year prior to commencement of commissioning work, the power unit should be provided with staff, and the process of staff training should be completed one month prior to hot-and-cold running-in. Before the start of hot-and-cold running-in staff should be attested with the involvement of a regulatory agency representative and given authorization to carry out independent work, with the issue of a corresponding certificate.

(5) General Contractor actions:
General Contractor may organize training and apprenticeship of Customer's staff at NPP and at training centres with an equivalent reactor unit.

(6) Indicators of success:
Power unit supplied with adequate number of trained and attested personnel who have duly received authorization to work independently on safe operation, maintenance and technical servicing of power unit equipment.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2.4. A.4.4 Sub-process

A.4.4 Sub-process — registration of equipment and acquisition of relevant licenses, permits, etc. for its commissioning and operation.

(1) Objectives:
Execution of requirements of normative documents for performance of mandatory procedures prior to commencement of operation of equipment and other power unit components at Armenian regulatory agencies.

(2) Scope:
- — Registration of equipment belonging to specific authorities;
- — Acquisition of permits for individual types of work;
- — Acquisition of licenses for activities established in Armenian law.

(3) Indicators of Customer readiness:
As readiness is attained and after handover to customer.

(4) Customer actions:
Registration of equipment and pipes that belong to a particular authority is carried out at the relevant agencies before they are commissioned for operation. Licences and permits for activities specified in law should be obtained, for example use of engineering research and surveying work or fresh nuclear fuel transportation.

(5) General Contractor actions:
None.

(6) Indicators of success:
- — Power unit equipment belonging to specific authorities registered with relevant organizations;

— Licences and permits obtained for all types of activity established by Armenian law.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2.5. A.4.5 Sub-process

A.4.5 Sub-process — expert appraisal and approval of equipment test programmes to confirm design specifications.

(1) Objectives:
Execution of customer duties for approval of scope, methods and criteria of tests, and also safety measures.

(2) Scope:
— Expert appraisal of test programmes with absolute observance of nuclear, radiation and technical safety requirements and approval of them by the customer;
— Approval of test programmes at Armenian regulatory agencies.

(3) Indicators of Customer readiness:
Twelve months prior to commencement of hot-and-cold running-in.

(4) Customer actions:
The Customer must examine and approve test programmes in order to be assured that all safety measures have been observed and that the test methodology enables compliance of the regimens and parameters under study with design values to be evaluated.

(5) General Contractor actions:
Liaison between Customer and General Contractor to examine and refine test programmes with detailed discussion of distribution of areas of responsibility and safety measures.

(6) Indicators of success:
Test programmes approved by Customer and Regulatory Agency, responsibility of all participants in tests established, along with individuals responsible for safety measures during testing.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2.6. A.4.6 Sub-process

A.4.6 Sub-process — organization of restricted access system to power unit process rooms and systems under voltage and with potentially hazardous parameters (temperature, pressure, chemical reagents, etc.).

(1) Objectives:
Execution of customer duties for provision of physical protection of power unit and safety measures for operating equipment.

(2) Scope:
— Introduction of strict entry regimen to power unit area with separation of access zones for different staff categories;
— Restriction of access to operating equipment using special measures (locking of rooms, etc);
— Organization of continuous monitoring of working equipment by shift personnel.

(3) Indicators of Customer readiness:
Before voltage is fed to internal needs busbars.

(4) Customer actions:
After completion of construction and installation work, and before commissioning and input of voltage, the Customer together with the General Contractor should introduce strict restrictions on access to certain zones and rooms for physical protection reasons and to support safety measures. Absolute access restrictions should be put in place in zones where equipment is under voltage or at high temperature or pressure, or where it contains chemical reagents.

(5) General Contractor actions:
Continuing liaison on approval of General Contractor's staff regimen of access to operating equipment.

(6) Indicators of success:
System of restricted access to power unit, including access to rooms with operating equipment, set up to ensure human safety.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2.7. A.4.7 Sub-process

A.4.7 Sub-process — participation in equipment and system tests and comprehensive tests.

(1) Objectives:
- Execution of customer duties for equipment operation during testing, in conjunction with General Contractor;
- Familiarization with operating modes (acquisition of practical experience) for new equipment.

(2) Scope:
- Provision of attested personnel to perform trials and tests on equipment in conjunction with equipment tuning staff and General Contractor's staff;
- Ensuring safe test conditions.

(3) Indicators of Customer readiness:
Start of operations to flush through equipment and pipes.

(4) Customer actions:
The Customer shall take part in all types of trials, tests and experiments in order to acquire reliable information on their results and ensure that safe regimens are maintained with equipment. Staff taking part in tests should be trained, attested and instructed in all features of the tests. Before the tests are carried out, the Customer and the General Contractor establish areas of responsibility, the role played by all test participants and also safety measures and the individuals responsible for seeing that they are in place.

(5) General Contractor actions:
Close liaison to support process regimens during testing.

(6) Indicators of success:
Customer's staff have taken part in tests and seen to it that they were carried out safely, and have obtained practical experience in equipment operation under normal operating regimens, with deviations from normal operation and in emergency regimens.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

5.2.2.8. A.4.8 Sub-process

A.4.8 Sub-process — organization of shift work to service process systems involving Customer's staff, system adjustment organizations and the General Contractor (entry into operating mode).

(1) Objectives:
- — Introduction of operating mode for functioning equipment;
- — Support for equipment servicing in continuous operating regimen (open distribution system, chemical water purification, battery equipment, pump stations, power unit process systems, etc.).

(2) Scope:
- — Servicing equipment with continuous operating regimen to run it in and fine-tune its operation;
- — Acquisition of practical experience in operation of new equipment;
- — Staged acceptance and handover of process systems to customer.

(3) Indicators of Customer readiness:
Start of operations to flush through equipment and pipes.

(4) Customer actions:
Prior to commencement of flushing out and trials of equipment, the Customer should organize shift work by trained staff together with the General Contractor's staff in order to ensure that safe regimens are adhered to and operating equipment monitored, and also to record the results achieved by flushing and trials. The shift staff must operate the equipment in line with the instructions and rules, including technical servicing, fault detection and organization of repair work if necessary.

(5) General Contractor actions:
Liaison with General Contractor's equipment tuning personnel as regards final adjustments to and trialling of process systems.

(6) Indicators of success:
Customer staff shift work organized with a view to ensuring continuous operation of equipment as envisaged in the installation design.

(7) Human resource assessment:
An assessment of HR needs is shown in Appendix IV.

6. ASSESSMENT OF VARIOUS PROJECTS PUT FORWARD FOR IMPLEMENTATION IN ARMENIA

This section presents an evaluation of human resource needs for two different project options; construction of the Russian Federation WWER-1000 or the Westinghouse AP-1000. The purpose of this section is to provide realistic examples to Armenia of human resource requirements for potential options. The WWER-1000 represents a design technology that has been constructed and is operating while the AP-1000 is a new advanced design currently only in the construction stage.

6.1. APPROACH TO HUMAN RESOURCE MOBILIZATION TAKING AS AN EXAMPLE WWER-1000 PROJECT IMPLEMENTATION IN THE RUSSIAN FEDERATION

Based on the requirements of Russian normative documents for a standard 2-units NPP project with WWER-1000 reactors, the following general approach is adopted:

— For timely commissioning of a new-build NPP facility, staff must be recruited and trained in advance of the established commissioning date of the facility;
— The projected number of employees for a new-build NPP facility is established on the basis of employee number norms laid down in the Enhanced Standards for Baseline Staff Numbers (industrial and operations staff) at nuclear power plants with WWER type reactors;
— Calculation of the total number of employees at a new-build NPP facility (power unit) is done by the project developer when drawing up his feasibility study or making technical/economic calculations, and is revised in the design documentation;
— The demand for employees, broken down by posts and occupations, for a new-build NPP facility should be established on the basis of the overall projected employee numbers and requirements for production and management work organization;
— A list of posts and occupations for employees of a new-build NPP facility and their skills requirements should be drawn up in line with the requirements shown in skills reference sources;
— Calculation of staff numbers by years to complete construction, installation and fine-tuning work shall be made by the General Contractor on the basis of design data and the features of the particular site, taking into account the proposed construction methods.

6.1.1. Stage of fitting out NPP unit

At this stage, the establishment of a new power unit construction Directorate using the following standard pattern is envisaged — see Fig. 2. The Customer for the state is the Concern Energoatom, and the design organization serves as the General Supplier.

On the Customer side a Customer Representative is established (Customer-Builder) in the person of the Central Capital Construction Administration (CCCA), which is responsible for the recruitment and training of Customer staff brought in to perform construction and assembly work on site. It plays a coordinating role among those involved in the construction work. Within the Capital Construction Administration (CCA), a capital construction section, a staffing section and an intake control group are set up. The post of Deputy Director for Capital Construction may be introduced for the construction period.

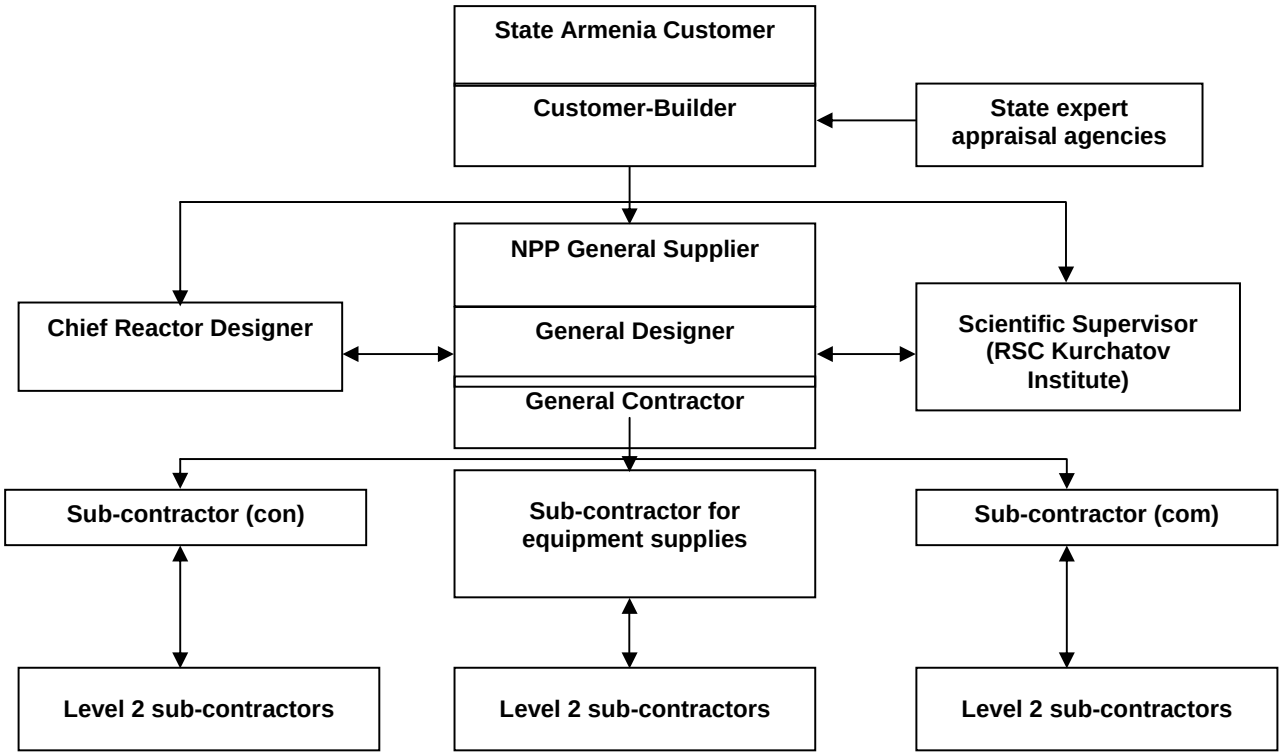

FIG. 2. Standard chart for Construction Directorate for NPP with WWER reactors.

Note: con = construction and installation work;
com = commissioning work.

The main actions at this stage are the following:

(1) The initial stage of work involves mobilization and deployment of resources of General Contractor (see Table 1 below).

(2) For the development and mobilization of staff, workplaces are set up and hotel-type locations for accommodation of significant numbers of personnel.

(3) To ensure that the NPP is supplied in a timely way with skilled personnel, the NPP Construction Directorate should draw up calculations of staff requirements and an enhanced staff recruitment schedule for the NPP[3].

(4) Calculations of staff requirements are drawn up on the basis of the feasibility study and the 'Enterprise Management' section of the NPP construction project, taking into account the requirements of standards for operating NPPs. Also taken into account is the peak employee intake (when major equipment overhauls take place) from specialist businesses and equipment manufacturers.

(5) The main staff recruitment sources for the NPP under construction when calculations are being made of staff needs and recruitment schedules are:
— Free-market hire;

[3] When two power units are being built, organization of flow construction is envisaged (creation of specialized construction and installation flows). This creates an additional requirement for:
— Organization of planning for the future and precise operational management of the construction process;
— The setting up at the construction site of continuously-functioning specialised sub-sections fitted out with the relevant construction and installation equipment and tools;
— Ensuring timely delivery of fabrications and materials in line with the work schedule.

— Planned intake of graduates from secondary and higher occupational education institutions;
— Intake of military personnel released from the armed forces.

(6) When new facilities are being constructed, to save on funds and shorten preparation times, use is also made of a mechanism of rotation, retraining and further training of employees at operating NPP units.

(7) When making calculations of staff needs, the potential for recruiting staff from labour resources in the area where the NPP is sited and constructed is considered.

(8) An enhanced staff recruitment schedule is drawn up by the NPP Construction Directorate taking into account each year for which construction work continues, and based on a calendar schedule for work on NPP construction.

(9) The annual demand for staff is established from the recruitment schedule for the year ahead which is drawn up by the NPP and forms part of the Annual NPP staff work plan schedule.

(10) Staff training for an NPP facility being built should be provided by NPP management from the moment a licence is obtained from Rostekhnadzor (safety inspectorate) giving a right to build the NPP.

TABLE 1. PERSONNEL MOBILIZATION FOR YEARS OF NPP CONSTRUCTION

Work types	Years of construction						
	Preparatory period (persons)		Main period (persons)				
	1	2	3	4	5	6 Reactor unit installation	7
Construction	1430	2150	2650	2900	3900	3700	1500
Electrical	15	15	30	40	80	1200	700
Heat		20	20	50	800	2200	1100
Chemical protection and insulation		10	30	90	250	320	200
Ventilation		10	20	70	150	250	180
Commissioning					120	370	260
Total	1445	2205	2750	3150	5300	7720	3940

6.1.2. Stage of preparation for commissioning

The main types of work and features of this stage are as follows:

(1) The lead time for staff recruitment for an NPP facility under construction is set in accordance with the deadlines for installation of the main heat engineering and electrical equipment and commissioning work on the facility. Specific training periods required for the different job classification to be hired must be considered.

(2) Advance recruitment and subsequent training of operating staff are carried out before commencement of commissioning work.

(3) Work process, job (post) descriptions and health and safety instructions should be drafted no later than 12 months prior to commencement of pre-commissioning work.

(4) Training programmes for jobs (posts) requiring long/maximum training periods should be drawn up no later than six months prior to commencement of pre-commissioning work. Training is carried out at the training centre at operating NPPs. If necessary, apprenticeships and shadowing work for staff at the facility being built are organized at NPPs that are already in operation and similar to the new-build facility.

(5) NPP management must complete recruitment, training and authorization of staff to carry out work in the scope of pre-commissioning programmes. This must occur prior to the performance of such work on equipment being commissioned.

(6) By the start of commissioning, NPP management should have introduced administrative instructions concerning the assessment, monitoring and analysis of staff actions.

(7) By the beginning of physical start-up of the power unit, NPP management should have in place:
- Rostekhnadzor permits conferring a right to carry on work involving the use of nuclear energy for staff taking part in work under the physical start-up programme;
- Protocols recording checks on the knowledge of staff taking part in work under the physical start-up programme;
- An order that has been issued by the NPP Director authorizing staff to carry out independent work in the physical start-up stage.

(8) By the beginning of power generation start-up of the power unit, NPP management should have in place:
- A full set of NPP staff in line with the personnel chart;
- Training for work in post and authorization to work independently for all NPP staff.

(9) During the period of construction of the new NPP power unit, an NPP training post (position) should be introduced (or an existing one enlarged), the capacity of which should allow:
- Development of the required training materials base envisaged in the NPP facility design, including organization of the development, commissioning and authorization of training hardware for NPP staff;
- Training of instructors;
- Drafting of the necessary documents, training programmes and training methodology material to support staff training;
- Organization and management of training and skills support for staff in line with established requirements.

(10) Provision should be made for commissioning of a set of hardware for training, including a full-scale simulator for the training of operating staff, six months prior to physical start-up of the power unit.

(11) Staff taking part in work to build the NPP undergoes testing on knowledge of safety standards and rules in line with the requirements for each specific post.

6.1.3. Stage of operation (taken as for WWER-1000 NPP projects implemented in recent times)

During this stage:

(1) The following principles are envisaged:
- Production-shop-based or non-production-shop-based operating structure;
- Independence of the operations staff in matters related to technical process to ensure safety of operations.

(2) The following categories of staff are envisaged:

— Administrative and technical staff (directors, managers of sub-sections and departments, their deputies, and also engineers and foremen to whom administrative functions are assigned);
— Operating staff;
— Operations and maintenance staff;
— Operations and equipment tuning staff.

(3) Other staff (ancillary sub-division staff). The following production sub-sections and services function as part of the NPP:
— NPP operational management;
— Technical service and maintenance;
— Technical support;
— Administrative and business management;
— Personnel support and staff training;
— The following liaison diagram may be considered (as an option) for turnkey construction of a new power unit in Armenia (see Fig. 3).

(4) In this layout, the state customer is the MoENR, which sets up a special organization to manage investments and construction (new power unit construction management company). This organization will be responsible for the rational expenditure of investor funds, setting up a Customer Office on site and running this office, and also for effective liaison with the general supplier. The new power unit construction management company for Armenia will be selected on the basis of the results of an international tender process.

(5) One very important task of the management company, in conjunction with the MoENR, is to recruit and train staff for all phases of construction work and up to the start of operation of the new power unit. Once the unit is commissioned, the management company may take upon itself the functions of operating organization.

(6) The functions of the Customer at all stages of construction (A.1–A.4), and also a description of the necessary human resources, are given in the Sections 5.1.1, 5.1.2, 5.2.1 and 5.2.2, and Appendix IV.

The number of staff requiring training prior to start-up is shown in Appendix V.

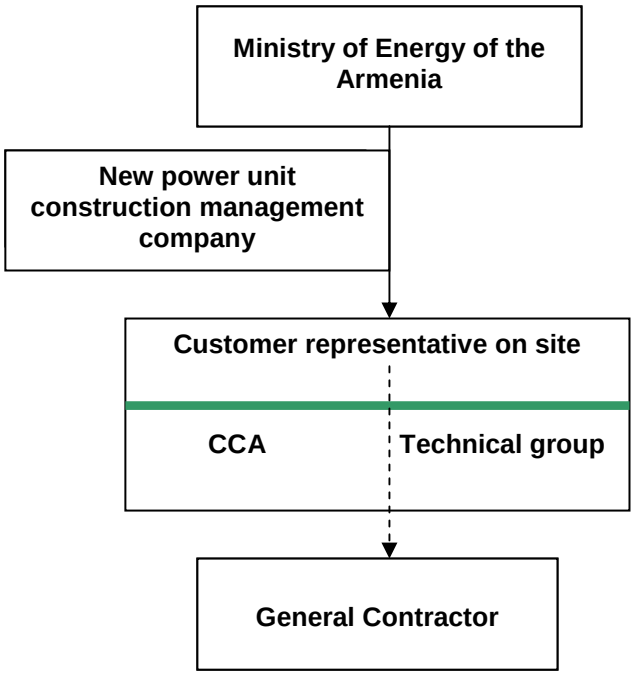

FIG. 3. Option for organization of liaison during new power unit construction in Armenia.

6.2. APPROACH TO HUMAN RESOURCE MOBILIZATION FOR CONSTRUCTION AND OPERATION OF ADVANCED-DESIGN WESTINGHOUSE AP-1000 REACTOR

Because the AP-1000 is a new advanced design reactor which is currently not operational and is only in the early stages of construction (Sanmen site in China), staffing data is limited to projections based on the reactor design, improved construction technologies and past experience with existing NPPs.

As part of Armenian approach to human resource development for construction and operation of a new NPP, consideration must be given to the current numbers of qualified nuclear workers *available* and the numbers of staff *needed* to construct and operate the new power unit and also the consequences for the labour market as a whole.

6.2.1. Considerations for human resource mobilization

Approaches to human resource mobilization and evaluation of staff numbers set out in this section take the following into account:

— The availability of skilled employees;
— Reviews of technical reports and other relevant documents regarding staffing demands; and
— Discussions held with representatives of utilities with an interest in AP-1000 construction.

These matters are examined below:

(1) As a part of this IAEA study the status of the current workforce in Armenia was reviewed by the team. Visits to Yerevan provided the IAEA team a general overview of the current status of the workforce (ANPP, Technical Services Organizations, Construction, Engineering, etc.). Based on this review there appear to be significant challenges in the areas of experienced construction workers, engineers and technicians with nuclear experience. During the last visit in August 2008, a ‘workshop on experience of member states in human resource development in conjunction with construction of a new NPP’ was conducted for key stakeholders. The workshop was designed to provide the participants with information and tools to manage the challenges of human resource development.

(2) Operations and maintenance (O&M) staffing estimates are available in a 2004 Department of Energy Report, ‘Study of Constructions Technologies and Schedules, O&M Staffing and Cost, and Decommissioning Cost and Funding Requirements for Advanced Reactor Designs’ [11]. It should be noted that this study addresses construction of new, advanced designed reactors in the USA. However, most of the data, conclusions, and information provided can be applied to construction of advanced design reactors in other countries. In addition, applicable IAEA documents were reviewed including ‘Considerations to Launch a Nuclear Power Programme’ [12] and ‘Milestones in the Development of a National Infrastructure for Nuclear Power’ (see Ref. [1]). These documents provided valuable information on activities and milestones that Member States should consider when planning and building new nuclear units.

(3) Several US utilities have submitted application to the Nuclear Regulatory Commission (NRC) for a Combined Construction and Operating License (COL). Discussions with representatives of utilities who are pursuing construction of the AP-1000 provided information on staffing data in construction and operations phases. Construction staffing data was at a high level, with utilities currently focused on priority workforce issues (e.g., skilled craft shortages) while O&M staffing data was more readily available.

Issues of organization structure and governance are addressed in the previous section and in applicable IAEA documents and will not be repeated in this section. Additionally, construction activities (e.g., electrical grid upgrades, road construction or improvement, rail line construction, building of housing for workers, etc.) not directly related to the building of the new NPP is not considered.

6.2.2. Approaches to the human resource mobilization for the construction stage

At the start of construction a Member State must ensure that a workforce with the necessary skills and training is in place. This includes the following areas:

— Technical: Engineers, quality inspectors, etc.
— Craft: Electricians, boilermakers, welders, etc.
— Managerial: Project control, planners, schedulers, etc.

For Armenia to build a pipeline of competent workers a national strategy on human resource development is needed that involves all key stakeholders (MoENR, academic institutions, engineering organizations, constructions organizations, regulator, etc.).

The AP-1000 is a two loop, four RCP units with a power rating of 1154 MW. For the 2004 DOE study (see Ref. [11]), Westinghouse provided the following construction schedule:

— 69 months Contract effective date to commercial operations;
— 36 months First concrete to fuel load;
— 6 months Fuel load to commercial operations.

During a meeting with the MoENR representatives, Westinghouse estimated the peak construction workforce at 1500–2000 for one unit. US utility representatives indicated that they estimated peak construction employment at 2600 for two units. While some labour efficiency in two units construction is expected, the higher Westinghouse estimate of 2000 at peak appears to be reasonable for one unit construction. A list by job title of skilled craft typically involved in the construction of a new NPP is shown below:

— Boilermaker;
— Carpenter;
— Combo Welder;
— Electrician;
— Heavy Equipment Operator;
— Insulator;
— Ironworker;
— Millwright;
— Pipe Fitter;
— Tube Welder.

The Westinghouse construction schedule considers parallel construction through modularization and open top (open roof to allow installation of pre-fabricated modular components) construction to achieve the overall schedule. Open top construction, prefabrication, preassembly and modularization should prove beneficial in that major components can be constructed and assembled at off-site locations, with controlled quality, less impact on site activities and lower numbers of skilled construction workers required on-site. Some of these activities may occur outside of Armenia. The extent of modularization for this project is not clear but the potential benefits of fewer on-site work activities are evident. The general contractor and/or architect and engineering firm selected will need to explore the feasibility of off-site construction/assembly and the location and availability of qualified facilities. A typical schedule for US utilities (two units construction) is shown below in Fig. 4.

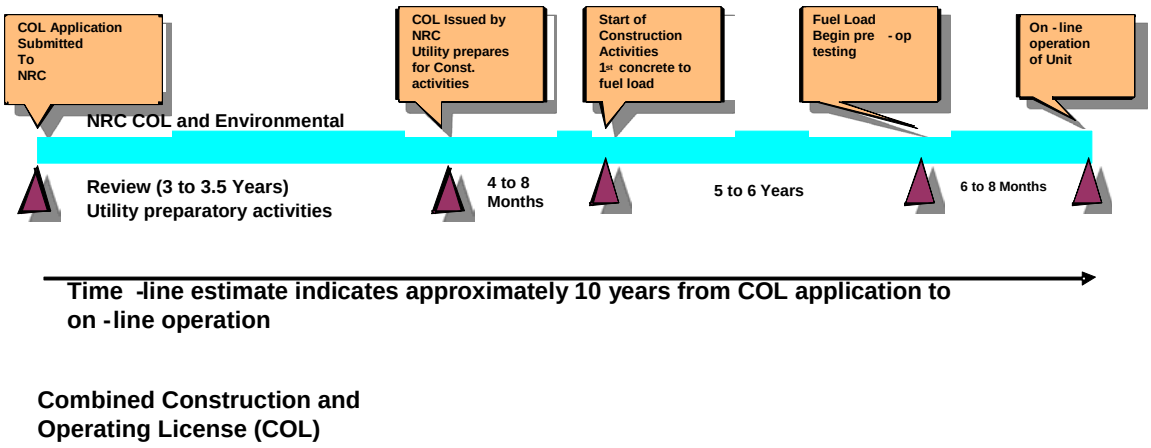

FIG. 4. Typical two units schedule for US utility.

With a planned date of 2017 for start up of the new NPP and the shutdown of the existing unit at the end of 2016, Armenia should begin efforts as soon as possible to develop a strategic national approach to human resource development to support the construction of the new unit. While it is understood that the construction of the new NPP will be a turn-key contract, several factors should be consider:

(1) The current situation finds most organizations in Armenia operating at minimum staffing levels. Construction workers are mostly involved in domestic construction projects (office building, apartments, etc.) and therefore have little or no nuclear experience. Efforts to increase the number of available, qualified construction skilled craft should be initiated as soon as possible.

Engineering organizations (e.g. ARMATOM, ATOM, etc.) must be expanded and training should be emphasized to support the new NPP project before start of construction. Universities will need to increase the number of nuclear specialist that graduate each year to ensure a supply of qualified candidates. Efforts to attract some of the qualified workers who have immigrated to other countries because of a lack of work or low salaries should be initiated. In additions, some skilled foreign workers could be recruited to fill skills gaps during the preparatory period and during construction and start-up. While most of the basic competencies exist in the various organizations, support for a new NPP will require significant expansion of qualified staffing and support infrastructure.

(2) It should be noted that Armenia is not alone in facing the challenges posed by an aging nuclear workforce, shortages of skilled craft workers, and declining enrolments in nuclear science and engineering. Many countries (USA, UK, Germany, China, etc.) that are considering or already operate NPPs are facing similar problems. The IAEA has conducted numerous assist visits, missions and workshops to assist Member States in their efforts to manage nuclear knowledge. The workshop held in Yerevan in August 2009, provided information about Member States experiences and best practices to meet the challenge. The common theme for all is the need to develop an integrated and strategic approach to human resource development.

(3) The benefits of improved construction technology, open top construction and prefabrication, preassembly and modularization are factored into the Westinghouse 36 month constructions schedule. The extent of these benefits on schedule and staffing must be evaluated during the preparatory period. Identifying available qualified facilities should be a priority of the general contractor.
(4) At the time of fuel load and the beginning of pre-operational testing, a trained and qualified operations staff must be in place. This requires training to begin early in the construction phase.
(5) The existing ANPP provides assets that may be used in the construction phase. Both experience workers and facilities such as the existing training centre can be utilized to support construction. Plans for the development of these assets should be included in the overall human resource development strategy.

6.2.3. Approaches to human resource mobilization for the operation stage

Considerations for mobilization of human resource for the operations stage of a new advanced design AP-1000 reactor should include:

(1) Mobilization for the operations of a new NPP must begin well ahead of commissioning and fuel load. The timing of recruiting and training to support pre-operational testing and operations must begin early in the construction phase, typically about three years before scheduled fuel load.
(2) The full scope simulator must be in place for training of operations personnel in time to qualify/license the required number operators. Necessary staffing levels to support the operations of the new NPP (e.g. minimum shift staffing as outlined in 10 CFR 50.54 for US NPPs) must be addressed. It is possible for initial simulator training to be conducted off-site, at other AP-1000 NPPs or vendor facilities.
(3) The existing ANPP constitutes a potential source of staffing for the new advanced designed reactor. Operations, maintenance, and engineering personnel would require significant retraining because of the major differences in design and technology of the advanced design units. However, employees in organizations such as radiation protections, security, and custodial services may be able to transfer with minimum retraining since these functions are somewhat generic to NPP operations. A clear understanding of the workforce demographics can provide data on the impact of future attrition in work groups so that estimates can be made as to what current staff will be available for the operations phase.
(4) Normally after start-up units experience increased workloads to support completion of non-operational construction activities, lower tier procedure development, general trouble shooting, and other issues related to new units. The increased work load can be assigned to staff augmentation workers (normally contractors). This increased staffing level would be expected to be reduced to a core level within 36–48 months.
(5) A significant amount of operation and maintenance (O&M) staffing data is available for existing US NPPs. In addition, staffing projections for advanced design reactors, including the AP-1000 were obtained from the 2004 Dominion DOE study and from utilities pursing construction of the AP-1000. Staffing comparisons for existing operational NPPs and estimates for the AP-1000 are shown below in Table 2.
Operational staffing of existing PWRs and projections from the 2004 Dominion DOE study appear to be consistent with expected staffing levels based on the advanced, simplified design (fewer pumps, valves, piping, electrical cable, etc.) of the AP-1000. However, when developing staffing plans for a new NPP, care should be taken to account for specific site physical characteristics, regulatory requirements, industrial capacity, supply chain efficiency, etc. For example, security staffing for a single unit

plant may be as high as a multiple unit site base on the size and layout of the protected boundary. Also, if the supply chain and industrial base is not capable of supporting non-core work activities, additional staffing may be required.

(6) Since the AP-1000 is not currently operational, human resource mobilization is based to a large extent on estimates of required staff. However, many Member States are at various stages of planning, licensing, or construction of advance designed reactors. Currently, the Sanmen site in China is in the early stage of construction of the AP-1000. A total of four AP-1000 units are currently planned. In addition, several US utilities have applied to the Nuclear Regulatory Commission (NRC) for a COL to construct and operate the AP-1000. This provides an opportunity to benchmark and benefit from lessons learned from the experiences of others.

(7) The Nuclear Steam Supply System (NSSS) vendor and general contractor can play a major role in mobilizing (recruiting and training) the human resource assets required for operation of the unit. The responsibility for training and qualifying operational workers is often included in the contract and can extend beyond commissioning and start up activities.

TABLE 2. O&M STAFFING LEVELS (PWR UNITS)

	Onsite	Offsite	Total
Existing US 2 Unit	759	188	947
Existing US 1 Unit	607	202	809
Dominion DOE Rpt. 1 Unit AP-1000	647	51	698

7. CONCLUSIONS

The following observations and conclusions represent the views of the expert team and IAEA representatives involved in the project. Team members were selected from Member States with established nuclear power programmes and brought both technical and management experience to the project. The general observations and main conclusions are drawn from information gathered from a variety of sources, including the MoENR, ANRA and other Armenian organizations, IAEA publications, utility experience and internet searches. It is the team's view that Member States considering expanding existing programmes or introducing nuclear power for the first time can gain valuable insights from the experiences of Armenia.

7.1. IMPACT OF DESIGN OPTIONS ON HR DEVELOPMENT

Having considered information and data from available sources (the internet, printed publications, utility experience, etc.) concerning the construction of power units with WWER-1000 and AP-1000 reactors, the following general observations are offered:

(1) Staff mobilization at the site at the power unit construction stages, in the event that an AP-1000 installation is chosen, may be significantly reduced since the plan is to use pre-assembled modular components and advanced construction technology. However, the question of the integral costs linked to the involvement of assembly workers (number, housing on site, training in special NPP construction processes, delivery of special installation equipment and other issues) remains open. There is currently inadequate data for the situation to be resolved.

(2) Meanwhile further attention on the question of whether it is possible to deliver pre-assembled modules to the power unit construction site using available means of transport. An assessment of the capital investment in the transportation infrastructure required to achieve such delivery is needed.

(3) Available information on the AP-1000 is limited because NPPs with this type of reactor are not yet in the operation stage and are only under construction. Consequently only estimates have been used, taken from the US industry generally, including the duration of construction work and the required human resources. Nevertheless we can say that the estimated construction periods for an AP-1000 unit are less than the equivalent for a WWER-1000. However, the time needed to create the infrastructure for such modular construction must be considered. This makes it difficult to draw a comparison between equivalent time and cost characteristics for the AP-1000 and WWER-1000.

(4) Both approaches are based on the premise that staff already available at the ANPP site will could be utilized on a permanent and temporary basis during the construction period. For either choice language issues should be taken into account. If an AP-1000 is built, local skilled workers will need to be taught English, or a fair quantity of working documentation will need to be translated into Armenian. As an alternative to this, it will be necessary to keep local staff involvement to a minimum, which will in turn lead to an increase in the overall cost of construction. If a WWER-1000 design is chosen, potential language problems will also need to be borne in mind. While the Russian is the language used in operations at the existing NPP[4], new worker may be competent in the language. It is not entirely clear at present what type of language problems should be considered in the event that the WWER-1000 design is chosen.

(5) For a WWER-1000 installation, the entire range of ancillary production processes is located on site and forms part of the cost of the turnkey project. A list of ancillary production processes is given in the document OTP-86 (see footnote [2]), which the Armenian side has. In addition, ANPP staff has the relevant competence at working with WWER technologies. Because of this, extra study of the capital component will be needed (in view the return-on-investment requirements) with selection of any project.

(6) Staff training will have its specific features, including the following:

— *Measurement system;*
The system of measurement in the USA differs from the International System of Units (SI) system, and advance training of staff at US NPPs or at manufacturers' premises must therefore be taken into account for the AP-1000 option.[5] Additionally, amendments to higher education curricula would need to be made. This could be difficult given the absence of an operational unit. Advance training at WWER-1000 power units will require that the operators know Russian, and will be possible at several sites in the Russian Federation and abroad.

— *Training on operating computer control systems;*
For reactors of the WWER-1000 design (or more precisely, the WWER-1200, which is envisaged as a commercial design for delivery abroad), digital computer control systems like those introduced at the Kalinin NPP and EB-3 (the Russian Federation), the Kudankulam NPP (India) and the Bushehr NPP (Iran) will be used. If AREVA is to be brought in to implement the project for the new power unit in Armenia, there is a precedent in the form of two power units at the Tianwan NPP (China) and at the two-reactor Belene NPP in Bulgaria. This means that there are objective conditions allowing advance training of staff in computer control system matters, plus a substantial cost saving on this training.

[4] Experience in IAEA Member States shows the language of operation is also important; as a rule the language of operation is largely chosen on the basis of design data; in the event of an AP-1000, clearly this should be English. For the Tianwan NPP, for example, the language of operation is English (the same as the language of the contract); documentation is drawn up in English and Russian, and in the event of any discrepancy, the English version takes precedence.

[5] For two projects with AP-1000 in China an adaptation of measurement system to the SI has been done.

For a power unit design with an AP-1000, no available data was found concerning experience in introducing reference computer control systems (or system components). In the event that the AP-1000 is chosen, given that the project in China is only in the early stages of implementation, special consideration will have to be given to staff training in computer control system operation.

— *Man-machine interface solutions and computer control system solutions overall;*
If either of the designs referred to above is chosen, work will need to be planned to analyse solutions relating to the man-machine interface and the computer control system overall. These solutions will be directly linked to the development of a full-scale simulator for NPP operating staff training. ANRA regulations require that a simulator be up and running at least six months prior to physical start-up of the NPP. Given the specific features of development of a computer control system and its current non-readiness, by the time that data developed for the simulator, synchronisation of work on computer control system design and the simulator will be needed. One solution is the use of reference models of power units to check design solutions for the computer control system; a similar approach is used for the WWER-1000 design and for the AP-1000. Timely planning and inclusion of such work in the cost of NPP construction will enable the time spent on design, and in turn, on construction of the NPP to be substantially reduced. For this to be done, however, the General Contractor and the Customer must have suitably skilled staff in place.

7.2. DIFFERENCES IN PROPOSED TECHNOLOGIES

WWER technology is familiar to ANPP staff (the existing power unit is a WWER-440); experience in the re-training of staff has shown that little extra work is required to draw up and introduce training programmes and training hardware that take into account the specifics of the system and the equipment of a new power unit with WWER-1000 reactor. Such efforts should be comprehensive in nature, and should be applied primarily with a view to matters relating to the unit's computer control system and the power system.

The AP-1000 technology is new, and generally less known compared to the WWER. This will give rise to extra demands in the drawing up and delivery of training programmes, including a large amount of training of the Customer's staff by the General Contractor and equipment suppliers. Corresponding efforts will also have to be made at the higher education level, to ensure that the relevant information is reflected in study plans and curricula at Armenian higher education institutions (currently all training in the nuclear sphere at higher education institutions is oriented towards WWER technology).

Comparison of staff numbers for operation, technical servicing and maintenance is difficult, as staffing projections for the AP-1000 concerning the technical servicing and maintenance required (only design information on operating staff is available). For a WWER-1000, the average numbers are:

— Achieved, including labour outlay on maintenance, 950–1100 individuals per power unit on condition that the basic maintenance staff form part of NPP personnel.
— The calculated (planned) numbers for the new power unit with digital control system are given in Appendix V.

7.3. MAIN CONCLUSIONS

(1) Developing a skilled workforce, (engineers, skilled trades, project managers, etc.) to support construction and operations of a new NPP, requires many years. Strategic

planning and initial actions to develop these human resource capabilities should be initiated as early as possible in the project (Pre-preparation and Preparation stages). Key stakeholders (universities, technical organization, trade unions, Ministry of Education, etc.) should be involved in these initiatives. Such efforts are not dependent on the selection of a specific design.

(2) To ensure that construction work is conducted in an efficient and cost effective manner, recommendations that should be considered during key construction activities are provided in Appendix I. This approach is not dependent on the selected design technology.

(3) The assessments of labour outlay (cost and staffing numbers) should be carried out in a comprehensive way, taking into account matters relating to the development of infrastructure for the new construction work. Developments in the proposed technologies should be used in assessing the required labour cost and staff needs for each stage of NPP construction.

(4) On the basis of the data evaluated, it is difficult to draw conclusive comparisons between the known technology of the WWER-1000 and the new design of the AP-1000. Further study by the Customer and customer representatives is recommended, taking into account the information and observations presented in this report.

Appendix I

KEY ASPECTS WHICH MUST BE BORNE IN MIND WHEN IMPLEMENTING CONSTRUCTION PROJECT FOR NEW-BUILD NPP UNIT IN ARMENIA

I.1. PROJECT PARTICIPANTS

(1) Supervisory agency (ANRA).

— An up-to-date normative base for NPP construction is essential. To this end, a considerable amount of attention needs to be devoted to reviewing the existing normative base and starting work to develop (or re-work) the normative base to meet modern demands in the area of safety, Emergency Control Room (ECR) requirements and the latest IAEA recommendations;
— The Regulatory Agency should develop an upgraded (development) plan, to include measures to strengthen the organizational structure of ANRA and add extra skilled staff to ensure absolute support for the new project;
— ANRA should play a direct role in checks on the quality of services provided to the Customer and work performed, and also in checking the skills of the Customer's staff;
— Staff skills and the quality of human resources should be monitored by ANRA at all stages of the NPP's life cycle;
— There is a need to establish the requirements for staff skills before work on NPP construction is commenced. The role of ANRA is to establish these requirements (to check that such requirements are established by the New Power Unit Directorate). There must be monitoring of the level of skills of staff permitted to carry out safety-related work, and also such work as preparing for and running the tender process for construction of the NPP power unit. For staff categories with an impact on NPP safety, requirements must be set for licensing and for the introduction of a licensing procedure.

(2) At the project start-up stage, the following steps need to be taken:

— Creation of a special sub-section at the MoENR with powers conferred on it by Armenia to carry out Customer functions for construction of the new power unit (see A.2.1 in Appendix IV);
— Education of and support for the work of expert groups in the following areas:
  - Normative base;
  - Human resources and infrastructure;
  - Construction;
  - Drafting of programmes and ensuring continuing project funding.

(3) Apparent problems with human resources and ways of addressing them with the aid of the regulatory agency, in connection with construction of the new power unit.

— Need to draft requirements and manuals for human resources management for each phase of the NPP life cycle and NPP staff. This may be addressed by putting out a document (or set of documents) stipulating the requirements for staff recruitment and advance training of NPP staff (RF).
— ANRA should have the authority to make an assessment of elements relating to the human factor for the new NPP design.
— This is important because in building the new power unit, staff will lack operating experience. Since the design (regardless of NSGI supplier) will have a modern computer control system with digital control centre, work needs to be done to

verify and validate design ChMI (man-machine interface). The NPP's organizational structure also requires analysis to check whether established requirements are being met. Finally, monitoring of skills of staff of the General Contractor and Construction Directorate must be provided.

— Need to establish and put into practice the principles of ALARA (As Low as Reasonable Achievable).
— This may be done through the development and compulsory additional training of Customer staff and contract organizations with subsequent attestation.
— Possible low quality of services and products provided; lack of clear policy in human resources management sphere.
— Questions of checking human resources quality must be included in inspections carried out by the regulatory agency for the new power unit being built. Indicators for evaluation of staff functioning at the earliest stage of the NPP power unit construction project must be drawn up. The role of the regulatory agency consists in:
  - establishing human resources requirements at the initial stage of the project;
  - monitoring that human resources questions are fully taken into account in the project in accordance with requirements; and
  - checking that the stipulated requirements are put into effect.
— Provision should also be made for integration of human resources requirements and the existing normative and legislative base in Armenia. Various IAEA safety standards include human factor resources and guidelines, but detailed and procedural requirements should be addressed at the national level.
— The regulatory agency should draw up requirements (check that such requirements have been drawn up and introduced) for staff skills, as well as requirements and guidelines for effectiveness assessment programmes for human resources for the NPP. Such requirements should be made manifest at the earliest stage of NPP construction.

I.2. STAGES IN CONSTRUCTION AND HUMAN RESOURCES

(1) Pre-preparation stage.

During this stage, which runs up to the time of FS drafting and approval, a programme of work is put into effect to provide training for all organizations and individuals who will be involved in the project from the time it begins. An assessment is made of the case and potential for nuclear installation construction on the given site or in Armenia generally. This stage generally features a lack of appropriate resources (organizations) supported by funds for the performance of a wide range of work to evaluate the potential for new construction. The government's (parliament's) administrative capacity is generally utilized to make the relevant assessments.

(2) Preparation stage.

During this stage, a programme of work is carried out for full-scale development and preparation of the infrastructure for project implementation. Actions at this stage are divided into three parts and should be organized at:

— the Ministry of Energy and Natural Resources;
— the new power unit construction site (Customer Representative — hereinafter referred to as CR);
— the Armenian Nuclear Regulatory Agency (ANRA).

This stage is crucial to power unit construction. During this stage the main requirements are established for the future power installation, including how it is to be funded and the

conditions of construction. During this stage the principles and criteria for selection of supplier are established and there is competitive selection of installation type and general contractor, a general contractor contract is concluded and a project management system is set up. All initial data and special features governed by local conditions should be gathered and submitted to the general contractor for detailed design work.

(3) Resource mobilization stage.

During this stage work is done to mobilize resources, select, recruit and train staff and set up a staff training system. Effective work with the General Contractor is essential at this stage in order to 'remain on schedule' and within the budget made available, and also to ensure the required quality of work and supplies. During this stage, the full construction work programme is put into effect on the main power unit facilities.

The Customer organizes processes of liaison with the general contractor and ensures that all Customer functions are acted on, including duties to construct (and introduce) facilities that fall within the Customer's area of responsibility. Within his organization, the Customer must provide adequate resources to support all requests from the general designer, including expert appraisals of acceptance and other documentation submitted, and also to ensure that acceptance of work takes place without delays.

The configuration of the Staff Training System is shaped and laid down in documents, including the Staff Training System Concept, administrative procedures for the training process, information technologies for staff management, use of training hardware and involvement of external organizations

(4) Phase of NPP handover for operation.

During this stage work is carried on with a view to preparation for and progressive handover of responsibility to the Customer prior to the stage of functional trials on equipment and structures. Actions taken at this stage are generally established at earlier stages, but are additionally conditioned by the need for:

- Performance of the customer's duties of acceptance of installed equipment;
- Commissioning of equipment and structures;
- Performance of expert appraisal of acceptance documentation;
- Drafting of operating instructions and training of relevant staff for commencement of operation;
- Organization of registration of equipment belong to specific organizations;
- Confirmation of readiness of equipment, procedures and staff for performance of trials, tests and comprehensive checks on power unit systems for compliance with design specifications.

During this stage, all the features of the operating organization need to be put in place, namely:

- The operating organization structure needs to be in place, and the NPP sub-section management structure;
- Responsibility of officials for all safety-related processes needs to be established;
- The structure of operating procedures needs to be established generally, including drafting of Safe Operating Regulations;
- Staff suitable for the organization of work to check power unit systems and carry out their acceptance in line with operating organization responsibility needs to be trained and attested;
- At this stage, checks are normally made on the operating organization (OO) by external partners (IAEA, World Association of Nuclear Operators (WANO), etc.).

(5) Recommendations:

- Provision should be made for real work by an expert (multidisciplinary) group for real 'start-up' of work;

— A long-term plan should be drawn up for work in the sphere of human resources, which will enable:
  - all organizations offering staff training services to become involved;
  - a Staff Training System Concept to be developed;
— A solution to questions of funding for the new construction project (including support for work of expert group);
— An upgrading of the normative base is needed (ANRA) in the human resources sphere, including manuals for skills acquisition and requirements for the recruitment and advance training of staff for the new power unit;
— The Regulatory agency (ANRA) needs to be reinforced to provide work to support the new construction project, including a readiness to analyse (make an expert appraisal of) the NPP design and supervise construction work;
— There must be provision of checks on the skills of the General Contractor's staff, and quality control of work carried out on the part of the Customer. Questions relating to the quality of staff with construction and installation specializations should not be forgotten, as they have a very substantial impact on implementation and in the final analysis, on NPP safety) at the initial stage of power unit construction (regardless of the design selected);
— A 'staff mobilization plan with suitable types of training' (General Contractor, Customer) is required. Monitoring of the existence and implementation of a plan falls within ANRA's area of responsibility.

I.3. HUMAN RESOURCE DEVELOPMENT LINKED TO NEW CONSTRUCTION

I.3.1. Staff skills

(1) Principles underlying Customer staff recruitment:
— Implementation of Armenian policy for new power unit construction;
— Capacity to reproduce staff for NPP needs at all stages of operation;
— Provision of quality construction and economic use of refunds (minimization of cost add-ons);
— Acquisition of maximum experience at construction and installation work stage for subsequent operation;
— Staff training on plant equipment (simulators, models, real equipment);
— Maximum involvement of national resources in construction of new power unit;
— Development of plant engineering and high-tech companies to support operation.

(2) Categories of Customer's staff.
To address construction tasks, the following temporary staff is required:
— Investment managers (to run management companies);
— Heads of construction sub-sections;
— Middle managers for construction work areas;
— Economists specializing in construction;
— Construction engineers;
— Designers;
— Supply people;
— Construction workers.

The following permanent staff is required for preparation for operation:
— Expert appraisal of technical assignment, specifications, etc;
— Equipment orders;
— Equipment acceptance;
— Running construction and installation work;

— Acceptance of premises and completed construction work;
— Expert appraisal of design documentation;
— Expert appraisal (drafting) of operating documentation;
— Expert appraisal of test programmes;
— Involvement in fine-tuning and testing;
— Acceptance of power unit systems for operation.

(3) General requirements for Customer's Representative's staff:
— Knowledge of international requirements for basic safety criteria for NPP design and construction;
— 8–10 years of experience in construction industry;
— Knowledge of requirements of normative base adopted for new power unit construction;
— Knowledge of pressurised-water reactor technology;
— Good knowledge of language in which power unit design is written;
— Good knowledge of modern construction technologies (new materials, mechanisation technologies, supply management, etc.);
— Readiness to work with numerous suppliers of services and goods/components;
— Knowledge of modern production and project management instruments.

(4) Recommendations:
— Set up an effective multi-authority committee to address tasks in the preparation period and to provide funding;
— Set about forming a technology group for new unit construction needs without delay;
— Increase existing station staff to cope with matters related to training and delivery of specialists for new construction work needs;
— Experience in setting up a CO gained at similar sites should be drawn on;
— A state budget for the needs of the preparation stage of construction should be established.

I.3.2. Staff training system

(1) Recommendations for setting up staff training system (STS) for new power unit:
— A priority task is to make an inventory of data on potential project participants and resource suppliers, including the potential offered by higher education institutions;
— A 'Staff training policy' and a 'Staff training system concept' need to be drawn up in the early stages of power unit construction;
— Questions of how to fund the creation of the STS in line with the Concept must be addressed;
— A detailed schedule/plan for creation of the STS to implement the ratified Concept needs to be drawn up and ratified (up to 50–60 months);
— Requirements for STS components need to be ratified;
— The question of an IT system for knowledge management to support new power unit construction needs to be addressed in the early stages of the project;
— A staff skills management system needs to be rolled out. This is a component of the NPP's knowledge management system;
— A project group for commencement of work is needed (taken from experienced staff, not instructors);
— Procedures should be drafted for the training process and training held in their application.

(2) Recommendations for how to develop NPP staff training programmes — general principles:

- Experience shows that each organization can optimize existing resource utilization in this phase;
- The method of analysis should be selected carefully and with consideration;
- The phase of analysis of the systematic approach to training (SAT) should be introduced as described in the Training System Procedures;
- The key factors are support for leadership, the existence of highly-skilled experts in the area in question and experts in analysing how activities are being run;
- The results of the analysis phase should be precisely linked to training objectives;
- Analysis of data should be correspondingly maintained and stored (appropriate software may be an effective way of doing this);
- Maximum use must be made of experience that is available within Armenia. When external sources are used, an analysis of their applicability must be performed;
- One mandatory condition is to establish the competence of staff to commence development of training (these should be recorded in skills manuals and official instructions);
- A systematic study approach methodology must be employed. This is a component of the integrated management system (in line with IAEA Safety Guide GS-G-3.1);
- Customer's specialists must be trained in SAT methodology in order for them to be involved in work on the development of training programmes;
- For all actions relating to the development of training programmes to be put into effect, training process procedures describing actions at each phase of the SAT must be drawn up and introduced;
- Checks on the skills and quality of the workforce brought in to work on the site must be carried out;
- Setting up of project group; administrative support for its work;
- Organizing project group training in SAT methodology;
- It is also important to draw up training process procedures, at least for the stages of Analysis and Planning of Training;
- Establishment of target audience for training programme development;
- Approval (synchronization) of schedule for drafting of training programmes and training schedule;
- Drafting of training programme descriptions;
- Development of study materials.

Appendix II

LINKS TO CUSTOMER PROCESS, TIME AND WORK

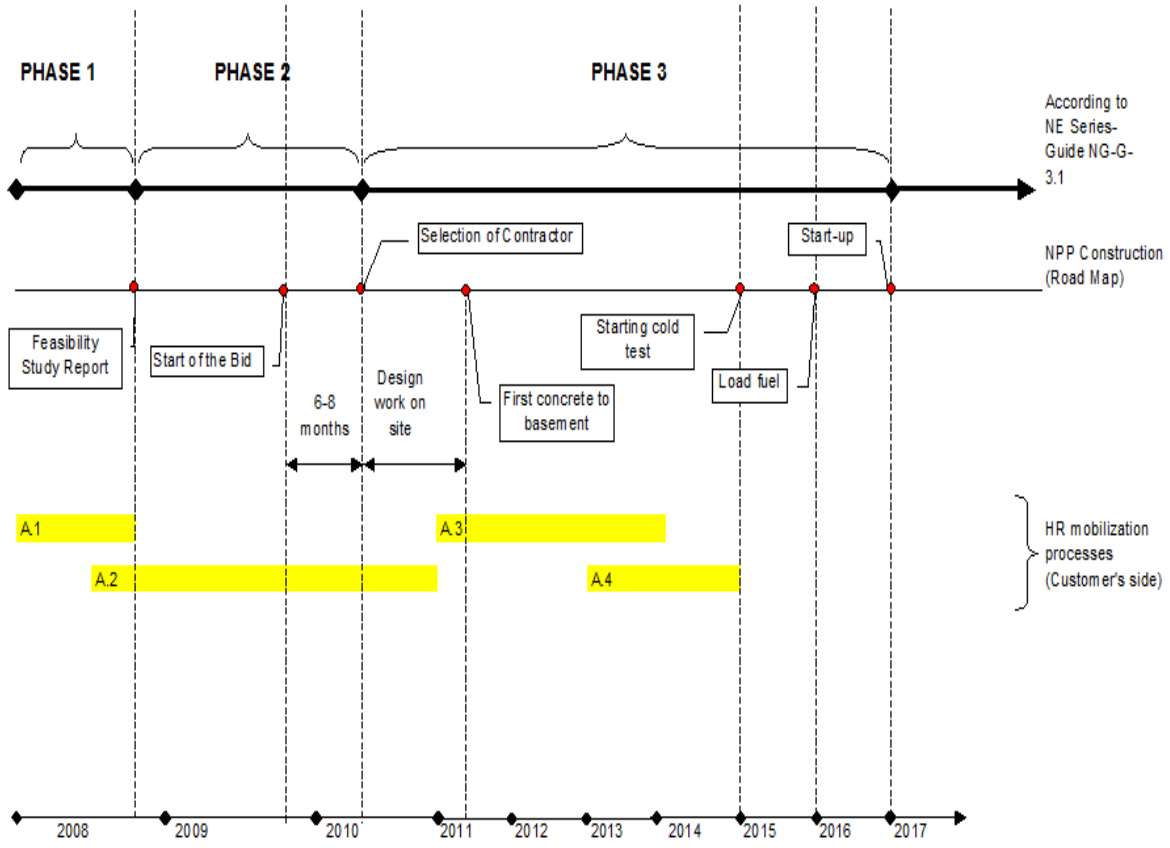

FIG. 5. Illustration of links to Customer process, time and work.

Appendix III

DIVISION OF RESPONSIBILITIES FOR STAGE A.2

Actions during stage A.2 are divided into three parts, and should be organized:

— At the Ministry of Energy and Natural Resources;
— On the new power unit construction site (Customer Representative);
— At the ANRA.

Preparation work will include:

(1) At the Ministry of Energy and Natural Resources:

— A.2.1 — Creation of a special sub-section (department) on which the parliament of Armenia will confer powers to implement the function of Customer to build the new power unit;
— A.2.2 — Identification of a source of investment for construction of the new power unit (including passage of the necessary laws establishing the principles for investment in the new power unit);
— A.2.3 — Calculation of provisional costs for the preparation period, setting of a special budget and financing mechanism for preparation work[6];
— A.2.4 — Setting up of multi-authority committee with the participation of:
  - Ministry of Energy and Natural Resources;
  - Ministry of Urban Planning;
  - Ministry of Economics;
  - Ministry of Transport and Communications;
  - Ministry of Foreign Affairs;
  - Ministry of Finance;
  - Ministry of Internal Affairs (Ministry of Defence);
  - Ministry for Environmental Protection;
  - Ministry of Education;
  - Academy of Sciences of Armenia;
  - ANRA and other interested authorities;
— A.2.5 — Gathering of information, assessment of quality and scope of production and systemization of data on products manufactured by businesses in the Armenia that could be used in the construction stages (for transfer to General Contractor at the detailed project stage);
— A.2.6 — Gathering of information, analysis and systematization of data on construction and installation organizations which might be involved in setting up facilities during the building of the new power unit (for transfer to General Contractor during detailed design work);
— A. 2.7 — Gathering of information on human resources in the construction zone who might be involved during construction in work of all types, including ancillary work;
— A.2.8 — Organization of the preparation of initial site data (organization of research and surveying work as required) to launch prepared tender procedures and tie in the selected installation at the detailed design stage, including data on the seismic hazard, the presence of reserves of water to remove residual heat, the method of residual heat removal, overhead power lines and their features, purification facilities, etc.;

[6] This stage may be formally included under stage A.1, but this calculation can only be made when all other stage A.1 work is completed.

— A.2.9 — Case for the type of installation and its main parameters (power, handling features, fuel type, technical and economic baseline figures, etc.).
— A.2.10 — Preparation of requirements for installation for the organization of an open tender process (competition, selection with restricted number of participants);
— A.2.11 — Organization and performance of independent expert appraisal 'Installation requirements' for compliance with generally-accepted (in place or anticipated) international standards;
— A.2.12 — Organization of tender (competition) for selection of supplier of NPP or nuclear power unit equipment (performance of successive actions beginning with announcement of tender and ending with selection of winner as General Contractor);
— A.2.13 — Creation of a working agency (customer representative) on site to manage the construction of the power unit and interact with the General Contractor;
— A.2.14 — Shaping of human resources to manage quality at the stages of supplier selection, design, construction and commissioning of the new unit.

(2) At the Armenian Nuclear Regulatory Agency:
— A.2.15 — Expert appraisal of data (report) and issue of licence for site selection;
— A.2.16 — Organization of a council (working agency) of all regulatory agencies in Armenia (for the environment, construction, health, fire fighting, physical security, etc.) to coordinate work associated with the performance of expert appraisals of documents and the issue of approvals (licences) for the relevant types of work;
— A.2.17 — Analysis and involvement in expert appraisal of FS for various power unit options;
— A.2.18 — Approval of tender documentation to check that it complies with rules, norms and standards applicable in Armenia and accepted international requirements.
— A.2.19 — Involvement in evaluation of proposals put forward by potential General Contractors;
— A.2.20 — Approval of designs at detailed design stage;
— A.2.21 — Issue of individual approvals for design, construction, equipment manufacture, etc.

(3) At the Customer's site office (in charge of power unit under construction or management of capital construction work at the MoENR):
— A.2.22 — Planning of expenditure (payments) and accounting for this expenditure (payments) on building of power unit in accordance with the adopted construction schedule and estimates;
— A.2.23 — Organization and performance of preparatory work to accommodate the General Contractor and create the infrastructure for future operating staff at the new unit, including:
  - Building of residential accommodation in Metsamor;
  - Building of facilities with social significance (canteens, domestic service facilities, heat and water supplies, electricity supplies, purification plants, etc.);
  - Transport communications.
— A.2.24 — Organization and performance of preparation work on the construction site:
  - Preparation of warehousing space;

- Preparation of premises for preparatory production work (section for production of precast reinforced concrete, section for pipe amalgamation, section for manufacture of ventilation ducts, chemical protection section, etc.);
- Erection of temporary housing for construction and assembly workers;
- Preparation of approach roads and lifting gear for loading and unloading work;
- Organization of Customs post for clearance of imported equipment and materials;
- Drinking and process water links and electricity supply to site.

— A.2.25 — Organization and monitoring of performance of preparation work for provision of the main materials for the construction work (sand, gravel, cement, building bars, etc.), and also evaluation of potential to supply General Contractor with construction machinery and mechanisms and vehicles;

— A.2.26 — Customer management of design process, including:

- Organization of design of facilities falling within the zone of responsibility of Armenia;
- Supply of data to General Contractor on request;
- Approval of design amendments;
- Analysis of design and elimination of errors, including in links to General Layout.

— A.2.27 — Management of drafting of agreements and support of these, including agreements for the building of facilities falling within the zone of responsibility of Armenia;

— A.2.28 — Control over purchases and deliveries;

— A.2.29 — Control over equipment manufacture;

— A.2.30 — Control of construction, assembly and fine-tuning of facilities falling within the zone of responsibility of Armenia in the preparation stage;

— A.2.31 — Management of finance, expenditure and accounts (reporting back on investments);

— A.2.32 — Coordination of work of General Contractor and other organizations to coordinate main and ancillary work on construction of the entire set of facilities for introduction of the new power unit;

— A.2.33 — Acceptance of concealed and completed work;

— A.2.34 — Geodesic work and running of General Layout.

Appendix IV

ASSESSED HUMAN RESOURCE NEEDS

TABLE 3. STAGE A.1 'PRE-PREPARATION'

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.1.1	Establishing strategic plan for development of human resources in Armenia	MoENR	Deputy Minister	Up to 6–8 specialists in various areas	For 8–10 weeks after decision is taken	MoENR, ANPP	
A.1.2	Planning of essential human resources for performance of pre-preparation work	MoENR	Managers and specialists in the sphere of: – normative regulation – NPP technology – personnel management	5–8 ANRA 4–6 government up to 6 specialists from relevant organizations	For 6–12 months after decision is taken	MoENR, ANPP, ANRA	Group of highly-skilled specialists needs to be set up for continuing work on planning
A 1.3	Gathering, analysis, review and drafting of new supervisory agency requirements to take account of requirements of new construction	ANRA	Specialists in sphere of: – nuclear law – NPP technology – ecology	6–8 individuals	For period of drafting and entry into effect of new norms and rules	From ANRA(2) and ANPP (6) resources	Up to 4 individuals needed to oversee current normative documents (full time)
A 1.4	Performance of essential organizational work to set up infrastructure for subsequent preparation for tender process, including drafting of tender procedures	MoENR MF ANRA	– construction – jurisprudence – environmental management – supervisory functions	Up to 8–10 specialists in area in question	Up to 6 months		

TABLE 3 (cont.). STAGE A.1 ‘PRE-PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.1.5	Regular assessment, monitoring and upgrading of efforts on national level to achieve aims in human resource development	MoENR MF ANRA	– SAT methodology – personnel management – knowledge of NPP safe operating requirements – construction	Up to 4-6 specialists in area in question	Throughout NPP life cycle		
A 1.6	Establishing and upgrading infrastructure to support introduction of integrated KM system	MoENR, MF, ANRA	– knowledge of KM methodology – existence of experience in introducing KM system at enterprises – knowledge of technology of NPP with WWER reactor	Up to 8 individuals. In initial stage, up to 4 individuals when all is up and running	Throughout NPP life cycle	Higher ed. Institutions, External organizations (outsource)	
A 1.7	Drafting of initial requirements, tech. Assignment and FS for construction of new NPP power unit	MoENR, ANRA	– construction – jurisprudence – environmental management – knowledge of supervisory requirements	Up to 8–10 specialists in area in question	Up to 6–10 months from time decision is taken	ANPP	

TABLE 4. STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.1	Creation of special sub-section (department) at MoENR with powers conferred on it by the Government of Armenia to perform the functions of Customer for building work on the new power unit. (or allocation of new powers to existing sub-section at MoENR and enlarging its resources for the organization of work in stage A.2)	MoENR	Armenian government level	n/a	n/a	MoENR ANPP	
A.2.2	Establishment of source of investments for construction of new power unit	MoENR, Ministry of Finance	Managers and specialists at ministries	5–6	3 months	MoENR MF	
A.2.3	Calculation of provisional costs of preparation period, establishment of special budget and mechanism for the funding of preparation work	NPD	Engineer/economist, Construction engineer	2–3	All of phase A.2	MoENR, construction and other organizations	

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.4	Setting up of multi-authority committee with the participation of: – Ministry of Energy and Natural Resources – Ministry of Urban Planning – Ministry of Economics – Ministry of Transport and Communications – Ministry of Foreign Affairs – Ministry of Finance – Ministry of Internal Affairs (Ministry of Defence) – Ministry for Environmental Protection – Ministry of Education – Academy of Sciences of Armenia – ANRA and other interested authorities	MoENR	Head of MoENR	n/a	n/a	n/a	
A.2.5	Gathering of information, assessment of quality and scope of production and systematization of data on products manufactured by businesses in Armenia that could be used in the construction stages (for transfer to General Contractor at the detailed project stage)	MoENR	Construction engineer	1–2	3 months	Ministry of Economics	

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.6	Gathering of information, analysis and systematization of data on construction and installation organizations which might be involved in setting up facilities during the building of the new power unit (for transfer to General Contractor during detailed design work)	MoENR	Construction engineer	1	3 months	State Statistical Committee	
A.2.7	Gathering of information on human resources in the construction zone who might be involved during construction in work of all types, including ancillary work	MoENR	Personnel specialist	1	3 months	MoENR, higher ed. Institutions	
A.2.8	Organization of the preparation of initial site data (organization of research and surveying work as required) to organize tender procedures and tie in the selected installation at the detailed design stage, including data on seismic risk, the presence of reserves of water to remove residual heat, the method of residual heat removal, overhead power lines and their features, purification facilities, etc.	MoENR	Construction engineer, Seismic survey engineer	6	6 months	Construction organizations, design organizations	

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.9	Case for the type of nuclear installation and its main parameters (power, flexibility, fuel type, technical and economic baseline figures, etc.)	MoENR (organization only)	Heat and power engineer, Physics engineer (specialising in NPP)	2	6–8 months	Design organization, ANPP, engineering organization	Work carried out by design organization
A.2.10	Preparation of requirements for nuclear installation for the organization of an open tender process (competition, selection with restricted number of participants)	MoENR (task management)	Heat and power eng. Electrical engineer Construction eng. Engineer/economist Engineer specialising in radwaste and chemical technologies	2 1 1 1 1	6 months	ANPP, design or engineering organization, ANRA	Work carried out by design organization or engineering organization
A.2.11	Organization and performance of independent expert appraisal ‘Installation requirements’ for compliance with generally-accepted (in-place or anticipated) international standards	ANRA	Heat and power eng. Radiation protection engineer, Construction eng. Eng./seismologist Process engineer for radwaste and chemical technologies Environmental eng. Fire protection eng.	3–4 1 1 1 1 1 1	4–6 months	All organizations	Implementation to involve specialist expert organizations of relevant ministries and authorities

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.12	Organization of tender process (competition) to select supplier of NPP or nuclear power unit equipment. (Note: includes following stages: – organization; – evaluation; – summarization)	MoENR	Heat and power eng. Electrical engineer Construction eng. Engineer/economist Radiation protection engineer Radwaste and chemical technologies engineer	2–3 1 1 1 1 1	6–8 months	All organization	For evaluation work, specialists to be brought in from ANPP, ANRA, construction organization, etc. (ca. 15–20 individuals)
A.2.13	Setting up of working agency (customer representative – CR) on site to manage power unit construction and liaise with General Contractor	MoENR	Ministry of Energy and Natural Resources or head of special sub-section of MoENR (see A.2.1)		n/a	n/a	
A.2.14	Creation of a resource for quality management at the stages of supplier selection, design, construction and commissioning of the new power unit	CO	Quality management engineer Work safety eng. Fire protection eng.	5 1 1	All of phase A.2	ANPP, higher ed. Institutions	
A.2.15	Expert appraisal of data (report) on site selection	ANRA	Construction eng.	2–3	2 months		Involving expert organizations in seismology, the environment, etc.

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.16	Organization of a council (working agency) of all regulatory agencies in Armenia (for the environment, construction, health, fire fighting, physical security, etc.) to coordinate work associated with the performance of expert appraisals of documents and the issue of approvals (licences) for the relevant types of work	ANRA			At all stages of construction and commissioning		
A.2.17	Expert appraisal of FS for power unit options	ANRA	Heat and power eng. Radiation protection engineer Construction eng. Eng./seismologist Process engineer for radwaste and chemical technology Environmental eng. Fire protection eng.	3–4 1 1 1 1 1 1	1–2 months	All organizations	Involving expert organizations in seismology, the environment, etc.
A.2.18	Approval of tender documentation to check that it complies with rules, norms and standards applicable in Armenia and accepted international requirements	ANRA	Heat and power eng. Radiation protection engineer Construction eng. Eng./seismologist Process engineer for radwaste and chemical technology Environmental eng. Fire protection eng.	3-4 1 1 1 1 1 1	2–3 months	All organizations	Involving expert engineering organizations

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.19	Participation in evaluation of proposals from potential General Contractors	ANRA	Heat and power eng. Engineer specializing in metals and welding technology Radiation protection engineer, Construction eng. Eng./seismologist Process engineer specializing in radwaste and chemical technology Environmental eng. Fire protection eng.	3–4 1 1 1 1 1 1	1–2 months	All organizations	Involving expert engineering organizations
A.2.20	Approval of design decisions at detailed design stage	ANRA	Heat and power eng. Radiation protection engineer Construction eng. Eng./seismologist Process engineer specializing in radwaste and chemical technology Environmental eng. Fire protection eng. Engineer specializing in metals and welding technology Specialist in physical protection	3–4 2 1 1 2 1 1 3 1	All of phase A.2		

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.21	Issue of individual permits for design, construction, equipment manufacture, etc.	ANRA	Heat and power eng; Radiation protection engineer Construction eng. Eng./seismologist Process engineer specializing in radwaste and chemical technology Environmental eng. Fire protection eng. Personnel skills inspector	2–3 1 1 1 1 1 1 1	All of phase A.2	All organizations	
A.2.22	Planning and accounting for costs of power unit construction	CO	Engineer/economist	4–6	All of phase A.2	ANPP, higher ed. Institutions	
A.2.23	Organization and performance of preparation work on accommodation for General Contractor and creation of infrastructure for operating personnel at new power unit, including: – building housing – building facilities for social and domestic purposes (canteens, domestic service facilities, heat and water supply, electricity supply, purification plants, etc.. – transport communications	CO	Construction eng. Engineer/economist Electrical engineer Engineer specializing in heating, ventilation, water supply and sewage systems	4–6 2–3 3–4 3–4	All of phase A.2	Construction organizations, higher ed. Institutions	

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.24	Organization and performance of preparation work on site: – preparation of storage facilities – preparation of premises for preparatory production processes (section for production of precast reinforced concrete, section for pipe amalgamation, section for manufacture of ventilation ducts, chemical protection section, insulation section, etc.) – construction of temporary accommodation for construction and installation workers – preparation of approach roads and lifting gear for loading and unloading work – organization of Customs post for clearance of imported equipment and materials – delivery of drinking and process water and electricity to site	CO	Construction eng. Electrical engineer Engineer specialising in heating, ventilation, water supply and sewage systems Engineer/economist	5–6 2–3 3–4 2–3	All of phase A.2	Construction organizations, higher ed. Institutions	
A.2.25	Organization and performance of preparatory work to provide basic materials (sand, gravel, cement, building bars, etc.), machinery and mechanisms and transport	CO	Construction engineer	2–3	All of phase A.2	Construction organizations, higher ed. Institutions	

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.26	Project management	CO	Heat and power eng. Process engineer Electrical engineer Engineer specializing in monitoring and measuring equipment Construction eng.	4–6 4–6 3–4 3–4 4–6	All of phase A.2	ANPP, engineering and construction organizations, higher ed. Institutions	
A.2.27	Management of agreement drafting and oversight of agreements	CO	Engineer/economist	6–8	All of phase A.2	ANPP, engineering and construction organizations, higher ed. Institutions	
A.2.28	Monitoring of supplies, including: – incoming control – supplier evaluation	CO	Mechanical engineer Electrical engineer Quality engineer	6–8 2 2	All of phase A.2	ANPP, engineering and construction organizations, higher ed. Institutions	
A.2.29	Monitoring of equipment manufacture	CO	Process engineer	4–6	All of phase A.2	ANPP, engineering and construction organizations, higher ed. Institutions	

TABLE 4 (cont). STAGE A.2 ‘PREPARATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Possible source to supply specialists	Note
A.2.30	Management of construction, installation and fine tuning of facilities falling within the zone of responsibility of Armenia at preparation stage under main contract	CO	Construction eng. Process engineer	4–6 4–6	All of phase A.2	ANPP, engineering and construction organizations, higher ed. Institutions	
A.2.31	Management of finance, costs and accounts	CO	Accountant	6–8	All of phase A.2	ANPP, engineering and construction organizations, higher ed. Institutions	
A.2.32	Coordination of work of General Contractor and other organizations	CO	Construction eng.	2	All of phase A.2	ANPP, construction organizations	
A.2.33	Acceptance of concealed and completed work	CO	Construction eng.	4	All of phase A.2	ANPP, engineering and construction organizations, higher ed. Institutions	
A.2.34	Geodesic works and keeping of the General Plan	Representative of the Customer	Engineer-geodesist Geodesist	4–6	All of Phase A.2	Construction companies, universities	

TABLE 5. STAGE A.3 ‘HUMAN RESOURCE MOBILIZATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Potential sources of specialists	Note
A.3.1	Setting up production-shop-based or non-production-shop-based structure at the new power unit Directorate	New power unit Directorate	Director, Chief Engineer, Dep. Chief Engineers	Up to 6	Over a period of 4–6 weeks after decision is taken on type of power unit management structure	MoENR, ANPP	
A.3.2	Development (creation) of operating organization for new power unit	General Director of operating organization	GD, Dep. GDs, MoENR, ANRA	Up to 20	Over a period of 4–6 weeks after decision is taken on type of power unit management structure	MoENR, ANPP	Jointly with A.3.1
A.3.3	Implementation and completion of creation of essential engineered infrastructure	CO	Construction eng. Electrical engineer Engineer specialising in heating, ventilation, water supply and sewage systems Engineer/economist	5–6 2–3 3–4 2–3	All of phase A.3	Construction organizations, higher ed. Institutions	
A.3.4	Completion of creation of essential infrastructure for future operating staff of new power unit	CO	Construction eng. Engineer/economist Electrical engineer Engineer specializing in heating, ventilation, water supply and sewage systems	4–6 2–3 3–4 3–4	All of phase A.3	Construction organizations, higher ed. Institutions	

TABLE 5 (cont.). STAGE A.3 ‘HUMAN RESOURCE MOBILIZATION’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Potential sources of specialists	Note
A.3.5	Management of construction, installation and fine-tuning of facilities falling within the area of responsibility of Armenia at the resource mobilization stage	CO	Construction eng. Process engineer	8–10 8–10	All of phase A.3	ANPP, engineering and construction organizations, higher ed. Institutions	
A.3.6	Supervision of production, purchase and supply of equipment to new power unit site and its acceptance	CO	Mechanical engineer Electrical engineer Quality engineer Process engineer	8–10 4 6 6–8	All of phase A.3	ANPP, engineering and construction organizations, higher ed. Institutions	
A.3.7	Training of new power unit staff	Dep. Chief Engineer for staff training – director of training centre	Training centre instructor Process engineer Engineer/economist Training centre methods specialist Training organization group engineer	4–6 2–4 2 2 2	All of phase A.3	ANPP, engineering organizations, higher ed. Institutions	Assessed scope of training given in table 6.1.7-2

TABLE 6. STAGE A.4 ‘ENSURING CUSTOMER READINESS TO TAKE RESPONSIBILITY FOR STAGED COMMISSIONING OF EQUIPMENT, BUILDINGS AND STRUCTURES AND PROGRESSIVE HANDOVER OF RESPONSIBILITY TO CUSTOMER’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Potential sources of specialists	Note
A.4.1	Setting up working commissions for acceptance of equipment, buildings and structures, and also State Acceptance Commission, and organization of their work.	MoENR, OO	Directors of MoENR, OO, NPP	35–40	4–6 months	MoENR, OO, ANPP	
A.4.2	Expert appraisal and ratification of operating instructions and drafting of other documentation for trials and testing stage	OO(NPP)	Production shop managers and their deputies. Section managers. Senior shift staff	70–80	10–12 months	Operating NPP, engineering organizations	
A.4.3	Attestation of staff for right to operate equipment	OO(NPP)	Chief engineer, chief engineer’s deputies, production shop managers and their deputies Training centre staff	15–20 5–10 Training centre	2–5 months	Operating NPP, engineering organizations, external training organizations, certification agencies	
A.4.4	Registration of equipment and receipt of relevant licences, permits, etc. for its commissioning	OO(NPP)	Production shop managers and their deputies Section managers	12–15	4–5 months	Operating NPP, engineering organizations	
A.4.5	Expert appraisal and approval of equipment test programmes for confirmation of design specifications	OO (NPP), ANRA	Chief engineer, chief engineer’s deputies, production shop managers and their deputies	10–12	6–8 months	Operating NPP, engineering organizations	

TABLE 6 (cont.). STAGE A.4 ‘ENSURING CUSTOMER READINESS TO TAKE RESPONSIBILITY FOR STAGED COMMISSIONING OF EQUIPMENT, BUILDINGS AND STRUCTURES AND PROGRESSIVE HANDOVER OF RESPONSIBILITY TO CUSTOMER’

№ of sub-process	Name of sub-process	Owner of sub-process	Skills required (decision-making level) for sub-process	Number of specialists	Duration and period of sub-process	Potential sources of specialists	Note
A.4.6	Organization of system of restricted access to power unit process rooms and systems that are under voltage and with potentially hazardous parameters (temperature, pressure, chemical reagents, etc.)	Armed Forces Ministry	–	60–70	Continuously	Armed Forces Ministry	
A.4.7	Participation in equipment and system tests and comprehensive tests	OO (NPP), ANRA	All shift staff, chief engineer, chief engineer’s deputies, production shop managers and their deputies	30–35	6–8 months	Operating NPP, engineering organizations, ANRA	
A.4.8	Organization of shift work to service process systems involving Customer’s staff, equipment tuning organizations and General Contractor (introduction of operating regimen)	OO(NPP)	All shift staff	350	Continuously	Operating NPP, engineering organizations	

Appendix V

ASSESSED REQUIREMENTS FOR STAFF TRAINING FOR NEW POWER UNIT

TABLE 7. ASSESSED REQUIREMENTS FOR STAFF TRAINING FOR NEW POWER UNIT

№	Item	Total number of individuals
1	Power unit [a]	
	Management and sub-sections	50
	Operating personnel for NPP process management (non-production-shop-based)	20
	Production sub-sections, including: – operating staff – maintenance staff	 220 120
	Ancillary sub-sections	40
	Total (for power unit)	450
2	Operating organization [b]	
	Top management	10
	Management personnel	15
	Operating organization sub-sections	25
	Total (for operating organization)	50

Notes:
(a) The assessed numbers are given for an NPP power unit with a new-generation WWER-1000 reactor and for automation level EB.
(b) Maximum numbers are given taking into account creation (upgrading) of the operating organization.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Milestones in the Development of a National Infrastructure for Nuclear Power, IAEA Nuclear Energy Series No. NG-G-3.1, IAEA, Vienna (2007).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Initiating Nuclear Power Programmes — Responsibilities and Capabilities of the Owners and Operators, IAEA Nuclear Energy Series No. NG-T-3.1, IAEA, Vienna (2009).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Managing Human Resources in the Field of Nuclear Energy, IAEA Nuclear Energy Series No. NG-G-2.1, IAEA, Vienna (2009).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Workforce Planning for New Nuclear Power Programmes, IAEA Nuclear Energy Series No. NG-T-3.10, IAEA, Vienna (2011).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Energy and Nuclear Power Planning Study for Armenia, IAEA-TECDOC-1404, IAEA, Vienna (2004).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Safety Infrastructure for a National Nuclear Power Programme Supported by the IAEA Fundamental Safety Principles, INSAG Series No. 22, IAEA, Vienna (2008).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Responsibilities and Capabilities of a Nuclear Energy Programme Implementing Organization, IAEA Nuclear Energy Series No. NG T 3.6, IAEA, Vienna (2009).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Evaluation of the Status of National Nuclear Infrastructure Development, IAEA Nuclear Energy Series Report No. NG-T-3.2, IAEA, Vienna, (2008).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Risk Management of Knowledge Loss in Nuclear Industry Organizations, STI/PUB/1248, IAEA, Vienna (2006).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Knowledge Management for Nuclear Industry Operating Organizations, IAEA-TECDOC-1510, IAEA, Vienna (2006).

[11] UNITED STATES DEPARTMENT OF ENERGY, Improved Construction Technologies, O&M Staffing and Cost, and Decommissioning Costs and Funding Requirements Study conducted by Dominion Energy, NP2010, Vol. 1, USDOE, Washington, DC (2004).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Considerations to Launch a Nuclear Power Programme, IAEA, Vienna (2007).

ABBREVIATIONS

ALARA	as low as reasonable achievable
ANPP	Armenian Nuclear Power Plant
ANRA	Armenian Nuclear Regulatory Authority
AP-1000	two-loop pressurized water reactors (PWR)
CCA	Capital Construction Administration
CCCA	Central Capital Construction Administration
ChM I	man-machine interface
CJSC	closed joint-stock company
CO	Customer Office
COL	Combined Construction and Operating License
CR	Customer representative
EC	European Commission
ECR	Emergency Control Room
ENPP	Energy and Nuclear Power Planning
FS	Feasibility Study
HR	human resources
IAEA	International Atomic Energy Agency
IT	information technology
KM	knowledge management
MoENR	Armenian Ministry of Natural Resource and Energy
NEPIO	Nuclear Energy Programme Implementing Organization
NPD	Nuclear Power Department
NPP	nuclear power plant
NRC	Nuclear Regulatory Commission
NSGI	nuclear steam-generating installation
NSSS	Nuclear Steam Supply System
O&M	operations and maintenance
OO	operating organization
PWR	pressurized water reactors
QAP(Com)	Quality Assurance Programme for the commissioning stage
QAP(Con)	Quality Assurance Programme for the construction stage
RCP	reactor coolant pump
RF	The Russian Federation
SAT	systematic approach to training

SI	International System of Units
SPDS	Safety Parameters Display System
STS	staff training system
TC	Technical cooperation
WANO	World Association of Nuclear Operators
WWER	water cooled water moderated power reactor

CONTRIBUTORS TO DRAFTING AND REVIEW

Boyles, J.E.	Consultant, United States of America
Chupov, A.	International Atomic Energy Agency
Gevorgyan, A.	Ministry of Energy and Natural Resources of Armenia
Gest, P.	International Atomic Energy Agency
Kandalova, M.	State Central Institute for Continuing Education and Training, Russian Federation
Kosilov, A.	International Atomic Energy Agency
Kuznetsov, V.	International Atomic Energy Agency
Popov, S.	National Nuclear Energy Generating Company 'Energoatom', Ukraine
Yanev, Y.	International Atomic Energy Agency
Yuzhakov, A.	All-Russian Research Institute for Nuclear Power Plant Operation (VNIIAES), Russian Federation

A number of expert missions, workshops and working meetings have already been conducted under TC projects Arm0005 and Arm0006 in 2007–2009.

IAEA
International Atomic Energy Agency

Where to order IAEA publications

In the following countries IAEA publications may be purchased from the sources listed below, or from major local booksellers. Payment may be made in local currency or with UNESCO coupons.

AUSTRALIA
DA Information Services, 648 Whitehorse Road, MITCHAM 3132
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: service@dadirect.com.au • Web site: http://www.dadirect.com.au

BELGIUM
Jean de Lannoy, avenue du Roi 202, B-1190 Brussels
Telephone: +32 2 538 43 08 • Fax: +32 2 538 08 41
Email: jean.de.lannoy@infoboard.be • Web site: http://www.jean-de-lannoy.be

CANADA
Bernan Associates, 4501 Forbes Blvd, Suite 200, Lanham, MD 20706-4346, USA
Telephone: 1-800-865-3457 • Fax: 1-800-865-3450
Email: customercare@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Company Ltd., 1-5369 Canotek Rd., Ottawa, Ontario, K1J 9J3
Telephone: +613 745 2665 • Fax: +613 745 7660
Email: order.dept@renoufbooks.com • Web site: http://www.renoufbooks.com

CHINA
IAEA Publications in Chinese: China Nuclear Energy Industry Corporation, Translation Section, P.O. Box 2103, Beijing

CZECH REPUBLIC
Suweco CZ, S.R.O., Klecakova 347, 180 21 Praha 9
Telephone: +420 26603 5364 • Fax: +420 28482 1646
Email: nakup@suweco.cz • Web site: http://www.suweco.cz

FINLAND
Akateeminen Kirjakauppa, PO BOX 128 (Keskuskatu 1), FIN-00101 Helsinki
Telephone: +358 9 121 41 • Fax: +358 9 121 4450
Email: akatilaus@akateeminen.com • Web site: http://www.akateeminen.com

FRANCE
Form-Edit, 5, rue Janssen, P.O. Box 25, F-75921 Paris Cedex 19
Telephone: +33 1 42 01 49 49 • Fax: +33 1 42 01 90 90
Email: formedit@formedit.fr • Web site: http://www. formedit.fr

Lavoisier SAS, 145 rue de Provigny, 94236 Cachan Cedex
Telephone: + 33 1 47 40 67 02 • Fax +33 1 47 40 67 02
Email: romuald.verrier@lavoisier.fr • Web site: http://www.lavoisier.fr

GERMANY
UNO-Verlag, Vertriebs- und Verlags GmbH, Am Hofgarten 10, D-53113 Bonn
Telephone: + 49 228 94 90 20 • Fax: +49 228 94 90 20 or +49 228 94 90 222
Email: bestellung@uno-verlag.de • Web site: http://www.uno-verlag.de

HUNGARY
Librotrade Ltd., Book Import, P.O. Box 126, H-1656 Budapest
Telephone: +36 1 257 7777 • Fax: +36 1 257 7472 • Email: books@librotrade.hu

INDIA
Allied Publishers Group, 1st Floor, Dubash House, 15, J. N. Heredia Marg, Ballard Estate, Mumbai 400 001,
Telephone: +91 22 22617926/27 • Fax: +91 22 22617928
Email: alliedpl@vsnl.com • Web site: http://www.alliedpublishers.com

Bookwell, 2/72, Nirankari Colony, Delhi 110009
Telephone: +91 11 23268786, +91 11 23257264 • Fax: +91 11 23281315
Email: bookwell@vsnl.net

ITALY
Libreria Scientifica Dott. Lucio di Biasio “AEIOU”, Via Coronelli 6, I-20146 Milan
Telephone: +39 02 48 95 45 52 or 48 95 45 62 • Fax: +39 02 48 95 45 48
Email: info@libreriaaeiou.eu • Website: www.libreriaaeiou.eu

JAPAN
Maruzen Company, Ltd., 13-6 Nihonbashi, 3 chome, Chuo-ku, Tokyo 103-0027
Telephone: +81 3 3275 8582 • Fax: +81 3 3275 9072
Email: journal@maruzen.co.jp • Web site: http://www.maruzen.co.jp

REPUBLIC OF KOREA
KINS Inc., Information Business Dept. Samho Bldg. 2nd Floor, 275-1 Yang Jae-dong SeoCho-G, Seoul 137-130
Telephone: +02 589 1740 • Fax: +02 589 1746 • Web site: http://www.kins.re.kr

NETHERLANDS
De Lindeboom Internationale Publicaties B.V., M.A. de Ruyterstraat 20A, NL-7482 BZ Haaksbergen
Telephone: +31 (0) 53 5740004 • Fax: +31 (0) 53 5729296
Email: books@delindeboom.com • Web site: http://www.delindeboom.com

Martinus Nijhoff International, Koraalrood 50, P.O. Box 1853, 2700 CZ Zoetermeer
Telephone: +31 793 684 400 • Fax: +31 793 615 698
Email: info@nijhoff.nl • Web site: http://www.nijhoff.nl

Swets and Zeitlinger b.v., P.O. Box 830, 2160 SZ Lisse
Telephone: +31 252 435 111 • Fax: +31 252 415 888
Email: infoho@swets.nl • Web site: http://www.swets.nl

NEW ZEALAND
DA Information Services, 648 Whitehorse Road, MITCHAM 3132, Australia
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: service@dadirect.com.au • Web site: http://www.dadirect.com.au

SLOVENIA
Cankarjeva Zalozba d.d., Kopitarjeva 2, SI-1512 Ljubljana
Telephone: +386 1 432 31 44 • Fax: +386 1 230 14 35
Email: import.books@cankarjeva-z.si • Web site: http://www.cankarjeva-z.si/uvoz

SPAIN
Díaz de Santos, S.A., c/ Juan Bravo, 3A, E-28006 Madrid
Telephone: +34 91 781 94 80 • Fax: +34 91 575 55 63
Email: compras@diazdesantos.es, carmela@diazdesantos.es, barcelona@diazdesantos.es, julio@diazdesantos.es
Web site: http://www.diazdesantos.es

UNITED KINGDOM
The Stationery Office Ltd, International Sales Agency, PO Box 29, Norwich, NR3 1 GN
Telephone (orders): +44 870 600 5552 • (enquiries): +44 207 873 8372 • Fax: +44 207 873 8203
Email (orders): book.orders@tso.co.uk • (enquiries): book.enquiries@tso.co.uk • Web site: http://www.tso.co.uk

On-line orders
DELTA Int. Book Wholesalers Ltd., 39 Alexandra Road, Addlestone, Surrey, KT15 2PQ
Email: info@profbooks.com • Web site: http://www.profbooks.com

Books on the Environment
Earthprint Ltd., P.O. Box 119, Stevenage SG1 4TP
Telephone: +44 1438748111 • Fax: +44 1438748844
Email: orders@earthprint.com • Web site: http://www.earthprint.com

UNITED NATIONS
Dept. I004, Room DC2-0853, First Avenue at 46th Street, New York, N.Y. 10017, USA
(UN) Telephone: +800 253-9646 or +212 963-8302 • Fax: +212 963-3489
Email: publications@un.org • Web site: http://www.un.org

UNITED STATES OF AMERICA
Bernan Associates, 4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4346
Telephone: 1-800-865-3457 • Fax: 1-800-865-3450
Email: customercare@bernan.com · Web site: http://www.bernan.com

Renouf Publishing Company Ltd., 812 Proctor Ave., Ogdensburg, NY, 13669
Telephone: +888 551 7470 (toll-free) • Fax: +888 568 8546 (toll-free)
Email: order.dept@renoufbooks.com • Web site: http://www.renoufbooks.com

Orders and requests for information may also be addressed directly to:

Marketing and Sales Unit, International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 (or 22530) • Fax: +43 1 2600 29302
Email: sales.publications@iaea.org • Web site: http://www.iaea.org/books

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA
ISBN 978–92–0–113510–0
ISSN 1011–4289