

## EXECUTIVE SUMMARY

This report describes the results of the Pre-Operational Safety Review (Pre-OSART) mission conducted at the Barakah Nuclear Power Plant in the United Arab Emirates from 16 September to 3 October 2017.

The purpose of a Pre-OSART mission is to review the operational safety performance of a nuclear power plant against the IAEA safety standards, make recommendations and suggestions for further improvement and identify good practices that can be shared with NPPs around the world.

This OSART mission reviewed twelve areas: Leadership and Management for Safety; Training and Qualification; Operations; Maintenance; Technical Support; Operating Experience Feedback; Radiation Protection; Chemistry; Emergency Preparedness and Response; Accident Management; Human – Technology – Organization Interaction; and Commissioning.

The mission was coordinated by an IAEA Team Leader and Deputy Team Leader and the team was composed of experts from Finland, France, Hungary, the Russian Federation, Slovakia, Slovenia, Spain, the United Kingdom, Ukraine and four IAEA staff members. The collective nuclear power experience of the team was approximately 430 years.

Unit 1 will be the first of the four units to be commissioned, with fuel load anticipated in 2018. The review team made plant observations on this unit and reviewed the programmes and processes that apply to the whole site. As a result of the review the team identified 21 issues resulting in 10 recommendations and 11 suggestions. 4 good practices were also identified.

Several areas of good performance were noted:

- The plant has established a leadership development programme adapted to the multi-cultural, multi-national nature of the organization, to ensure that cultural diversity is addressed, maintained and leveraged to build strong teams with a focus on safe operation.
- The plant is leading the development of the ‘qualification for nuclear positions’, administered by Nawah, and their recognition by the UAE National Qualification Authority (NQA). This allows the plant to take credit for prior learning and qualification from another NQA accredited organization, thereby reducing the amount of training and time required to produce qualified employees.
- The plant has established a good relationship with Off-site Organizations and other interested parties. This allows for rapid communications should an event occur at the plant, a forward planning function that can advise incident controllers and extensive facilities for the reception of people affected by an incident.

The most significant issues identified were:

- Plant should reinforce the effectiveness of the ‘managers in the field’ programme.
- The plant should improve the execution of its oversight of maintenance activities performed by contractors in order to ensure equipment safety and reliability.
- The plant should ensure timely development, validation and approval of a comprehensive surveillance programme and implementation procedures.

- The plant should enhance configuration control over design changes done by the contractor during construction and commissioning to assure that all design changes are reflected in Operation and Maintenance procedures, and training.

Barakah NPP management expressed their commitment to address the issues identified and invited a follow up visit in about eighteen months to review the progress.

## INTRODUCTION AND MAIN CONCLUSIONS

### INTRODUCTION

At the request of the Government of the United Arab Emirates the IAEA conducted a Pre-Operational Safety Review mission (Pre-OSART) at the Barakah Nuclear Power Plant between 15 September and 3 October 2017.

The purpose of the mission was to review operating practices in the areas of Leadership and Management for Safety; Training & Qualification; Operations; Maintenance; Technical Support; Operating Experience feedback; Radiation Protection; Chemistry; Emergency Preparedness and Response; Accident Management; Human, Technology and Organizational Interactions, and Commissioning as the plant approaches completion and prepares for the first loading of nuclear fuel to the Unit 1 reactor. In addition, an exchange of technical experience and knowledge took place between the experts and their plant counterparts on how the common goal of excellence in operational safety could be further pursued. As the plant is still under construction the review concentrated on the conditions on Unit 1 but also the integrated management programmes and procedures being instigated for whole-site operations.

The Barakah Nuclear Power Plant is located in the Al Dhafra region on the southern shore of the Arabian Gulf, approximately 53 km south-west of the city of Ruwais and 280 km west of Abu Dhabi. The surrounding area is generally flat, low lying and relatively sparsely populated. The local environment is essentially categorized as desert with high temperatures and humidity for much of the year. Four units are being constructed and commissioned at the site, each of the Korean APR-1400 design using a pressurized water reactor capable of producing 4000 MW thermal. Unit 1 is the lead unit and construction is declared to be 96% complete with commissioning at an advanced stage. Initial fuel load is anticipated in 2018 (the date was under review at the time of the mission), followed by normal initial criticality and power ascension test programmes and a short maintenance outage prior to the declaration of ‘substantial completion’. The other units follow sequentially, nominally one year apart. When fully operational the site will have a total electrical generating capacity of 5560 MW and the operating organization will employ approximately 2500 people supported by long-term contractors.

The UAE nuclear regulator is FANR (Federal Authority of Nuclear Regulation), an independent federal agency responsible for the licensing and authority of regulated activities. As well as the Authority’s main offices in Abu Dhabi there is a site office where resident inspectors are based.

The organizational structure and contractual arrangements for the construction, commissioning and operation of the Barakah NPP are unique and reflect the particular circumstances of the ‘turn-key’ nature of the plant supply and the fact that the UAE is embarking on a completely new nuclear power programme.

- ENEC, the Emirates Nuclear Energy Corporation is responsible for the design, construction and operation of Barakah. ENEC holds the license issued for construction of the plant.

- The ENEC Construction Project Office (CPO) administers the ‘prime contract’ for the project and receives Structures, Systems and Components from the constructor (KEPCO).
- KHNP is KEPCO’s operating company and is providing operational resources and expertise to the project in support of pre-operational testing and transitional commissioning of the plant to the operating organization.
- Korea Plant Services and Engineering (KPS) will provide the majority of the maintenance services to KHNP until each Unit reaches substantial completion and then to the plant through a long-term maintenance agreement (LTMA).
- Barakah One Company is the financing arm of the project and also manages the power purchase agreement for the power produced at the site.
- Nawah Energy Company will hold the operating license for the plant when it is issued by FANR. It is a private joint stock company owned 82% by ENEC and 18% by KEPCO. The Barakah plant personnel are employed by Nawah.

An important aspect of how the construction commissioning and operation of the plant is managed is the concept of Care, Custody and Control. These are the responsibility of the contractor during construction and pre-operational testing. The owner accepts control of each unit at the time the core is loaded with nuclear fuel. The owner participates in operation of plant equipment during pre-operational testing as part of their preparations to assume overall control of operations. The owner participates in operation of plant equipment after construction completion with the technical assistance of the contractor. The contractor retains the financial risk for the plant until substantial completion. The owner takes full responsibility for Care, Custody and Control and assumes financial risk of plant operation at substantial completion. Importantly: plant critical activities such as operating mode changes and reactivity and power level changes are subject to Nawah pre-review and approval and are conducted by Nawah’s certified operators in the Main Control Room.

The Barakah Pre-OSART mission was the 196th in the programme, which began in 1982. The team was composed of experts from, Finland, France, Hungary, Slovakia, Slovenia, Spain, the Russian Federation, Ukraine, the United Kingdom and four IAEA staff members. The collective nuclear power experience of the team was approximately 430 years.

Before visiting the plant, the team studied information provided by the IAEA, the plant and the corporate organization to familiarize themselves with the plant's main features; status of construction and commissioning; staff organization and responsibilities; and important programmes and procedures. During the mission, the team reviewed many of the plant's programmes and procedures, observed work in progress, and held in-depth discussions with plant personnel.

Throughout the review, the exchange of information between the review team experts and plant personnel was very open, professional and productive. Emphasis was placed on assessing the effectiveness of operational safety rather than simply the content of programmes. The conclusions of the Pre-OSART team were based on the plant's performance compared with the IAEA Safety Standards.

The following report is produced to summarize the findings in the review scope, according to the IAEA’s OSART Guidelines document. The text reflects only those areas where the team considers that a Recommendation, a Suggestion, an Encouragement, a Good Practice or a Good Performance is appropriate. In all other areas of the review scope, where the review did not reveal further safety conclusions at the time of the review, no text is included. This is reflected in the report by the omission of some paragraph numbers where no text is required.

## MAIN CONCLUSIONS

The Pre-OSART team concluded that the managers of Barakah NPP are committed to achieving and sustaining high standards of operational safety and reliability of their plant. During the mission the management team and plant staff were open, transparent and demonstrated a commitment to continuous improvement. The review team identified 21 issues resulting in 10 recommendations and 11 suggestions. 4 good practices were also identified.

The team found several areas of good performance, including the following:

- The plant has established a leadership development programme adapted to the multi-cultural, multi-national nature of the organization, to ensure that cultural diversity is addressed, maintained and leveraged to build strong teams with a focus on safe operation.
- The plant is leading the development of the ‘qualification for nuclear positions’, administered by Nawah, and their recognition by UAE National Qualification Authority (NQA). This allows the plant to take credit for prior learning and qualification from another NQA accredited organization, thereby reducing the amount of training and time required to produce qualified employees.
- The plant has established a good relationship with Off-site Organizations and other interested parties. This allows for rapid communications should an event occur at the plant, a forward planning function that can advise incident controllers and extensive facilities for the reception of people affected by an incident.

A number of proposals for improvements in operational safety were offered by the Pre-OSART team. The most significant proposals include the following:

- Plant should reinforce the effectiveness of the managers in the field programme.
- The plant should improve the execution of its oversight of maintenance activities performed by contractors in order to ensure equipment safety and reliability.
- The plant should ensure timely development, validation and approval of a comprehensive surveillance programme and implementation procedures.
- The plant should enhance configuration control over design changes done by the contractor during construction and commissioning to assure that all design changes are reflected in Operations and Maintenance procedures, and training.

The Barakah plant management expressed a determination to address the areas identified for improvement and indicated a willingness to accept a follow up visit in about eighteen to twenty four months.