



المجلس الاستشاري الدولي
INTERNATIONAL ADVISORY BOARD

Tenth Semi-Annual Report 2014

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.

Contents

Introduction	1
Safety	2
Security	5
Non-proliferation	7
Transparency	10
Sustainability	11
Conclusion	13





Dr. Hans Blix, IAB Chairman

CHAIRMAN'S PREFACE

On behalf of the International Advisory Board I have the honour to convey to the Government of the UAE the tenth 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 and I were pleased to see that since its last visit great progress has been made on the plant and that the program remains on time and budget. This report discusses several topics which include an updated status of the Barakah Nuclear Power Plant, the trip to Barakah, physical protection of the plant, capacity building, cybersecurity as well as waste management.

At its next meeting the Board would appreciate further reports on IAEA's role with the UAE, on readiness in high-stress conditions and on on-site security plans.

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, nonproliferation, transparency and sustainability.

With respect,
Dr. Hans Blix

BOARD MEMBERS



Mr. Jacques Bouchard



Mr. Takuya Hattori



Ambassador Thomas Graham



Dr. KunMo Chung



Lady Barbara Thomas Judge



Dr. Mujid Kazimi



Mr. Jukka Laaksonen



Sir John Rose

Introduction



The tenth semi-annual meeting of the International Advisory Board (IAB) for the United Arab Emirates (UAE) nuclear power program was held in Abu Dhabi on October 12th and 13th, 2014. The Chairman, Dr. Hans Blix, presided and all other members were present. The first two briefings were carried out by the Ministry of Foreign Affairs (MOFA) and the Federal Authority for Nuclear Regulation (FANR) at the Shangri-La Hotel the evening of October 12. The Board at the ninth meeting had requested for the tenth meeting to once again include a visit to the Barakah site—its third visit to the location—and therefore on October 13th the briefing by the Emirates Nuclear Energy Corporation (ENEC) was carried out at the Barakah Nuclear Power Plant (Barakah NPP) site. The Board conducted its private discussion at the Barakah site following the ENEC briefing.

First, Ambassador Hamad Al Kaabi who was representing MOFA opened the meeting by briefing the Board on the major areas being addressed by MOFA with relevance to the UAE nuclear program including: implementation of international instruments; the Nuclear Security Summit 2014; UAE progress on Nuclear Security Summit Commitments; and the IAEA Peer Review Service. FANR was represented by several officials; they briefed the Board on all the subjects that FANR is

currently addressing in its work. These include: the license to construct Units 3 and 4 of the Barakah Nuclear Facility; ENEC submissions on the Molten Core Concrete Interaction (MCCI); FANR review of ENEC outstanding issues; physical protection of the Barakah Nuclear Facility; cyber security; aircraft impact assessment; radioactive waste management; and FANR capacity building.

The following day at the Barakah site, ENEC senior officials, led by the Chief Nuclear Officer (CNO) of the Operating Company, briefed the Board on all matters ENEC is currently working on. ENEC's efforts are now focused on progress at the Barakah site which, with over 15,000 workers on the site, is truly impressive.

Progress since the previous October when the Board last visited the site has been considerable. The central focus now is preparing the site for the commencement of operations at Unit 1 in 2017. Among the subjects addressed by ENEC were: Operational Readiness and the Integrated Management System of the Operating Company; the Operating License Application; Capacity Building; Construction at Unit 2; and other subjects such as the Corrective Action Program, AC Power Supply Reliability, Spent Nuclear Fuel and Waste Management, and Confirmatory Analyses for MCCI (Molten Core Coolant Interaction) when using limestone based concrete.

Safety

Safety assessment and recommendation

FANR then began the presentation to the Board on Safety. Following the 9th IAB meeting, FANR had completed its review of ENEC's application for a license to construct Units 3 and 4 at Barakah and accordingly the license to construct Barakah NPP Units 3 and 4 was issued on September 2014, 15. Conditions in this license include the following: requiring ENEC to provide a revised design of the Alternative AC power source (AAC) that meets FANR requirements, and to obtain the written approval of FANR before implementing such revised AAC power source; and requiring ENEC to provide additional information to FANR demonstrating the validity of its MCCI calculations, or, if such demonstration turns out not to be possible, to provide a revised design that complies with FANR requirements. The construction license for Units 1 and 2 was also amended since it needs to be consistent with the amendments of construction license for Units 3 and 4.

At the time of the 9th IAB meeting one significant issue of safety for the Barakah NPP site remained unresolved, that is the MCCI impact on containment integrity in the analysis of severe accidents. Additional information had been requested of ENEC and a number of technical clarification meetings between FANR and ENEC have been held. However, considerable work and additional meetings among FANR, ENEC and KEPCO still lie ahead. FANR noted the new submissions by ENEC on MCCI: an analysis of the loss of all AC electrical power scenario— (station blackout) focused on a severe core damage scenario that had been identified within the Probabilistic Risk Analysis (PRA), the analysis investigated especially the MCCI phenomena and had been conducted with version 5.02 of the MAAP computer code. This new code version contains significantly improved models; in addition to the base case analysis, the submittal involved considering twelve sensitivity cases to address uncertainties in the phenomena and code modeling. All cases indicate that molten core materials will stabilize in the reactor cavity without breaching the containment liner.

FANR said that the scope of scenarios analyzed satisfies FANR guidance and the results show compliance with FANR requirements. However, additional information

is required to confirm the validation of the analytical models and computer code. ENEC has made a written commitment to provide a revised severe accident analysis with complete validation information. The Board asked whether there have been any considerations for replacing MAAP5.02 with some other code. FANR explained that MAAP5.02 currently has the most advanced models for the severe accident analysis. The Board noted that the program may not necessarily be bound by industry protocol, and analysis by another code that is sanctioned by a regulatory agency may be prudent. FANR stressed the importance of industry practices in utilizing best estimate costs and believes that appropriate attention was given to them.

ENEC also addressed the severe accident analysis issue in its briefing. ENEC asserted that ENEC/KEPCO successfully presented a safety case to FANR and submitted appropriate responses to MCCI related information. There was justification presented for the use of MAAP5.02 as an accepted industry computer code. ENEC provided an explanation of the differences between MAAP5.02 and the previously used MELCOR code. MAAP5.02 results, in a single best estimate/realistic event, are showing the design is acceptable and meets FANR requirements. ENEC Engineering Project Director added that looking at molten core loads on the concrete in the Barakah NPP design, the application of the new computer code MAAP5.02, is the most realistic. An earlier analysis by MELCOR code is considered too conservative for the wet reactor cavity analysis and, as a result, the simulated scenarios that would never happen. ENEC does not believe it has a problem with the limestone concrete used for containment, as was thought on the basis of earlier analyses. The new code models, after having been fully validated against test results of the OECD program, give more reliable answers. In discussions on the severe accident analysis stress tests conducted after the Fukushima accident, recommendations included that arrangements should be made for provision of independent reactor core cooling even without AC power. This "preventive type" measure would reduce the risk of severe core damage and thus reduce the total accident risk.

Safety assessment and recommendation



However, severe core analysis would still be needed for ensuring adequacy of “mitigation type” measures that are aimed to reduce risk of large radioactive release. Concerning the mitigation measures, FANR stated that something like a “core catcher” may need to be considered by ENEC to be added to the design, should the future analyses conclude that such an addition is necessary

A second safety issue for Barakah NPP, addressed by FANR, was the alternate AC power source. This refers to an on-site emergency power source, which could provide power to equipment needed for implementing fundamental safety functions in the event that the connection to the off-site power sources would be lost and the primary on-site power sources (Class 1 emergency diesel generators) would fail. A FANR review revealed that the alternate AC power source design for the Barakah site that was proposed by ENEC did not meet the following FANR requirements: sufficient alternate diesel generators to back up all four units; determining the adequate number of AAC diesel generators for the Barakah site by probabilistic analysis; diversity between the AAC diesel generators and Class 1 emergency diesel generators; and independence between the Class 1E power distribution system and distribution system supplied by the AAC diesel generators. FANR requirements are supported by the preliminary PRA that shows station blackout to be the dominant contributor to the risk of core damage. ENEC has committed to providing

a revised AAC design for FANR review by November, 2014.

In general, most (but not all) commitments for Unit 1 and 2 apply to Units 3 and 4 and vice versa; commitments for Units 3 and 4 apply to Units 1 and 2. Occasionally, due to minor or even major design changes, commitments made on one pair of NPPs may not apply to the other pair of NPPs.

Lastly, with respect to safety in the FANR presentation, the current status of FANR’s review of Counterfeit, Fraudulent and Suspect Items (CFSI) issues was described. There will be a follow up CFSI inspection at Barakah in late 2014 and outside experts are assisting with the development of methodology for the inspection of the Korean supply chain, with the first inspection in the first half of 2015.

The Chief Nuclear Officer of the operating company stated that there were 719 days and 3 hours until the first fuel load. There is an integrated schedule to get there. Operational safety is dependent on proactive process development.

Construction continues vigorously at Units 1 and 2. The containment structure is progressing well at Unit 1. Mechanical component installation is moving along and electrical system installation work for Unit 1 is also making good progress. The breakwater is nearly complete. Electrical installations to provide connections to the external power

Safety assessment and recommendation

grid is advancing for all four NPPs and the switchyard is moving toward completion in 2015. The power block for Unit 3 was in readiness for first concrete by October, 2014; and excavation for the power block for Unit 4 is underway.

As for operational readiness, there were positive developments to report. The operating company is getting ready with much of the team in place. There are 42 officers in place; there will be important Korean additions; Emiratis are being recruited from other industries. Cultural differences are being overcome.

While making ample progress in the last quarter it has not been possible to eliminate schedule risk. Nevertheless the integrated schedule is growing in integrity—operations are integrated with the construction schedule.

- ENEC is driving the organization more and more by the schedule—with a focus on critical milestones that could threaten operational readiness.
- The Korean part of the leadership team (and organization group) is growing in effectiveness and impact. There is an understanding of how the Korean operational model works day-by-day—which is a very important element to the success of safety-driven operations.
- Operational License Application (OLA) is a critical milestone to the project. All parties involved are working to achieve submission of the OLA to FANR by March 2015, which is the program milestone.
- As a result of this, the organizational focus has turned to the OLA. The critical hurdle is the FANR acceptability review – due 60 days post submission.
- The IAB deems that KEPCO/KHNP need to improve the timeliness and quality of its interim submissions.

Both the Korean regulator agency (KINS) and FANR are working to improve the Operating License Application process and to align their systems and procedures to obtain further improvements. Several immediate actions are in progress in Korea, and an ENEC assistance team has been assembled and is mobilizing in Korea. This approach has worked so far but

there is a lot of work ahead. A comprehensive corrective action plan has been developed and is being reviewed.

The Corrective Action Program has seen a steady improvement across ENEC and includes implementing a series of initiatives to continue its improvement. For example, the operating company is driving toward operational readiness but there is a high reliance on human performance improvement which has not yet been entirely internalized. Human performance is being improved by tools such as peer review and peer checking. A phonetic alphabet has been adopted to overcome cultural differences in communication. Meanwhile the operating company is becoming increasingly ready, recruitment has been good and there has been an evolution of the leadership team to bring in a greater Korean and Emirati presence. More senior reactor operators are currently being trained.

The baseline date for completion of the review and issuance of the BNPP Unit 1 and 2 Operating License is 30 September 2016. The early completion date was 31 July 2016. Due to delays in getting a complete and accurate FSAR from KEPCO it will not be met. ENEC is instead focused on getting the Operating License by the original date of 30 September 2016. The OLA is currently on track and will be submitted on or before end of March 2015.

The offsite AC power reliability was discussed. The Barakah nuclear power plants will have two switchyards, Switchyard A for Units 1 and 2 and Switchyard B for Units 3 and 4. Each switchyard is connected to the TRANSCO grid by a minimum of two overhead lines (OHLs) (each has two conductor sets capable of transferring a full power of the 2 units). Each OHL is linked to a different substation, which is connected to a different part of the TRANSCO transmission system by separate OHLs from the other. Also a separate OHL will link Barakah NPP to another transmission system, which is a separate Gulf Cooperation Council network and owned and operated by a different operator. The design work for the transmission system is complete and construction is in progress.

Security

Security assessment and recommendations



The next ENEC briefing was on the security project portfolio which engendered an exchange of views on the relationship of security to safety. ENEC reported that a new security system has been created in the operational readiness program to enable better visibility and accountability of the security projects which are critical to the arrival of fuel on site and fuel loading. Additional project management resources are being procured, and the initializing scheduling efforts have resulted in an improvement in the Physical Protection System (PPS) schedule.

The Board asked how security interacts with safety and, where does security fit within the CNO's portfolio. The CNO replied that he is responsible for nuclear safety and also for security. His office is where safety and security come together. The requirements for safety and security may collide. The objective of streamlining safety and security under the authority of the CNO is to integrate safety with security.

The Board advised that the Physical Protection Plan (PPP) be overseen by someone who is nuclear sensitive. The CNO stated that ENEC will have to ensure and also properly train security officers to respect the authority of the reactor operators who have responsibility for nuclear safety. The chain of command must have a plan to deal with any kind of safety and security related emergency, and such a plan needs to be developed.

The CNO explained that inside the plant the Emergency Director is in charge in case of emergency situations including

security incidents, and in all cases has the responsibility to call the emergency situation and make the decisions on actions for responding to the emergency. Outside the plants, the emergency and security measures to protect the public are the responsibility of the Emergency Response Center, located in Ruwais.

The CNO said that the task of the Emergency Director will be the responsibility of the most senior person of the operating organization and this person has to always act with public safety in mind. Dr. Blix and Lady Barbara said that the relevant laws and regulations must be very clear and decisive, and that roles and responsibilities of the relevant authorities also need to be clear. The Chairman commented that the shift supervisor/SRO on duty is like the captain of the ship. The Board also asked about the emergency planning people, what is their function? The CNO replied that all members of the staff have some emergency role; there is their regular job, their outage job, and their emergency job.

There was a presentation on physical protection during the FANR briefing. ENEC as the owner and operator has the sole responsibility for physical protection within the site. The plan for the ongoing construction phase was reviewed by FANR and ENEC received an approval letter for its implementation from FANR on April 2014, 24. Revision 1 of the PPP Construction Phase 2 was submitted by ENEC on September, 1 2014.

There would be two inspections conducted by FANR in 2014 of the implementation at

Security assessment and recommendations

Barakah site of the various physical protection plans. Physical protection for operations will be submitted by ENEC as part of the OLA. FANR wants to see a fully integrated plan. A first version of the target set analysis has been reviewed by FANR – additional information was requested – and a conceptual design of the PPP for operations is to be submitted soon to FANR. Also the PPP for the transportation of nuclear fuel and the PPP for the temporary storage of fresh incoming fuel on the Barakah site are to be developed by ENEC and submitted to FANR.

The Cyber Security Plan, which is part of the physical protection plan for operations was submitted by ENEC in June, 2014. It has been reviewed by FANR and with 13 commitments from ENEC was accepted as part of the construction license for Units 3 and 4. During the OLA review, ENEC will establish: a plan to implement a cyber-security incident response plan, a disaster recovery plan which includes business continuity, emergency and contingency plans and a sustainability program. There will be a workshop on cyber security to be organized jointly with US-NRC on 14-12 October, 2014.

On the issue of the Aircraft Impact Assessment (AIA), the last of the security issues addressed at the 10th IAB meeting, updated reports were submitted by ENEC in February, 2013 and reviewed by FANR. With seven additional commitments by ENEC, the AIA was accepted as part of the construction license for Units 3 and 4. ENEC provided actual or forecast construction completion dates for the design enhancements which is very important in mitigating the consequences of an aircraft impact. FANR prepared an action plan to verify the implementation of the design enhancements. During the OLA review ENEC will submit reports on the loss of a large area due to fire and explosion. FANR will also verify that the actions required to maintain the fundamental safety functions can actually be performed in spite of the impact consequences.

Non-proliferation

Non-proliferation assessment and recommendations

MOFA briefed the Board on non-proliferation and international cooperation. The first addressed issue was the implementation of international instruments. On July 2014, the UAE joined the Convention on Supplementary Cooperation for Nuclear Damage (CSC), an international treaty that was developed as an umbrella for international liability conventions, providing the basis for a global nuclear liability regime. By joining the CSC, all international instruments mentioned in the UAE Nuclear Policy Document have been concluded and implemented by the UAE.

On the 28th of March, 2014, the UAE presented its 2nd National Report during the 6th Review Meeting of the contracting parties of the Convention on Nuclear Safety at the International Atomic Energy Agency (IAEA) in Vienna. The UAE also participated in the third Nuclear Security Summit (NSS) held at The Hague. It was focused on nuclear terrorism and security and was well organized. The UAE has been an active participant in the NSS series since its beginnings in Washington in 2010 and has implemented all commitments from the Summit Series.

- The UAE has progressed well in implementing these commitments;
- The UAE is party to all international instruments relevant to nuclear security and has adopted the relevant legislation and regulations.

The UAE supports the nuclear security activities of the IAEA through participation in expert committees, Nuclear Security Guidance Committees, and by providing experts for the development of the Nuclear Security Series publications. The Integrated Security Support Plan for the UAE was signed in August 2012 by the UAE and the IAEA and is being implemented. An Integrated Work plan was signed in 2013 by the UAE and will in the 2017–2013 timeframe enhance the effectiveness of the IAEA–UAE partnership. The UAE contributed 1\$ million to the IAEA project to upgrade its Safeguards Laboratory.

The UAE endorsed the Code of Conduct on the Safety and Security of Radioactive Sources and in cooperation with the IAEA convened the International Conference on Safety and Security of radioactive sources in Abu Dhabi in October of 2013. This was one of the pledges made at the Security Summit in Seoul.

The UAE concluded nine bilateral and international agreements on nuclear cooperation and multiple MOUs between UAE entities and counterparts in the areas of nuclear security and nuclear safety. UAE is an active participant in the Global Initiative to Combat Nuclear Terrorism.

It has become a tradition of the Nuclear Security Summits for participants to announce national voluntary commitments by individual heads of state. These are referred to as "House Gifts" and are in addition to the collective commitments in the Summit Joint Communiqué. There were 14 House Gifts announced for the 2014 Summit, UAE joined eight of them:

- Counter Nuclear Smuggling (ongoing from the previous Summit)
- Supply Chain Security (measures to remove nuclear and radiological materials that are outside of regulatory control from the global supply chain)
- National Legislation Implementation Kit on Nuclear Security (Development of template legislation for nuclear security)
- Nuclear Information Security (ongoing from the previous Summit)
- Nuclear Security Training and Support Centers of Excellence (develop human resources in nuclear security)
- Radiological Security (intent to secure IAEA Category 1 radioactive sources within each country's territory by 2016)
- Strengthening Nuclear Security Implementation (subscribe to the IAEA Fundamental Principles)
- Implementation of UNSC Resolution 1540 (full and universal implementation of UNSCR 1540)

Non-proliferation assessment and recommendations

UAE policy states that in addition to making liberal use of IAEA technical assistance in a number of areas it is the intention of UAE to seek IAEA peer review on a continual basis. UAE has requested all major review services from the IAEA relevant to its program deployment timeline.

In May 2014, IAEA conducted a detailed evaluation of the legal, regulatory, administrative and technical arrangements undertaken by UAE relevant to its international obligations in the area of nuclear non-proliferation and safeguards, including a thorough review of the state system of accounting for and control of nuclear material. The activities and processes employed by various key stakeholders such as the Federal Customs Authority, Abu Dhabi and Dubai customs and ENEC were reviewed. The draft report highlights the readiness of the UAE for full implementation of its safeguards and non-proliferation obligations and provides suggestions for further improvement.

Ambassador Al Kaabi included in his presentation a timeline of planned IAEA Peer Review services in 2015 which included missions by the Integrated Regulatory Review Services (IRRS), the Emergency Preparedness Review (EPREV), the Occupational Radiation Protection Services (ORPAS), the Operational Safety Review Team (OSART), and also a follow up Integrated Nuclear Infrastructure Review (INIR) – probably in 2015 but in any case before initial plant operations.

The Board commented that there are many missions, but would like to know what feedback has the UAE received from the missions, Ambassador Al Kaabi replied that feedback focuses on the evaluation of UAE progress against IAEA guidance in a holistic and integrated manner. One paramount item was the importance of integrated reviews, which would provide the UAE with a good list of recommendations that would establish an endorsement for UAE progress in areas such as safety and security framework and other relevant infrastructure. The Board noted that it was important to work with the IAEA in advance of an EPREV mission to ensure accurate plans for schedule and content of each interview made with national

stakeholders and that there should be good coordination with those stakeholders.

Ambassador Al Kaabi also commented on the subject of waste management. He said that the UAE plan for waste management is not yet finalized. Consultation continued between government entities and the industry. He had in the past presented an overview and the timelines. The funding of the management of nuclear waste needs to be decided upon. There is active work going on but the plan is not yet finalized. The Board noted the good work that the UAE was doing with IFNEC. The UAE should seek more support from the IAEA on this issue. The Board said that the UAE is near to licensing operations. Human resources will be very important; UAE needs to get a lot of assistance from IAEA on this as well. Ambassador Al Kaabi commented that there should be more cooperation among stakeholders, also that both ENEC and FANR have their own programs and are in fact working closely with the IAEA on training.

The Board noted that Japan, China, Taiwan, Korea and others have problems even with siting of interim waste storage because of fear and local opposition after the Fukushima accident, although interim storage and final disposal are very different from the time perspective of a hazard. On the other hand, Sweden and Finland have settled their approach for getting approval for sites of final disposal facilities. Korea has constructed an interim storage for low and medium radioactive wastes. UAE could study and follow the example of Sweden and Finland but needs a deadline for the plan and firm timelines. Perhaps a final decision is premature and at present interim storage is a possibility.

FANR has been active in the waste management issue. FANR Regulation number 11 on pre-disposal management of nuclear waste is in place. In addition, a new Regulation, number 26 that includes a new regulatory guide, is under development for the disposal of nuclear waste including high level waste. Also a regulation guide on a near surface waste disposal is to be drafted. The Board questioned what organization

Non-proliferation assessment and recommendations

would ultimately be responsible for waste management. FANR replied that national policy states the licensee for this function will eventually be named by the Cabinet.

A Decommissioning Trust Fund will be established by the Cabinet upon recommendation of the FANR Board. FANR will develop implementing regulations. The Trust Fund will cover the costs of decommissioning and nuclear waste management. The Operator will pay the fund to cover the costs of waste management, decommissioning, regulation and associated research and development. Legislation on funding must be in place by the time UAE nuclear power plant operations begin.

ENEC noted with respect to low and intermediate waste management that it will follow Shin Kori 3 and 4 (the reference plant) on its waste pre-treatment practices. Storage on site will be for 10 years. As for the discharged nuclear fuel, including high level waste, ENEC will meet national policy and FANR regulations. At the Barakah site, there will be an initial storage space for the spent fuel pool for 20 years of operation. Other options are being explored for storage beyond 20 years. One of the options adopted in many countries is the use of dry storage units to provide interim storage. Designs are available to hold the nuclear spent fuel for 60 years and beyond. Two potential locations for such dry storage casks, near the spent fuel pond, have been identified at Barakah. Beyond that, disposal for all levels of waste awaits the pending UAE national policy.

Chairman Blix asked whether a fee will be

added to electricity costs to pay for waste storage; the Ambassador replied we do not have that yet but we will. The Chairman said that there is much to do here for the IAEA; there are such decisions considered in Vietnam, Turkey and others. It will be important for the IAEA will be hard pressed to keep up the pressure on this subject. The Ambassador replied that the UAE was studying whether it had enough support to do this by itself without IAEA; the IAEA can only do so much. The Chairman said that the IAEA may have to charge for its services. The Ambassador replied that a partnership model would be a good model; the Board commented that some countries already do pay the costs of the IAEA missions and that costs for this kind of service could be shared among countries so that the IAEA could optimize its assistance. Ambassador noted that the UAE already contributes funding for some missions and services provided to the UAE.



Transparency

Transparency assessment and recommendations



FANR reported that it has done public outreach sessions in Dubai and in Sharjah. Also, ENEC hosted an important visit by the Ruler's representative in the Western Region, H.H. Sheikh Hamdan bin Zayed in September 2014. His Highness noted that: "The use of peaceful nuclear energy has an important role for the future of our country" and also said: «The UAE attaches major importance to the principle of operational transparency in dealing with its nuclear programs.»

Sustainability

Sustainability assessment and recommendations

FANR is continuing its active sustainability efforts with respect to local expertise. Two students who graduated with Master's degrees through the UAE Nuclear Scholarship Programs in 2013 joined the FANR Nuclear Safety Department. The FANR Board has agreed to establish a FANR scholarship program to complement the ENEC nuclear scholarship program. The UAE has thus established a nuclear scholarship program, which will produce nuclear plant staff, regulatory staff, and educational infrastructure. The scholars can pursue their studies in the UAE (e.g. at Khalifa University) or internationally.

KINS in cooperation with KAIST operates an International Nuclear Safety Master's Degree program in Korea; two graduated in 2014, one FANR employee joined the program in 2014 and will graduate in 2015.

There is a Gulf Nuclear Energy Infrastructure Institute course conducted at Khalifa University and supported by the US Departments of Energy and State. It is a foundation course on safety, security and safeguards lasting four months. Twenty-four FANR employees have completed the course and four more are enrolled for 2015. The course is offered as a regional activity and attracts students from the Gulf countries as well as other countries in the Middle East.

In 2013 a workshop was held in the UAE to advance security education program curriculum development. The workshop was organized jointly by Khalifa University and the Partnership for Nuclear Security and covered:

- Information Security; CICPA and FANR collaborated to develop an Information Protection Program Operating Manual which has been provided by FANR to program stakeholders as the requirement for protection of sensitive nuclear information. The regulations for the physical protection of nuclear materials require that operators develop a Cyber Security plan to protect the facility.

- The regulation for security of high activity radioactive sources requires the management of sensitive information as well as background checks on the personnel involved

A plan of action for individual employees has been developed at FANR for each UAE national employee. The employee is to outline how he or she will meet their specific objectives. Forty-seven such plans were created for employees in the Operations Division in 2014.

FANR has an internship program to expose potential future employees to the daily work of FANR and the opportunity to learn from its senior staff; FANR had two interns in 2014. There is also a mentoring program to help give long-term sustainability to FANR and to ensure that UAE nationals develop appropriate levels of technical competency and overall capability. An employee development program tailored for new employees takes the employees on a journey of training and meetings to familiarize them with their assigned department. Two employees completed this program in 2014. A number of in-house training programs are available for employees focusing on technology and management such as the introduction to nuclear energy, safety and security culture, APR 1400 design features, and its security.

A knowledge management program helps to share knowledge across the departments and enhance work performance through knowledge sharing and best practices. FANR has agreements with other UAE governmental entities as well as international organizations pursuant to which a FANR employee is provided the opportunity to work for a chosen outside organization for a period of six to nine months. FANR does not yet have a strategic plan to ensure proper levels of Emirati nationals and female employees in various departments but one is needed. In response to Lady Judge's questions, FANR noted that the work force is currently comprised of 37 percent women.

ENEC has amplified its efforts to bring more

Sustainability assessment and recommendations

women into construction and operations with the assistance of the international organization Women In Nuclear (WIN) through its ENEC Chapter, which was established last year. The ENEC Chapter's strategic objectives include supporting the Global and UAE Chapters, ensuring the Barakah NPP is a female choice of employment, providing an open channel to external professional and technical organizations and supporting WIN members seeking professional excellence. Abu Dhabi will host a World Women In Nuclear (WIN) Conference in 2016.

The ENEC Chapter tries to reach out to females in grade school and is completely committed to equal pay for equal work. The global average of women in nuclear is 20.4 percent. In 2012 ENEC was at 30 percent, in 2013 it was at 24 percent and in 2014 it dropped to 21 percent. The recent drop in numbers is due to the current focus on hiring technical personnel to work on-site (i.e. far away from major cities) as well as the recent influx of Koreans laborers, but ENEC is determined to at least stay with the global average and hopefully do better. Currently, 18 percent of the work force on site is female.

Recent recruitment initiatives have involved the increased use of outsourcing and consultants as well as streamlined approval processes. Hiring has been vigorous but there are many critical positions to fill. The total number of employees joining ENEC continues to increase.

The Energy Pioneers scholarship program, continues to progress. Its aim is to build expertise among the UAE nationals in areas relevant to nuclear power plants. There are 181 students pursuing the Higher Diploma in Nuclear Technology at Abu Dhabi Polytechnic, including 56 females. For the Bachelor of Engineering degree there are 92 at Khalifa University, 75 in the United States and three at the University of Manchester in the U.K. Twenty-six of this overall group are women. There are nine students seeking the degree of Master of Engineering, eight at Khalifa University and one at Texas A&M; five of these

are women. Also, there is 1 student seeking a PhD at MIT in the U.S. The Abu Dhabi Polytechnic provides a direct pipeline to ENEC and this is a large part of ENEC's long-term Capacity Development plan. ENEC also has two students at KEPCO International Nuclear Graduate School, which trains professionals in nuclear power plant engineering.

There are 240 Energy Pioneers enrolled in Units 1 and 2 training—all university graduates. Among those, six groups of 22 Senior Reactor Operators and Reactor Operators are scheduled for training. The 240 pioneers that have been hired are all being trained in technical specialties such as Electrical Maintenance Technician, Mechanical Maintenance Engineer, Chemistry Technician, Core Management Engineer, etc. Of those Pioneers taking the FANR examination on basic power plant theory in the first two groups, a significant number did not pass the first time although of those that failed the first time most passed the second time. In the third and fourth groups all passed the first time.

Manpower mobilization overall stood at 15,325 the week of the IAB meeting. This included approximately 12,000 on the power block, nearly 1,000 of these are APR-experienced Korean professionals and workers. As for infrastructure it is similar, 72 Koreans versus over 2,000 non-Koreans. Koreans make up a critical part of the work force but not in numbers.

ENEC also has a plan in place aimed at reducing human error. It has a number of elements such as peer checking and pre-job briefing and has been quite successful. The most important element, however, has turned out to be the introduction of the phonetic alphabet. This overcame cultural differences in communication.

Conclusion



The IAB review of activities included an in-depth review of progress in analysis of consequences of severe accidents. As part of the Construction Permit review FANR has required ENEC to demonstrate that a large radioactive release from the containment would be very unlikely even with a severe accident causing reactor core meltdown. This is in line with the most recent issue (2012) of the IAEA Safety Standard on safety of nuclear power plant design. Such requirements on robustness of containment integrity have also been emphasized worldwide after the Fukushima Daiichi accident. ENEC has presented its arguments on maintaining the integrity and leak tightness of the reactor containment after a severe accident but the issue is still open and needs to be closed before the issuance of an Operating License for Barakah Unit 1.

The main question that has been studied and was reported to the IAB relates to the capacity of the Reactor Containment Building to maintain integrity in events such as core meltdown and a lack of a dedicated molten core catcher. ENEC has presented extensive analysis to FANR to prove insignificant risk of containment bottom penetration (i.e. erosion of the concrete bottom plate) by the molten reactor core. According to the information provided by both FANR and ENEC, progress

has now been made and independent analyses suggest that there would be an adequate layer of concrete left at the time when the molten core solidifies, the concrete erosion of the reactor cavity concrete stops, and the liner plate is not breached. Solidification takes place in all studied accident scenarios when the molten core has spread to a large enough area in the cavity below the reactor vessel and is cooled under the water that fills the cavity. The positive feature of the APR1400- plant type is that the floor of the reactor cavity is wide and the molten core can spread to a layer that is thin enough to ensure its effective cooling by the above water pool. The tentative positive conclusion on resolving the issue is based on comparison between different calculation methods and the results of the calculations made by different organizations.

Calculations have been made independently by the plant supplier (KEPCO) and by two separate consortiums of expert organizations contracted by ENEC and FANR, respectively. The computer codes used are the globally best known severe accident analysis codes, one code (MAAP) was developed by EPRI, which is the research organization of the power industry and the other code (MELCOR) was developed by Sandia National Laboratory from the US Nuclear Regulatory Commission. Both

codes have been validated against several experiments and also against recorded data from accidents such as TMI2-

The most re-assuring results demonstrating adequate safety margin, related to the maximum conceivable concrete erosion by molten core impact, have been achieved by the latest version of the MAAP code, which has a new model describing accurately the situation. This model describes molten core-concrete interactions under water in a geometry that is similar to the reactor cavity in question. The earlier calculations causing concern on concrete bottom penetration were made with MELCOR but now the validation calculations of that code against measurements have shown, that MELCOR gave conservative results in water pool conditions, although in the dry cavity it under-estimates the concrete erosion. Additional arguments on MAAP code validation are being prepared, while new representative models are being added to MELCOR.

Another physical phenomenon that could endanger the reactor containment integrity is a steam explosion that may occur when the molten core drops to the water pool, which is reactor cavity below the broken reactor vessel. However, the structure of the reactor cavity is exceptionally robust in the APR1400-type plant and this gives confidence that it can withstand loads from even a large steam explosion.

The Board would be interested in its next meeting to hear an integrated summary of all physical phenomena that have been assessed as potential threats to the containment integrity, and the FANR conclusions on adequacy of protective measures. In addition to the containment bottom melt-through and steam explosion mentioned above, the other threats commonly considered include the following:

Reactor core meltdown while the reactor vessel is still in high pressure; unless this scenario is eliminated by credible dedicated design for ensuring timely pressure

relief, there is a risk of violent dynamic reaction when the melt is ejected to the containment atmosphere

Hydrogen explosion due to reactions of nuclear materials with water
Containment overpressure due to gradual accumulation of gas and steam inside the containment
Containment boundary bypass via a pipe penetrating the containment wall

The IAB discussed the management responsibilities in the event that an intruder group has occupied part of the facility and created an immediate threat of an unpredictable accident scenario. FANR representatives stated that their position is clear: plant management that bears overall responsibility for safety and security must retain its authority to decide and give orders to the security forces on counter-measures that are needed to eliminate the security threat. Any counter-measures must be planned and implemented so that they do not create new safety hazards. The commander for security forces has to take guidance given by the plant management into account in all operative actions. However, the IAB considers that it is necessary to confirm that the FANR position is fully understood and shared also by ENEC and CICPA. Therefore the IAB asks to have a joint presentation by all three parties on the on-site security plans, with special focus on the authorities and command relations during a potential security incident.

Recruitment for ENEC may become an even bigger problem with more reactors; people who will be reactor operators are not plentiful in the UAE. KEPCO and KHNP could help ENEC in this area if ample time is given in advance.

The Board believes that if ENEC is very successful and sets a very high standard, others will be challenged to match the standard. In addition, there is an interface between safety and security and FANR must ensure clear lines of authority. The chairman

noted that the board has not seen regulations on this yet. The Board agreed that these regulations and the law must be clear and must say that the Senior Reactor Operator is the "captain of the ship" in case of an emergency.

The Board congratulated ENEC for its work to enhance the ranks of women employees.

The Board commented that it was important to discuss the goals of each IAEA review mission fully with the IAEA; and that the IAEA is not a tool that should be used too often to do things beyond its scope. Also, ENEC should be communicating frequently with the KEPCO group including, KEPCO E&C and KPS, and Combustion Engineering through information exchange and consultations.

The Board said one role of the IAEA is to help countries start the right way and with a thorough understanding of the readiness to cope with high stress conditions in the post Fukushima inspections and preventive measures. The Board would like to hear more in depth on this subject and it is important to cover subjects like overpressure on the containment vessel.

The Board also noted that challenges lie ahead with the beginning of operations. Cultural misunderstandings come easily; there must be more thinking about how work will proceed in a multi-cultural environment. ENEC needs to be world class.

The meetings for the Board in 2015 are scheduled for March 15th and 16th and October 11th and 12th. As noted above the Board would like to hear more at the next meeting on a number of important considerations, such as the countermeasures for a terrorist threat and on the ENEC plan to cope with severe accidents.

The Board is grateful to the UAE and supporting entities for outstanding presentations and informative meetings at this tenth meeting. The IAB congratulates the UAE

on the continuing success and progress of the nuclear power program and finds that the UAE remains fully committed to the principles of safety, security, non-proliferation, transparency and sustainability in its program.

ACKNOWLEDGEMENT

The International Advisory Board would like to thank all who were involved in developing this report.