



المجلس الاستشاري الدولي
INTERNATIONAL ADVISORY BOARD

Eleventh Semi-Annual Report 2015

Brief summary on the International Advisory Board for the UAE nuclear program

The International Advisory Board (IAB) was a concept first developed by the UAE government to augment the transparency of its peaceful nuclear energy program. Indeed, the commitment to form such a body was among the original commitments undertaken by the UAE government in its original white paper describing its intent to evaluate and potentially deploy peaceful nuclear energy within its borders.

More specifically, the IAB represents an unprecedented collection of internationally recognized experts in various disciplines associated with the nuclear energy sector. The board includes world-class expertise in the areas of nuclear safety, security and non-proliferation, as well as regulation, quality assurance, operations, human resource development and waste management associated with the construction, operation and decommissioning of civil nuclear power plants. Led by Dr. Hans Blix, the former Director General of the International Atomic Energy Agency (from 1997-1982), the IAB is charged with conducting semi-annual reviews of the UAE's entire peaceful nuclear energy program and subsequently preparing a semi-annual report summarizing their observations, findings and recommendations. The decision by the UAE government to make these reports available to the public in hard-copy form and over the internet represents yet another example of the latter's commitment to achieving the highest standards of transparency in its peaceful nuclear energy program.

The IAB, while not invested with any legally binding powers, has nevertheless been designed to be an independent advisory body. As stated above, after each of its semi-annual meetings, the Board will issue a report detailing the consensus views of its members with regard to the progress achieved by the program, as well as any areas of concern that merit special attention. The government will not seek to edit these consensus IAB views and will undertake to publish them free of modification, as intended by the IAB members. Notably, however, the government and the IAB membership have agreed to work together to make those modifications necessary to avoid the dissemination of any sensitive security-related information to which the IAB may have access.

While the IAB's semi-annual reports may address additional topics, they will always be required to specifically address the issues of:

1. Nuclear safety
2. Nuclear security
3. Nuclear non-proliferation
4. Program transparency
5. Program sustainability

The UAE government, and those entities involved in the UAE will use the Board's semi-annual reports to improve performance and, where necessary, allocate additional resources in order to ensure the successful implementation of the over-all program. It is hoped that the UAE populace and the international community will use the reports as an objective source of information via which they may become more informed about and follow the progress of the UAE's nuclear sector.

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Dr. Hans Blix, IAB Chairman

CHAIRMAN'S PREFACE

On behalf of the International Advisory Board I have the honour to transmit to the Government of the UAE the eleventh report of the Board and to place on record the appreciation of the Board for the extensive and valuable insights given to the Board on the progress of the UAE peaceful nuclear program. The Board was happy to see that since its last visit great progress has been made on the plant and that the program remains on time and budget. The UAE peaceful nuclear energy program is now in the stage of developing maturity. This report discusses host of items: the updated status of the Barakah Nuclear Power Plant, emergency preparedness & response readiness, construction license and progress, sever accident assessment & mitigation, NAWAH integrated management system, capacity building, physical protection as well as international cooperation.

At its next meeting the Board would appreciate further reports on the fuel and its preparation, on waste management, on the margin approach, and on tests conducted before operations.

The Board congratulates the UAE on the continued success and progress of the nuclear power program and concludes that the UAE remains fully committed to the principles of safety, security, non-proliferation, transparency and sustainability.

With respect,
Dr. Hans Blix

BOARD MEMBERS



Ambassador Thomas Graham



Mr. Takuya Hattori



Dr. KunMo Chung



Lady Barbara Thomas Judge



Dr. Mujid Kazimi



Mr. Jukka Laaksonen



Sir John Rose

Introduction



The eleventh semi-annual meeting of the International Advisory Board (IAB) for the United Arab Emirates (UAE) peaceful nuclear energy program was held in Abu Dhabi on March 15th and 16th, 2015. At the opening a moment of silence was observed, as called for by the Chairman in memory of our member Mr. Jacques Bouchard, who passed away suddenly the previous month and will be greatly missed within the IAB. The Chairman Dr. Hans Blix presided and the remaining members were all present. Prior to the ENEC briefing, Mr. Abdulla Ahmed Al Yousef Al Suwaidi, representing the Executive Affairs Authority (EAA) and its Chairman H.E. Khaldoon Al Mubarak, greeted the IAB and offered his condolences on the passing of Mr. Jacques Bouchard. Mr. Al Suwaidi also mentioned that the EAA Chairman has been looking for a new Board member with operating experience to support the UAE's nuclear energy program as it continues to develop and is near completion. Complementing the IAB membership with operational experience has been under planning from the beginning of the year and is unrelated to the unexpected sad demise of Mr. Bouchard.

The first two briefings were conducted by the Federal Authority for Nuclear Regulation

(FANR) and the Ministry of Foreign Affairs (MoFA) in the early evening of March 15th, 2015. On March 16th, 2015, the Board heard the briefing by the Emirates Nuclear Energy Corporation (ENEC), which was followed by a joint briefing from the Critical Infrastructure and Coastal Protection Authority (CICPA), FANR and ENEC, specifically with regards to the on-site security plans and the continued collaborative engagement between CICPA and ENEC. The Board conducted its private discussion following these presentations.

The UAE peaceful nuclear energy program is based on upholding the highest standards of the five principles of safety, security, non-proliferation, transparency, and sustainability. The IAB is tasked with reviewing the UAE program bi-annually and with reporting how the UAE program has adhered to these principles. As a result, and in line with previous publications, this report is divided into five sections that review each of these principles based on the presentations of the FANR, MoFA, ENEC, and CICPA. While the structure provides a clear and heavy emphasis on safety, which is appropriate, all five principles declared to be observed by the UAE program are also well covered throughout this report.

The UAE peaceful nuclear energy program



is rapidly progressing with Unit 1 at Barakah Nuclear Power Plant (Barakah NPP) scheduled to commence commercial operations in just a little over two years. [There is equal or even bigger focus on Unit 1] The other three reactors under construction at Barakah NPP are planned to commence operations at one year intervals following Unit 1.

With the global community increasingly threatened by the effects of climate change, transitioning away from fossil fuels with an emphasis on energy sources that emit less carbon is essential. While the world community has slowly been reacting to this challenge, the UAE is among a few nations globally that is leading by example. It is expected by 2020, when Unit 4, is scheduled to commence operations that up to 25% of the UAE's electricity production will be generated from safe, clean, reliable nuclear energy.

Safety

Safety assessment and recommendation

FANR Director General and his staff briefed the Board on the main safety issues that FANR is currently addressing in its work. He was accompanied by senior staff members John Loy, Ian Grant, Saif Al Kaabi, Mohammed Al Zaabi, Rashad Al Falahi, and Osama Al Shekhi.

A short summary of safety-related developments since the last IAB Board meeting included the following:

- Preparation of the application for plant operation.
- FANR is expecting to receive the Operating License Application (OLA) from ENEC for Units 1 and 2 by March 27, 2015.
- A pre-submittal meeting has been held with ENEC on March 12, 2015. Review and assessment work for the operating license by FANR will last until October 2016; which is the prospective time of issuing the operating license.
- There are three resident inspectors of FANR working at the Barakah NPP site.
- The relevant Technical Service Organization (TSO) contracts, concerning independent analysis and advice to FANR to support its review of the OLA were ready for approval by the FANR Board of Management.

Other items mentioned included the notice that the regulation for pre-disposal management of radioactive waste has been approved. The regulation for the import and export of nuclear related items and nuclear related dual-use items has entered into force. There was an IAEA technical visit to Barakah NPP to support the implementation of a safeguards system for accounting for and control of nuclear material. This visit identified possible positions for IAEA surveillance equipment (cameras, seals and servers). The Director General noted that it is important to develop the infrastructure of inspections, both for equipment and procedures. Lastly, the FANR Board meets every few months and its members remain very active.

The IAEA Integrated Regulatory Review Services (IRRS) follow up mission was completed. The IAEA Emergency Preparedness Mission (EPREV) mission is scheduled to take place on March 21-31. This is a follow up from the 2011 mission. There

will be ten IAEA officials present for two weeks. The mission will be reviewing emergency response capabilities.

During the follow up mission of the IRRS, the IAEA team determined that the responses to 13 out of 14 recommendations and 30 of 34 suggestions had been effectively addressed and therefore could be considered closed. This is an excellent achievement by FANR.

However, the IRRS mission noted the following areas are still in need of development:

- The Government of the UAE should develop a national policy and strategy for the management and disposal of spent nuclear fuel and radioactive waste.
- FANR should consider strengthening its capacity to implement its regulations on the safe transport of radioactive material.
- FANR should consider developing a procedure, to be included in its integrated management system, to periodically review its regulations and guides to maintain consistency across the different regulated facilities and activities.
- The Government of the UAE should issue a Resolution on administrative penalties and fines, to provide FANR with the necessary authority to enforce its regulations.
- FANR and the relevant health authorities should develop and publish reference levels for radiation doses that patients are exposed to in connection with x-ray diagnostics.

ENEC will seek to request FANR to issue the operating license for Unit 1 prior to October 1, 2016 as nuclear fuel may only be loaded into the reactor of Unit 1 once the license is issued. In order to receive the license on schedule, ENEC has deployed significant efforts to ensure the quality and accuracy of the Final Safety Analysis Report (FSAR). Its overall content is consistent with FANR requirements and the application also covers the Physical Protection Plan (PPP). The focus will be on changes to the design since the FSAR was issued, as well as the operating organization and detailed operational plans. There will also be an inspection program to verify the as-built status of the plant, plus successful "non-nuclear" commissioning.

Safety assessment and recommendation



Nuclear fuel is expected to be first delivered to the Barakah NPP site in 2016. The construction license did not authorize receipt of nuclear material, therefore, ENEC has applied for a license to possess and use nuclear material in accordance with FANR regulations. Licenses will also be required to cover the safety and security of storage of nuclear fuel, as well as its import and transfer within the UAE.

During its tenth meeting the IAB expressed its interest to hear an integrated summary of all physical phenomena that have been assessed as potential threats to the containment integrity, in the event of severe reactor core damage (i.e. fuel meltdown). In addition, a FANR conclusion on the adequacy of the measures to protect the containment as the last barrier to prevent radioactive releases was expected.

FANR presented an assessment of severe accidents regarding Barakah NPP. The presentation highlighted that to date, FANR's found that the Barakah NPP satisfies FANR requirements for prevention of severe reactor damage and for mitigation should the prevention fail. FANR also informed the Board that ENEC has committed to providing a revised Severe Accident Analysis Report (SAAR) that outlines how the analytical models and computer codes used in the analysis have been verified. Furthermore, FANR presented a summary of physical phenomena that have been assessed as potential threats to the containment integrity. These threats are the following:

- **In-vessel and ex-vessel steam explosion:** Steam-explosion caused by dropping of molten reactor core material into water is a phenomenon that cannot be excluded in the Barakah NPP design. However, FANR has concluded that the largest conceivable pressure and impulse loads from potential steam explosions have been shown to be with adequate margins less than what the reactor vessel, in the in-vessel case, and the robust containment structures, in the ex-vessel case, can withstand such an impact.
- **Molten core concrete interaction:** Interaction between the molten core, postulated to have dropped to the reactor cavity, and the concrete floor of the cavity has been extensively studied with two of the most advanced computer codes that are recognized worldwide. The calculation model was tailored to the Barakah NPP scenario and calculations have been done independently by KEPCO, ENEC, and a specialized organization working for FANR. Calculations have shown that the molten core will be cooled and transformed into a solid state before the concrete floor erosion has progressed close to the leak-tight steel liner of the containment.
- **High pressure melt ejection from the reactor vessel:** FANR has analyzed the performance and assessed the reliability of the system that is designed to provide rapid depressurization of the reactor coolant system to a low pressure before the reactor vessel would be breached

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by impact of the molten core. FANR has concluded that the high pressure failure of the reactor vessel has been practically eliminated by the pressure relief system and there is no risk of violent melt ejection that would endanger the integrity of the reactor containment.

- **Combustible gas (hydrogen) control:** ENEC has calculated the maximum conceivable rate and amount of hydrogen generation in chemical reaction (oxidation) between high temperature core metals and water. This has been used as a basis for designing a system that reduces hydrogen concentration in the containment. FANR considers control and limitation of hydrogen accumulation inside the containment to be adequate.
- **Containment overpressure:** A dedicated system called "emergency containment spray back-up system" is included in the Barakah NPP design, taking into account the lessons learned from the Fukushima Daiichi accident. It uses mobile pumps to inject water to the containment through spray system pipes; in the event that the permanently installed spray system pumps malfunction. Based on the analysis presented by ENEC, FANR has concluded that the start of the spray system within 24 hours from the onset of core damage is adequate to prevent containment overpressure.
- **Containment bypass:** FANR has concluded that the design features and the credited operator actions are adequate to eliminate the potential leak paths that could by-pass the containment boundary via pipelines and cause radiological doses to exceed acceptance criteria.

FANR informed the IAB that it is participating in the multinational safety review of the APR-1400 type plant, starting as part of the Multinational Design Evaluation Program (MDEP) coordinated by the Nuclear Energy Agency of the Organization of Economic Cooperation and Development (OECD). This review is a joint project consisting of several nuclear safety regulators who are assessing APR-1400 safety in their own countries. The results of MDEP will comprise common regulatory positions on selected safety features of APR-1400 type plant. Furthermore, the Board was informed that the US NRC has

started a generic safety review of the APR-1400 type nuclear power plant, for issuing a Design Certificate to be used in the licensing of such plants in the USA.

The briefing on Barakah NPP's current status by ENEC was provided by several members of the company leadership and senior staff. The ENEC Chief Nuclear Officer (CNO), spoke first and introduced the Chief Program Officer (CPO) of ENEC.

At the beginning of the ENEC presentation, ENEC's CNO explained that every meeting at ENEC begins with a safety moment. He then related how off-site power was lost to Brunswick 1 and 2 power station in the United States in 1993 when salt deposits on switchyard insulators were rewetted and caused ground contact. The insulators had been inspected but the salt deposits were not visible on the dry white insulators. The significance of this event for Barakah is that it emphasizes the importance of being able to quickly identify and resolve issues before they arise to be problematic. With respect to this type of issue ENEC needs to regularly review its maintenance programs to ensure that lessons learned from other plants are incorporated into the program. In this case, risk caused by salt or dust deposits on the switchyard insulators would be eliminated by adequate maintenance and cleaning.

At this point the ENEC's CEO Mohamed Al Hammadi added that ENEC had already considered how to protect the insulators from sea water. The CEO stated that TRANSCO has considerable experience with this issue and experts there have worked on this problem. In addition, ENEC's CEO stated that the traditional design has already been improved by using contained insulators where salt deposits cannot accumulate.

Dr. Chung questioned who ENEC plans to interact with for support if something abnormal happens as it is important that the staff at Barakah understand the procedure. ENEC's CNO replied that in 2011 ENEC signed an agreement with Korea Hydro and Nuclear Power (KHNP) which calls for KHNP to provide the staff at Barakah NPP with names and dedicated channels on who and how you call for support.

Presently the operating staff at Barakah NPP

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is six percent Korean. However, ENEC is hiring additional Korean nuclear professionals, particularly experienced nuclear power plant experts who have recently retired but want to rejoin the industry for a few more years. ENEC expects to hire in the range of 300-400 more employees. In addition, Emiratis are beginning to develop to senior positions as part of ENEC's training program.

Lady Barbara inquired about expert hires from other countries. ENEC's CNO responded that there was a considerable amount of them. Mr. Hattori interjected that it was important to hire the best. ENEC's CNO replied that ENEC has a very sophisticated recruitment and training program aimed at determining who is going to work on what.

There has been significant progress in plant construction since the last Board meeting. Unit 1 construction is far advanced on the reactor containment building and the turbine generator building. The water intake structure is also expected to be on line in less than two months. With regards to Unit 2, construction of the containment vessel and construction of the turbine generator building are moving along smoothly. Unit 3, is expected to have the containment vessel walls by the summer and will begin rising as the containment liner is set. Lastly, Unit 4's basemat ground works are being constructed as it is required prior to the deployment of rebars. The casting of the concrete on the bottom plates of the reactor containment building and the turbine generator building are close to completion. This is in line with preparation for the placement of the first safety concrete for Unit 4, scheduled for Q3 2015. With respect to Units 2, 3 and 4, each is about one year behind its immediate predecessor. Unit 1 is 69.1% complete and Unit 2 is at 43.2%.

ENEC also gave a presentation on its future operating company's Integrated Management System (IMS). ENEC's operating entity is currently under formal establishment and will operate the Barakah NPP. In developing the IMS, ENEC studied the models of several foreign organizations involved in nuclear power that included KHNP, Exelon, Bruce Power, Duke Energy, Tennessee Valley Authority, EDF Energy, British Energy, and Sellafield. There were also site visits to Leibstadt NPP in

Switzerland and Koeberg NPP in South Africa. ENEC's operating company will follow the regulations and standards of FANR, the UAE federal government, WANO and the IAEA.

ENEC's future operating company will be a multinational, multicultural and Emirati-led organization with a robust safety culture underpinning the conduct of all safety related tasks. The IMS Summary Document defines the way officials work and the IMS handbook provides the information that employees need to know. Nuclear programs in the IMS exist through the lifetime of the power plant and each program will have a dedicated owner. The IMS Procedures are a standardized set of work instructions. There are 3,000 dedicated procedures which are safety related. The entire integrated process model was presented to FANR in three meetings. Recent achievements include: a navigational tool that integrates IMS (documents and systems) through multiple levels across the organization; the publication of the first revision of the IMS Summary Policy and the first releases of the Handbook, and the early submittal to FANR of Chapter 13- Conduct Operations of the Final Safety Analysis Report and the Quality Assurance manual.

During responses to questions, it was pointed out that ENEC's future operating company's system of management is based on European systems and it also parallels how Exelon in the United States is managed. ENEC's CNO added that safety is embedded into all activities and there is a booklet describing this. All employees receive the handbook along with the policy summary.

Once operational, there will be joint crews in all control rooms: Koreans, Emiratis and other expats. Once ENEC's operating company is formally established it will be the plant operator and operating license holder that has full liability for the safety of the plant and protecting the health and safety of the public; the Korean operators are part of the operations support activity for the Barakah NPP for at least 10 years. Each shift manager must have 20-25 years' experience. Success of Unit 1 will be an indication for the future. The briefing then turned to the Corrective Action Program (CAP). The CAP in its most basic form is the process by which ENEC identifies, analyzes and corrects its problems

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at the lowest level of consequence in order to prevent larger problems. FANR provides regulations for the program and internationally INPO and WANO provide industry guidance for the program through INPO 09-011, Achieving Excellence in Performance Improvement. The IAEA also provides guidance through its guideline, the Management System for Nuclear Installations. The CAP reached the initial stage of operational readiness in 2014 and stage 2 of its readiness was in place on March 31 of this year. These programs represent a healthy culture for identifying and resolving problems.

The briefing then turned to the issue of severe accident control and mitigation. ENEC's CNO noted that FANR had required ENEC to establish an effective accident management program. ENEC is in discussion with utilities around the world, and this is very much a work in process. Dr. Kazimi asked what the objectives of the program are. ENEC's CNO said that the first action in this program is to analyze previous significant accidents and to demonstrate that a Fukushima-type incident would not cause large radioactive release in the APR-1400 design. ENEC's CNO promised to report at the next IAB meeting on how Barakah NPP technology compares to what was used at Fukushima and an update on the actions of the Task Force. There were 38 actions stated in the 'Lessons learned from Fukushima' report and the Barakah NPP is the only new-build in the world to be implementing these many modifications.

The part of the ENEC briefing, "Potential Threats to Reactor Containment Integrity," tracked in substance the presentation by FANR the evening before. FANR REG-03 specifies that for accidents beyond the design basis, including severe accidents, best estimate methods may be used. The SAAR has been revised to present analysis of the single best estimate/realistic event using code MAAP 5.03.

When ENEC used a computer code specifically developed to calculate accurately the molten core cooling and core-concrete interaction in the reactor cavity, it was able to make an improved analysis and ended up – pursuant to the analysis – with a wider safety margin

than was previously thought to exist. FANR pushed ENEC to a safety margin-oriented approach that emphasizes the importance of healthy margins beyond design basis, in order to avoid "cliff edge" effects where a small deviation of acceptance criteria would lead to disproportionate consequences. Dr. Kazimi replied that this is exactly the problem – safety margin must always be added beyond the design basis limits; nobody in the United States or Korea has specified this margin. ENEC's CNO in response said that ENEC will retain a certain margin right now but will work to increase this over time. This margin management program is over and above the regulations set by FANR. ENEC advised it has made changes in the plant to get more safety margin beyond design basis.

The following issues were considered in an integrated assessment of potential threats to containment integrity as set forth by ENEC:

- Hydrogen Generation and Control
- Molten Core Concrete Integration
 - Containment Bottom Melt-through
- Fuel Coolant Interaction
 - In-Vessel Steam Explosion
 - Ex-Vessel Steam Explosion
 - Steam Spike
- High Pressure Melt Ejection (HPME) and Direct Containment Heating (DCH)
- Slow pressure increase inside the Containment

It was noted that the OLA submittal for Units 1 and 2 was imminent and the SAAR which will accompany the application has been concluded to reflect this analysis.

The most significant initiating event for an accident involving the highest contribution to core damage frequency is the Station Blackout (SBO), i.e. Loss of Offsite Power (LOOP) and failure of all onsite Emergency Diesel Generators.

For hydrogen generation and control, the two model cases were hydrogen generation due to metal water reaction and hydrogen generation due to molten core concrete interaction. Criteria for successful control were:

- Maintain hydrogen concentrations below

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- 10% by volume
- Demonstrate that no local hydrogen concentrations have the potential for detonation
- Demonstrate that the containment can withstand the pressure due to deflagration of hydrogen

The results of the analyses indicate that operation of the Hydrogen Mitigation System (HMS) keeps hydrogen concentrations generally below 10% due to the large volume of the containment. Temporary concentrations exceeding 10% in certain compartments are mitigated quickly.

In addressing the molten core concrete interaction and debris coolability for the OLA, it was observed that a relatively large amount of gas contained in the limestone concrete at Barakah is conducive to melt eruption. Melt eruption is the dominant cooling mechanism to stop erosion in the reactor cavity. The conclusions were that core debris on the cavity floor is quenched after only minor concrete erosion and is thus solidified with large margin before challenging the containment boundary. Also in the cavity sump ("drain" in the cavity floor), concrete ablation is stopped well before the containment liner. Dr. Kazimi commented that limestone concrete is more forgiving; he worked on that issue while Argonne National Laboratory was conducting experiments to simulate core-concrete interactions.

Another issue of potential concern is a fuel-coolant interaction caused by contact between hot fuel and the water coolant. An in-vessel steam explosion may occur as corium relocates to the reactor vessel lower head and an ex-vessel steam explosion can take place in a flooded reactor cavity following a reactor vessel failure. Also a non-explosive reaction – a steam spike – may occur because of contact between the reactor core material discharged from a breached reactor vessel and the underlying water in the reactor cavity. The various computational codes that were applied to these cases indicated that in this reactor design the maximum strain after in-vessel explosion remains far below the allowable limit of the reactor vessel and an ex-vessel explosion would not cause pressure higher than fifty percent of the critical containment pressure. The steam spike would also be well below the containment

performance.

A reactor vessel failure during high-pressure could result in core debris being ejected from the vessel. This would lead to Direct Containment Heating (DCH), which means a rapid temperature rise and high pressure inside containment as a result of the direct transfer of corium debris heat into the containment atmosphere. The Safety Depressurization and Vent System (SDVS) prevents the occurrence of high pressure melt ejection by rapidly depressurizing the reactor coolant system before reactor vessel failure. When analyzing the slow containment pressure increase, caused by complete loss of containment heat removal capability in parallel with core meltdown accident, it was found that during the initial 24 hours containment pressure does not exceed allowable containment pressure. After this period, it can be assumed that the emergency containment spray back-up system will reduce and control low temperature and pressure.

In summary, severe accident mitigation features at Barakah NNP, the performance of which has been analyzed include:

- Large dry pre-stressed concrete containment.
- An emergency containment spray back-up system, based on use of mobile pumps such as fire engine pumps.
- A gravity driven cavity flooding system to cool down corium that would drop to the reactor cavity after reactor pressure failure.
- The Hydrogen Mitigation System (HMS) to control in-containment hydrogen concentrations and to prevent concentration from reaching levels where flame acceleration could occur. It includes passive and catalytic recombiners and igniters.
- The SDVS which involves motor operator three-way valves for rapid depressurizing of the reactor coolant before reactor vessel failure, to preclude HPME causing DCH. The system can divert hydrogen or other materials blown out of the reactor vessel to a safer area. Dr. Kazimi asked how this operated and ENEC's CNO promised to give an answer at the next meeting.
- A robust and convoluted reactor cavity design which includes a large cavity floor volume.

Security

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FANR included in its briefing a discussion of physical protection for operations. The OLA will include:

- The physical protection plan for operations (PPP-O) including the security organization on site (to be defined taking into account the February, 2015 visit to France by FANR, CICPA and ENEC).
- The cyber security plan
- A target set analysis
- A vulnerability assessment
- The contingency plan

The PPP for the transportation of nuclear material as well as the PPP for the temporary storage of nuclear fuel is to be developed and submitted to FANR.

Much effort is going into cooperation and future collaboration in nuclear security. There was the aforementioned visit to France in February to discuss the physical protection of nuclear power plants. An MOU with the French Security Authority is to be drafted. An MOU with CNSC Canada is being prepared and FANR will participate in the IPPAS mission in Canada at the end of 2015. There is a general effort underway by countries to harmonize their efforts in physical protection.

In its tenth meeting the IAB requested joint presentations by ENEC and CICPA on the on-site security plans and the continued collaborative working between CICPA and ENEC.

In their presentations ENEC and CICPA indicated that the Physical Protection Plan

(PPP) and Physical Protection System (PPS) are being jointly developed by these two organizations and FANR. Work takes place in stages that take into account the progress of the project. Joint benchmarking and training missions to foreign countries have been made to learn about practices elsewhere.

The PPS is reviewed by experienced nuclear engineers, including the technical director of the ENEC Chief Program Office, and site security operations are discussed in weekly meetings. Safety and security interface is coordinated also in daily meetings. Continuous presence of the security organization on site is most helpful to develop mutual understanding. The regulations issued by FANR express very clearly that the authority of the senior on-shift nuclear plant supervisor shall take precedence over the security shift supervisor regarding the control of access to equipment and information important to safety.

Representatives of ENEC and CICPA assured the IAB that they understand in the same way who is the "captain of the ship" in contingency events. The safety and security interface will be further clarified in the PPP for Operations Stage, which will be submitted to FANR in connection with the OLA.

ENEC and CICPA continue to coordinate on the division of responsibility and are working jointly to ensure Barakah NPP complies with FANR regulation.

In its presentation CICPA began with its program of capacity building. Nuclear security training is developed in cooperation with the

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U.S. Department of Energy. A comprehensive training and qualification plan, which is site specific, has been developed. There is also a related program at Khalifa University. Two workshops with U.S. Department of Energy in the UAE have been hosted by CICPA.

The first, December 15-19, 2013, focused on physical protection for nuclear facilities and material. The second, on vital area identification, was held June 15-19, 2014. These workshops were attended by FANR and ENEC personnel.

There was a discussion of the historical evolution of the DBT and the Vulnerability Assessment which is based on the DBT. This assessment is part of a continually evolving process through the design phases. There is a continuing re-evaluation of the Vulnerability Assessment, both with respect to physical systems as well as staffing and response. An MOU was signed by CICPA and ENEC in 2011. Roles and responsibilities were established for the construction phase at Barakah NPP and the development of a matrix for the operations phase is underway. This includes the areas of training, operations, the safety/security interface and emergency preparedness. In addition to the safety/security interface, there are also collaborative programs between CICPA and ENEC on management systems, nuclear quality assurance and security operations procedures. Another collaborative program which should be mentioned is the Fitness for Duty program. In this context CICPA has implemented a behavioral observation plan to meet regulatory requirements. The ENEC and CICPA Fitness for Duty programs will be separate but closely aligned and consistent. ENEC has the first responsibility in incident and event reporting, however the CICPA plan co-ordinates and is consistent with it.

Non-proliferation

Non-proliferation assessment and recommendations

In line with previous meetings, the MoFA briefing focused primarily on international cooperation and non-proliferation issues. The MoFA briefing was presented by Ambassador Hamad Al Kaabi.

Ambassador Al Kaabi described first the growing close cooperation between the UAE and the IAEA.

The UAE obtains assistance and advice from IAEA experts, and requests peer reviews by the IAEA and assistance in developing its work and its standards. In 2014, there were more than 714 UAE participants in 150 IAEA activities. More than 59% of the participants were Emiratis. The three main areas of focus with respect to UAE activities with the IAEA are 1) nuclear safety and security, 2) nuclear infrastructure, and 3) emergency preparedness and response.

In 2014, the UAE also contributed to IAEA programs by providing more than 55 experts to 45 IAEA activities, primarily from FANR. The total number of UAE participants contributing to IAEA programs has continued to increase from year to year.

The IAEA technical cooperation (TC) program is the primary mechanism through which the IAEA helps the UAE to build, strengthen and maintain a safe, peaceful and secure nuclear program. In 2014, there were 7 national TC projects along with 16 regional TC projects and 3 that were international. In 2016-2017, the UAE will have 5 new national TC projects with additional support dedicated to the infrastructure for Radiation, Transport and Waste Safety and for Nuclear Emergency Preparedness and Response. Focused efforts such as the integrated work plan with the IAEA and TC projects are meant to strengthen and make more effective the UAE/IAEA partnership and are a response to the evolving needs of the nuclear program beyond 2017.

As part of the deep interest and commitment of the UAE to international nuclear affairs, MoFA has established an International Nuclear

Cooperation Office. The Office's main role will be to support the country's growing interests related to nuclear energy and nuclear non-proliferation. It will support and coordinate all of the international activities in nuclear related fields, will manage in cooperation with relevant government agencies the UAE's adherence to all international related obligations, and ensure an adequate representation of the country in diplomatic and international fora.

After discussion on international co-operation, Ambassador Al Kaabi turned to developments within the Nuclear Non-Proliferation Treaty (NPT) regime. He noted that at the 2010 NPT Review Conference an action plan document containing 64 actions was adopted. The 2015 Review Conference is coming up soon, scheduled for April-May 2015, in New York. It will face many challenges:

- Slow progress on nuclear disarmament. Distrust continues to grow between the nuclear weapon states parties and the non-nuclear weapon states parties.
- No progress on the issue of a dialogue, promised in 2010, on a weapons of mass destruction free zone in the Middle East.
- The changing security environment.
- The humanitarian impact of nuclear weapons. (The UAE recently joined the Austrian Pledge to agree to stigmatize nuclear weapons and to support serious discussion of the elimination of nuclear weapons in UN fora.)

The Board raised some questions following the presentation. Dr. Chung noted that Ambassador Al Kaabi had not mentioned cooperation among GCC nations. The Board was interested in learning more about the status of GCC cooperation and also about small modular reactors (SMR) in the region. The Ambassador responded that the UAE and Korea have the intent of working together with other countries on nuclear power issues to some degree. The UAE is working on an agreement for cooperation with the Kingdom of Saudi Arabia. Dr. Chung noted that the APR-1400 is on the US-NRC docket for its design

Non-proliferation assessment and recommendations

certification review. The APR-1400 is based on the US technology; information on the safety of that plant type should be shared so that all benefit. Ambassador Al Kaabi agreed that there should be continuous cooperation and high level discussions between the UAE and Korea and others. It is positive news that the US-NRC is willing to share APR-1400 review information with others. Agreements exist between the UAE and many experienced countries – but not with China yet. The UAE continues to build the right partnerships with all relevant international players.

The Chairman followed up by asking the Ambassador about safety. The Ambassador responded that after the post-Fukushima meeting there was an immediate global emphasis on safety. The Europeans took stress testing to a high level while every country also conducted their own stress tests including the UAE, China and others. The Swiss, at the 2014 Convention on Nuclear Safety Review Conference, proposed to amend Article 18 of the Convention to require stricter standards for nuclear power plant construction and safety improvements. If the Convention is amended countries will move faster towards adhering to the convention, the Swiss argued. Some non-European nuclear power countries however did not believe an amendment was needed at that time. In addition, to implement an amendment a diplomatic conference was required, as opposed to a review conference. It was agreed to hold a diplomatic conference within one year, and the UAE stated that

progressing on safety was part of its national policy in line with its vote for the diplomatic conference.

At the Diplomatic Conference, held in February 2015, the UAE, among others argued that only a majority vote for the amendment would be the wrong message to send on safety. There was therefore a compromise, a declaration that all states are guided by what are the IAEA safety standards on this issue, this was approved by all parties.

Chairman Blix noted that it was common to refer to 'renewables.' As the UAE has a large nuclear power program which represents sustainable energy, it would be desirable to normally use the term 'sustainable energy' that covers both renewables and nuclear power, neither of which generates CO₂. The Chairman went on to say there is no progress with respect to the proposal for a conference to discuss weapons of mass destruction / nuclear weapon free zone in the Middle East. He expressed the hope that this would change. The UAE made an important contribution in forswearing enrichment and reprocessing. The zone to be negotiated, in his view, should also cover enrichment and reprocessing in addition to weapons and fissile material for weapons. Ambassador Al Kaabi replied that the UAE approach of forgoing enrichment and reprocessing would indeed help to build more regional confidence when it comes to nuclear non-proliferation, but some countries in the region may not be willing to follow these steps.



Transparency

Transparency assessment and recommendations



Public outreach sessions were conducted by FANR in Fujairah and Ras Al Khaimah during the past several months.

Sustainability

Sustainability assessment and recommendations

FANR stated that its Board approved FANR's Education and Training policy, an important step in the realization of sustainability initiatives.

ENEC also delivered a positive report on the subject of sustainability. ENEC's HR Director and the Corporate Training Manager presented ENEC's report to the Board. Currently, ENEC has 1,469 staff members, 38 nationalities, of which 62% of these staff members are Emirati and women make up 21% of the work force. There were 509 new employees in 2014, 103 new employees in the first two months of 2015, and 450 new employees that are projected for the remainder of the year.

ENEC CEO, intervened and said that, "ENEC is changing the rules," especially with women but also with an extremely high level of qualifications that are required of all employees. "If one woman is hired, she brings 10 and they bring 100. ENEC's staff is nearly 1,500 people, we set our standards high. The oil and gas community is very impressed. We need to continue raising the bar." ENEC's CNO added that the organization's future operating entity will follow ENEC with 20% as 700 employees were females at the end of 2014 while over 50% of its top performers are females. The CEO also said that ENEC began recruiting for every vacant position beginning in 2014, with 30 per month at the beginning of the year, and reaching 80 per month by the end of the year. An ENEC employee, Head of Site Communications, engages females in a common community, which helps them stay despite the remote location of Barakah NPP. There are 50 female employees working at the Barakah NPP site. The site is gender friendly with facilities that include female gyms and a community clubhouse amongst other things.

Lady Barbara responded to this saying that this is the Gold Standard, not just only for forgoing enrichment but also everywhere. Diversity is an important part of that- "My congratulations!" In the U.S., UK, and Japan it is women who are most vocally critical of nuclear energy, so diversity is good for the plant and the nuclear industry overall.

The presentation then turned to scholarship programs. ENEC's Energy Pioneers program for Units 1 and 2 currently has 231 students in total.

Sixty of these students are Reactor Operators and Senior Reactor Operators who will complete their training in three to four months. 92 students have completed their training, and 139 students are still in progress. For Units 3 and 4, 280 students will be trained. There are also 143 male students and 25 female students in the Bachelor of Engineering program. 60% of these students are studying at Khalifa University and 40% outside of the UAE, mostly in US universities. 21 students to date have graduated with a degree of Bachelor of Engineering. There are also nine students of which four are females that are seeking Master's degrees in Nuclear Engineering and one student in the Ph.D. program for Nuclear Engineering at MIT. There are also 209 students at Abu Dhabi Polytechnic seeking the Higher Diploma in Nuclear Technology. This course is for maintenance technicians (mechanical, electric, and I&C), local operators, chemistry specialists and radiation protection specialists. Finally, there are 22 being trained as Reactor Operators and Senior Reactor Operators in Korea by KHNP. Once the students return, they are expected to return to the UAE and receive further training at Barakah NPP.

The total workforce at Barakah NPP is now 17,571. This includes 1,077 Koreans working primarily on the power block along with 13,407 workers from various other nationalities. On infrastructure related work, there are 56 Koreans along with another 1,795 others currently on site.

ENEC emphasized on the progress made in recruiting and training of staff for the Barakah NPP operating organization. It was noted that sustainability of the operating organization is confirmed by significant overstaffing. A minimum number of 18 licensed operators are needed for each Unit, to operate the Unit with six shift crews. At the time of the IAB meeting, 101 Senior Reactor Operators and Reactor Operators were in training for Units 1 and 2, while another 20 operators are being trained for Units 3 and 4. The number of trained field operators already exceeds the minimum number required. ENEC's management explained that the trained operators will be used for many other tasks that are necessary to support plant commissioning and normal operations.

Sustainability assessment and recommendations

ENEC's CNO stated that the digital control room requires three officers to operate it, and 50 officers per reactor on the team, working outside the Main Control Room (MCR), of the plant. ENEC staff will begin to occupy the control room prior to the fuel load. It is scheduled that the control room will be occupied by mid-2016 and the fuel loaded by the end of 2016. Most of the Emirati Reactor Operators and Senior Reactor Operators are currently in the ENEC Energy Pioneers Program, and will be returning from South Korea in time for commissioning. There will be 130 of the Reactor Officers for Unit 1 but then more will be needed for Unit 2.

Mr. Laaksonen asked whether there will be enough work for such large numbers of staff. The CEO responded that there will be adequate work as part of the project as a large number of engineers will be needed in maintenance. ENEC's CNO said that ENEC is planning for a 20% turnover, also adding that there will be plenty of work to do. It was also mentioned that there are 3,000 operating procedures and that every one of them has to be worked on. It is a good time to get everyone to see the plant from the inside before it starts up. The ENEC Chief Program Officer (CPO) noted that ENEC was working hard to maintain the one year divide for Units 3 and 4. Beginning in 2009 the program has been set up to complete construction of Units 1, 2, 3 and then 4 with a deployment of one unit per year. The UAE has been one of a few countries able to do stage the plant deployment and it is now. It is now yielding the benefits of complimenting the training and commissioning schedule. The operating organization requires one year at a time for commissioning each unit as planned.

Ambassador Graham asked about the price of oil, whether its decline had affected the program in any way. ENEC's CNO and ENEC's CPO all participated in the dialogue that followed. Construction has not been affected at all and that inspections had now increased given there was more equipment on site. The CEO said that ENEC was trying to be economical, cutting things that were not deemed necessary, however safety was and will never be compromised. ENEC's CNO added that ENEC sticks with the Gold Standard.

The CEO further added that ENEC stays with the five principles no matter what. The Abu Dhabi Crown Prince in his Government Summit speech had invited the crowd of 4,000 to come to the startup of power in 2017. Lastly, a senior Korean official had said to the ENEC CEO at a recent lunch, that Korea had learned nuclear technology from the Americans. He said, "I studied just like you, now I am teaching you."

ENEC's CNO also commented on recruitment. Two opportunities that had presented themselves to ENEC with regards to acquiring talent. First was that U.S. nuclear power plants were closing and highly capable people were becoming available, and second the retirement age in Korea being at 58, meant a number of outstanding Korean experts and executives were made available who wanted to continue their careers. ENEC's CPO said that the program is doing well because of its great partner, highly focused Korean workers and management, and the strong support of the UAE government.

The IAB Chairman, Dr. Blix, asked about retention. ENEC's CNO replied that everyone is committed to stay for the plant start-up and that staff departures are trending down.

Lady Barbara asked about after hour social opportunities. ENEC's CPO replied that ENEC was working hard on that, tournaments of all types, there were 100 participants in a dart tournament recently.

ENEC's CNO intervened to say that ENEC was hiring expat experts and putting them at a somewhat lower level to mentor Emiratis as mentoring is a full time job at ENEC.

Chairman Blix said that speaking again of leisure time, you need not just darts but intellectual activities as well. The CEO and others strongly agreed with this. Chairman Blix added, "You are now engaged in a great adventure," but after operations begin, there is the day to day routine. Some people need the chance to advance, to move on, employees should be encouraged to move on to a new phase, "another great adventure."

Conclusion



The IAB considered the presentations by FANR and ENEC on mitigation of severe reactor accident consequences very thorough and informative. Both parties have properly addressed the related safety issues and have come close to the final conclusion that the Barakah NPP design is adequate for protecting the environment from significant radioactive releases. However, the IAB considered that in addition to the ongoing validation of the computer codes, a few issues still need attention:

- A lesson from the Fukushima Daiichi accident was that a major contributor to the core melt was the difficulty of relieving primary coolant circuit pressure when control power to the relief valves had been lost. Pressure relief in all severe accident conditions is one of the key actions to be taken by the operators and increases the options for successful accident management. This possibility should be confirmed also after loss of normal control means. In order to manage properly severe accidents, it is necessary to give the operators unambiguous guidance on the accident stage where they should deviate from the normal operating rules and take emergency actions to avoid serious core damage, even though it might cause damage to some other plant equipment. For instance, they could be advised on

the conditions for starting fast pressure release from the primary circuit, in order to permit water injection into the primary circuit by means of low pressure pumps. Basis for such advice should be proven by an analysis of the respective scenario.

- Possible need to release non-condensable gas from the containment after serious core damage should be analyzed. Gas could be generated for instance in connection with concrete erosion. If necessary, a method for gas release should be planned.

Also, the margin approach is viable but should not neglect the probabilistic approach. The Board would like to hear ENEC explain at the next meeting its rationale for adopting the margin approach and how to decide on the appropriate margin.

The IAB was satisfied with the information on the safety and security interface, provided by ENEC and CICPA in their presentations.

The Board welcomed greater emphasis on security and non-proliferation and encouraged the exchange of information between Korea and ENEC; and also took note of the exchange of information within the umbrella of US-NRC, KINS and FANR – praise for that.



The Board was pleased to hear from ENEC that there would be no reduction in inspections or in readiness in Operations because of the decline in the price of oil. The Board noted that there is now a certain dynamism being demonstrated by ENEC. ENEC is also doing amazingly well with women – much praise for this.

ENEC's future operating company will eventually be the operating license holder, with Korean staff operating the plant, alongside Emirati and other expat Reactor Operators, at least for some time. The Board would like to hear if this future operating entity will have liability all the time?

Congratulations from the Board for firmly scheduling reactor units for start-up at one year intervals from the previous one. The Board would like to hear more about tests conducted before operations. It appears that corrective actions are applied quickly enough and there is no backlog – praise for this.

The Board asked whether there is any progress on waste management. Also at the next meeting the Board would like to learn more about the fuel and its preparation.

The Board expressed its gratitude once more to the UAE and the supporting entities for outstanding and informative presentations at this eleventh meeting of the Board. The IAB congratulated the UAE on the continuing success and progress of the nuclear power program and found that the UAE in its program remains fully committed to the principles of safety, security, non-proliferation, transparency, and sustainability.

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