Meeting Report on the

Technical Meeting of the International Nuclear Desalination Advisory Group (INDAG)

VIC, Vienna, Austria

7-9 January 2008

1. Background

The ninth meeting of the International Nuclear Desalination Advisory Group (INDAG) was held from 7 to 9 January 2008 at the VIC, Vienna. The meeting was attended by 13 members and two observers from Algeria and France.

Mr I. Khamis acted as the Scientific Secretary and Mr P.K. Tewari of India served as the Chairperson.

2. Objectives of the meeting

Following the previous meetings, the ninth IAEA Technical Meeting of the International Nuclear Desalination Advisory Group (INDAG) had the following objectives:

a) To provide advice and guidance and support implementation of the Agency's activities in nuclear desalination

b) To identify important topics for discussion at SAGNE and contribute to status reports, coordinated research projects, technical meetings and topical conferences in the field of nuclear desalination;

c) To provide a forum for the exchange of information on the progress of national and international programmes in this field;

d) To provide advice on preparatory action by Member States for implementing nuclear desalination demonstration projects;

3. Participants to the meeting and Agenda

The Meeting Agenda and the List of Participants are attached.

4. Summary of the work done and results achieved

THE IAEA (SCIENTIFIC SECRETARY)

The IAEA scientific secretary highlighted first the successful and full implementation of all activities regarding Program & Budget (P&B) 2007 on desalination including: the International Conference on Non Electric Applications of Nuclear Energy: Nuclear Desalination, Hydrogen Production, and other industrial Applications held in Oarai, Japan 16-19 April 2007, the initiation of the CRP on Advanced Heat Process Applications where the first RCM meeting was held during 24-26 Sept 2007 , the update and release of DEEP with new water transport cost model, followed by a Consultancy Meeting (CM) on the Validation, Verification and Benchmarking of DEEP (Desalination Economic Evaluation Programme) which was held in the VIC, Austria, 29-30 October 2007, and the Technical Meeting on Advances in Integrated Nuclear Desalination Systems which was held during 3-5 Dec. 2007, Cadarache, France. He also highlighted the current TC Projects with some MS and presented the 2007 publications on nuclear desalination which included:

- A Status Report on Nuclear Desalination Activities in the Member States was published as IAEA-TECDOC-1524 (2007).
- The results of the CRP on Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies were published as IAEA-TECDOC-1561 (2007).
- INDAG Newsletter No. 7 – Sept. 2007
- Update of the IAEA-Web site for all relevant nuclear desalination activities.

The scientific secretary presented the 2008 expected activities related to nuclear desalination which involves the followings: NEW CRP on: a consultancy meeting to initiate new CRP on Specific Advances in Nuclear Desalination Technologies (2008-2011), TM of the DEEP Benchmarking Feb 6-7, TM on integrated Nuclear desalination systems which is planned as an extra budgetary for the period of June 2-4, the 2nd Technical Meeting of the CRP on Advances in NP process heat Appl.1-2 July, the TM on ND technologies info Exchange 28-30 July, the TM on non electric applications of nuclear energy which is planned as an extra budgetary for the period Aug. 25-28, and the Training Workshop on ND in the GCC which is planned as an extra budgetary for the period Nov. 2-5.

Presenting the recommendations of previous two meetings of INDAG, the scientific secretary presented the agenda of activities to be discussed in the meeting which includes the followings:

- Discuss current and future activities: challenges of nuclear desalination (: 1- Focus on the use of currently available reactors vs. futuristic designs, 2- Study the economics of fully dedicated vs. 10% dedicated power for desalination, 3- Evaluate added value of water production vs. electricity production 4- Future feasibility studies to concentrate on the use of available technologies or the futuristic technologies etc).
- Discuss active participation of INDAG membership and new membership.
- Discuss cancellation and possible replacement of ICTP training workshop on DEEP (possibility to have extra budgetary support to convene in other MS)
- Discuss the CRP on Specific Advances in Nuclear Desalination Technologies (2008-2011): Benchmarking and Validation of DEEP
- Update of the performance cost data in DEEP library to consider current practices and real economic data of currently installed or contracted reactors)
- TMs on Integrated nuclear desalination system: Periodic &Timing, active participation, repetition of information, place and venue of upcoming meeting (Pakistan or Rep. of Korea) .

- Possible activities on the socio-economic aspects of nuclear desalinations.
- Topics of the upcoming INDAG Newsletter.
- Other issues.

CHINA (Mr Yajun ZHANG)

The coastal area of China includes 11 provinces, regions and municipalities directly and the coastline is more than 18,000 kilometers and there are more than 6,500 islands. In this area, the population accounts for more than 40% of the whole country and the total social output value accounts for about 60%. But, the per capita water resource volume of most coastal industrial city is lower than 500m3. Moreover, the per capita water resource volume of Dalian, Tianjin, Qingdao, Lianyungang, etc. is lower than 200m3. However, seawater desalinization has already been classified as one of priority developing technology in the Chinese "National Marine Economic Development Planning Outline" and the Chinese "National Sub-plan for Seawater Utilization" issued on Aug.2005. Since then, more than 20 plants have been established in China with a total capacity of 120,000m3/d. For the nuclear desalination in China, there are four projects will be mentioned: Liaoning Hongyanhe NPP project, SNDP project, Wenling nuclear desalination project and East part of Shenzhen desalination project.

The Liaoning Hongyanhe NPP project, which is situated in Dalian City of Liaoning Province, is a joint venture among CGNPG (China Guangdong Nuclear Power Group), China Power Investment Corporation (CPIC) and Liaoning Construction Investment Group. CGNPG will be responsible for the project construction and the operation of the first five years after commercial operation with participation from CPIC. A total of six PWR units of 1000 MWe class are planned for the site, which will be constructed in several phases. Phase I will be four CPR1000 units of 1000 MWe class. Nuclear desalination will be adopted in the project to provide water for the requirement of NPP operation in phase I. Four units in phase I will share one desalination station. The capacity of SWRO is 15,000m3/d in phase I and 100,000m3/d will be reached in phase II, supplying water to Dalian city.

Sandong Nuclear Desalination Plant (SNDP) is located in Yatai city, Shandong Province. The INET of Tsinghua University and Chinenergy are responsible for the project now. The feasibility study of SNDP project has be finished in 2005 and the further study is carried forward on NHR-II, Coupling NHR-II with hybrid RO/MED, different capacity plus process steam supplying and so on. It is expected that the achievement in the field of investor will be succeeded. Wenling nuclear desalination project will be responsible by NPIC (Nuclear Power Institute of China) and Beida Qingniao. This is a new pool-vessel type reactor coupled with a LT-MED facility. It is said that the pre-feasibility study has finished and the capacity from 80,000 m3/day, 100,000m3/day to 120,000 m3/day depending on deferent option. East part of Shenzhen desalination project is planned by CGNPG. The suggested site is near by Daya Bay NPP. The first aim of project is to be as the emergency water source of Shenzhen city and the second is to be as the secondary water source of Shenzhen city. The suggested capacity is 330,000 m3/day.

Based on the sub-plan, developing desalination industry in China should mainly rely on reverse osmosis and low temperature with multi-effects. Meanwhile, attention should be paid to some innovative integrated technology and joint production technology. For those massive-scale seawater desalination projects, it is advised to consider the integration of the use of nuclear power and multiple flash evaporation, and low temperature and multi-effects and anti-

penetration. It can even be combined with salt production industry and relating chemical industries.
There are several targets to be achieved. The key materials and unit should basically produced in China (more than 60% should be localized); 3-4 industrial bases should be constructed and 3-5 demo cities and zones should be built and 2-4 project research centres and experiment locales should be set up. The volume of RO seawater desalination plant should reach 20,000-40,000 tons per day; that of distillation plant should reach 20,000-40,000 tons per day; there should be 1-3 model projects which can handle 100,000 tons per day; cost of the equipment should be decreased by 30% and the cost of desalination should be decreased by 20%. In 2010, the daily desalination water volume should reach 0.7-1 million cubic meters, and the annual production value should amount to RMB 3-5 billion. Desalination should become an important part of water supply safety system in coastal areas. And China should become one of the countries with the most powerful desalination industry by laying a solid foundation for that.
The RO technology include the special membrane materials and high capability membrane and large scale membrane component for the membrane process of desalination, pressure vessel, energy recovery unit and high-pressure pump, building the RO desalination demo project with a daily handling volume of 100,000 tons and optimizing the system, single unit volume should be 10,000-30,000 tons daily, the production technology of multiple individual desalination equipment, the traditional technology improved by the membrane process and the technology of recycling waste water as a resource. Key equipment and materials of distillation include heat transferring, corrosion-proof and scale-proof materials special for the use of distillation, building MED demo project with daily treatment volume of 100,000 tons and optimizing the system; singe unit treatment 10,000-40,000 tons daily; technology of low degrade thermal energy, the combination of multiple distillation and solar energy technology, the development of the special coating for carbon steel and anti-corrosion technology. Materials for nuclear power desalination and large-scale desalination plant, it includes the special materials and technology for the nuclear power desalination process, building a demo project with a daily treatment volume of 100,000-200,000 tons and the single unit should be able to treat 10,000-40,000 tons each day; the optimizing and safety guarantee of the nuclear power station and low temperature pile desalination system.

EGYPT (Mr M. M. MEGAHED)

Due to the limited fossil fuel energy resources and the almost fully utilized hydro energy, Egypt has been considering for sometime the various options for satisfying the increasing demand for electricity, including nuclear energy. In the same time, the increase of population and the constant fresh water resources, the annual renewable fresh water per capita continued to decrease over time. As of 1997, the Egyptian fresh water per capita fell below 1000 m^3, indicating that it has become a water scarce country. Therefore, seawater desalination is expected to play an increasing role in mitigating fresh water deficit. In this regard, a nuclear reactor providing electricity to the grid can in principle provide also electricity and/or heat to a desalination plant.
The sharp decline of the Egyptian fossil reserves combined with huge increase in oil prices led the Government of Egypt to reconsider reviving the country's nuclear power programme that was frozen following the Chernobyl Accident in 1986. In September 2006, the President of Egypt declared that the peaceful uses of nuclear energy are monopoly to no one, and that Egypt will not start from scratches. Egypt had its nuclear programme since the 1950s, and it has the human resources needed to revive this programme. The President commanded the

Government to study all aspects of this option that represents a strategic issue concerned with the future of Egypt and its people. As a result Egypt approached the IAEA for technical assistance in the following fields:

1- Selection and Evaluation of sites suitable for nuclear power projects, including:
    a. Updating of El-Dabaa site studies and evaluation based on the current international codes and standards.
    b. Re-evaluation of sites previously screened out during the selection of El-Dabaa at the beginning of the 1980s
    c. Selection of additional sites.
2- Carrying out the Basic Studies needed for the introduction of nuclear power.
3- Review the on going studies related to Energy strategies and planning.
4- Enhance the capabilities of the Egyptian regulatory body.
5- Assistance in drafting nuclear law.

In the light of these studies and discussions, the President declared in October 2007 the decision to start a programme to construct a number of Nuclear Power Plant for electricity generation. He also declared that Egypt shall proceed with the programme because it is convinced that the energy security is an essential element in building the future of the country, and part and parcel of its national security. Although this strategic decision is focussed on use of nuclear energy for electricity generation, it will have a positive impact on nuclear desalination activities. Current activities related to the use of nuclear energy for seawater desalination are:

- Experimental Investigation of Feedwater Preheating on the Performance of RO Membranes.
- Development of an Integrated Economic and Financial Assessment Tool for Power/Desalination Systems (EGY-11973/R0)
- Simulation of Nuclear Desalination Plant (EGY/4/046)

FRANCE (Mr Simon NISAN) CEA activities in nuclear desalination

Over the last years CEA has concentrated on the following activities:

- Feasibility studies in the context of our divers collaborations with other countries
- Specific studies on the environmental impact of desalination by fossil energy based systems; evaluation of the external costs related to this impact.
- Detailed economic evaluations taking into account the environmental costs.
- Development of thermodynamic models to permit calculations of HTR types of reactors providing virtually free waste heat for desalination.
- Development of an MED/VC simulator (in collaboration with BARC, India).
- Development of specific correlations for the mathematical treatment of Reverse Osmosis with preheating; investigations of the complex behaviour of recovery ratio curves as functions of feed water temperature, salinity and feed flow.
- Step by step elaboration of the zero brine discharge strategy for nuclear desalination systems; research on global protocols to extract strategic or valuable materials from the rejected brine, before its conditioning for surface storage; elaboration of specific chemical protocols for the extraction of Rubidium and uranium (in collaboration with BARC, India)
- CEA is also currently engaged in theoretical and experimental studies aiming to use the Tajoura experimental reactor in Libya as a nuclear desalination demonstration programme (in collaboration with REWDRC, Libya).

INDIA (Mr P.K. TEWARI)

Desalination of water is one of the key drivers under non-power applications of Atomic Energy Program in India. Bhabha Atomic Research Centre (BARC) has been engaged in development and deployment of desalination and water purification technologies for a wide range of water related applications. It includes sea water Reverse Osmosis (RO) plant for coastal areas, brackish water RO plant in villages for producing safe drinking water, Multistage Flash (MSF) plant for seawater desalination using low grade steam, Low Temperature Evaporation (LTE) plant using waste heat for seawater desalination, Membrane (Ultra-Filtration) based Water Purification Technologies for domestic and community use, Waste Water Recycle and Reuse using membrane processes. RO technology and Domestic Water Purifier have been transferred to various parties. BARC has put up several big and small plants in different parts of the country and provides guidance and consultancy. We have successfully developed and commissioned next generation seawater desalination technologies for producing ultra-pure water (> 10 mega-ohm-cm) based on Multi Effect Distillation-Vapour Compression (MED-VC) and Low Temperature Evaporation with Cooling Tower (LTE-CT).

The 30,000 Litres/Day (LPD) nuclear desalination plant based on Low Temperature Evaporation (LTE) integrated with CIRUS for the utilization of nuclear waste heat (first-of-its-kind) has been operating well as per design intent since last four years. Product water from desalination unit is utilized for meeting the make up requirement of CIRUS reactor. Based on success story of this plant, it is now planned to integrate a nuclear desalination plant to another nuclear research reactor 'Dhruva' at Trombay for seawater desalination. Preliminary studies have been taken up. RO section (1.8 Million Litres/ Day (MLD) capacity) of Nuclear Desalination Demonstration Project (NDDP) of 6.3 MLD capacity has been operating on regular basis since last five years. MSF section (4.5 MLD capacity) of NDDP is nearing completion. It is proposed to integrate a 500,000 LPD capacity nuclear desalination plant with Advanced Heavy Water Reactor (AHWR) for seawater desalination. The reject from the desalination plant contains a number of valuable materials and is a source of many chemicals. R&D work has been taken up to investigate the recovery of valuables from reject brine of desalination plant/ seawater.

We are participating in Coordinated Research Projects (CRPs) of IAEA including CRP on waste heat utilization of HTGR for nuclear desalination and sharing valuable information with Member States. We are also involved in validation and further development of DEEP code. BARC (India) has offered to IAEA regarding organizing and conducting training programmes in India on nuclear desalination for the interested Member States. Director General, International Atomic Energy Agency (IAEA) visited desalination facilities at BARC Trombay on October 9, 2007. As per bilateral agreement, India and France are working on integrated nuclear desalination systems which include waste heat utilization, hybrid systems, and environmental aspects of nuclear desalination. India, Brazil and South Africa (IBSA) are proceeding ahead to collaborate in the field of water purification/ treatment.

JAPAN (Mr T. Ishida)

The total capacity of the current nuclear power stations for electricity generation in Japan is about 50GWe with 55 reactors. About 3GWe with two reactors under construction will be added in a few years. Eleven reactors with 15GWe moreover have been prepared for construction. Meanwhile status of reactor operation cannot be satisfied with availability. The operating records of nuclear power plants in Japan have shown very low capacity factors such as about 57% in November 2007 on the average due to impact of the 2007 Niigata Chuetsu-

oki earthquake occurred on July 16, 2007 on the Kashiwasaki-Kariwa nuclear power stations, where seven BWRs have been stopping operating.
The 'Framework for Nuclear Energy Policy' stating a basic principle of the nuclear energy policy of over the forthcoming decades was issued October 11, 2007 by the Japan Atomic Energy Commission. For steady promotion of utilization of nuclear energy, it states the guidelines to maintain or increase the current level of nuclear power generation, 30 to 40% of the total electricity generation even after 2030, and to prepare advanced models of the current LWRs for the replacement of the existing nuclear power plants, which will start around 2030, where the large-size LWRs will be prime candidates although a standardized medium-size reactor may be optional.
For development of FBR, the target year of FBR commercial use is around 2050, reflecting situations such as progress of the nuclear fuel cycle project and operation of the "Monju", which should be resumed and demonstrating reliability of the plant and establishing sodium handling technology. For the nuclear fuel cycle, the basic policy is, aiming at using effectively nuclear fuel resources, to reprocess the spent fuel which is conducted within the country and to effectively use the recovered plutonium and uranium. For research and development of innovative concepts including the ITER and a high temperature gas reactor, it states that the government should specify the approach to pursue the feasibility of commercialization. It also emphasizes importance of the international cooperation and maintenance of the Nuclear Non-proliferation regime.
With regard to the nuclear desalination, at the moment, Japan has no new national projects, international projects and inter-regional projects, while 10 nuclear reactors have been continuously operating the desalination facilities with capacity of 1000 to 2600 m3/d to use the water inside the plants without any serious troubles since 1973 (Ohi-1, the oldest one). Voluntary answers to inquiries on the current nuclear desalination operation have been obtained from two electric-companies. They include the following items:

- The reason why this nuclear plant has adopted the desalination system
- Records of operation of desalination system for desalted water
- The breakdown of fresh water use in the plant and the effect of desalination operation on the electricity generation
- Matters to be attended to operation of desalination system, etc.

On the other hand, potential needs for supplying potable water to residents exist especially in the west parts of Japan and non-nuclear seawater desalination systems have been working: The potable water of 50,000m^3/day is supplied in Fukuoka district and 40,000m^3/day in Okinawa City. The new RO system developed by Toyobo and Toray is adopted in the plant of Fukuoka, in which the recovery ratio is improved to 60 %.

REPUBLIC OF KOREA (Mr Moon-Hee CHANG)

The objectives of Korean nuclear desalination program is mainly to develop an integrated desalination plant with SMART (System-integrated Modular Advanced Reactor; thermal power of 330MWt) both for electricity generation and for seawater desalination. The SMART reactor, an integral type pressurized water cooled reactor, is coupled with the Multi-Effect Distillation Thermal Vapour Compression (MED-TVC) process.
The program is being carried out by the Korea Atomic Energy Research Institute (KAERI) as the leading organization with the support of government and participation of nuclear industries. Both the conceptual design and basic design of the SMART with a desalination system were successfully completed in March of 1999 and in March of 2002, respectively. Major components such as steam generator, reactor coolant pump, and control rod drive mechanism were developed and performance tests were performed. A series of performance

tests and safety tests for SMART reactor systems have been performed at high-temperature high pressure thermal hydraulic test facility built at KAERI. In order to demonstrate the SMART technologies and to assess the overall performance and safety, a detail design and construction project for a pilot plant at 1/5 scale (65 MWt) of the SMART, called SMART-P, launched in July of 2002. The first phase focused on the design and technology verification by way of tests and experiments. However, during the licensing review for the construction permit of the SMART-P by the Korean nuclear regulatory authority, SMART-P project was suspended due to the site and budget problem.

In 2006, one year SMART design optimization study has been carried out to expedite realization of SMART and to improve the economical efficiency, licensability, manufacturability and maintainability. Power up-rating was considered to raise the economical efficiency. Steam generator cassette design was modified to accommodate the in-service inspection of tube elements. Passive/active hybrid safety system was adopted instead of full passive safety system symbolized by the safeguard vessel. After an extensive effort and evaluation to incorporate the safeguard vessel, full passive concept was reserved for the timely realization of the SMART.

From the very beginning stage, the SMART project has been widely opened for the international cooperation and the project had kept very close relationship with the Agency activities for nuclear desalination. Korea has participated in the CRP whose title is “Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies.” The CRP launched in 2001 and finished with the publication of TECDOC entitled “Economics of Nuclear Desalination: New Developments and Site Specific Studies” in 2007. After successful completion of the preliminary economic feasibility assessment of SMART desalination plants in Madura Island as the IAEA interregional cooperation project, a few Member States expressed interest in SMART for seawater desalination and electricity production and willingness for bilateral technical cooperation. A joint feasibility study with one of those Member States who expressed interest in technical cooperation is in the final stage. Besides that, dialogues with a couple of Member States for the bilateral potential cooperation for the SMART dual purpose application are currently underway.

LIBYAN ARAB JAMAHIRIYA (Mr S. Ghurbal)

Launching a nuclear desalination program requires supporting infrastructure**s** which must be managed in line with the major programme creation phases. The envisaged nuclear desalination programme comprises two disciplines of technology, the desalination technology and the nuclear technology. The design approaches for a nuclear desalination plant are essentially derived from those of the nuclear reactor with some additional aspects to be considered in the design of a desalination plant and its integration with the nuclear system. World-wide experience has shown that there are no technical difficulties in the coupling of the desalination system with the reactor system. However, it is necessary to include an intermediate circuit with pressure reversal. Some consideration needs also to be given to avoid the product water contamination and the possible impact on the reactor operation in the case of the shutdown of coupled distillation plants. In view of sever water shortage problem Libya has retained the desalination of seawater to be one of the major option to augment national efforts for the supply of potable water and decided to conduct certain activities toward capacity building and cost optimization in this field. In the frame of national strategy for energy mix to sustain socio-economic development and recognizing the possible role of nuclear energy in seawater desalination Libya decided to pursue nuclear desalination.

Since the nuclear desalination project constitutes the country's initial introduction to nuclear energy a clear view of obligations and commitments aspects relating to the nuclear project has

been thoroughly considered. For realizing nuclear desalination and having in mind the obligations and commitments, the following steps have been taken to promote the activities:

- Steps toward establishing and developing some of the required supporting infrastructures and human resources development related to the nuclear energy applications.
- Establishing and developing the regulatory body
- A programme of capacity building in the field of desalination technologies was launched in collaboration with specialized companies in Europe. The aim of the program is to increase the level of local participation in the construction and O&M of desalination plants, as part of the cost reduction strategy. This programme was designed in a manner to enable the trainees to acquire the skills and know how to design, manufacturing, build, operate and maintain the desalination plant. With this we guarantee the ownership of the technology and its development.
- A TC Project was launched with the agency on Simulation of ND of seawater (LIB/4/010) with view to build local capabilities in modelling of ND systems.
- Carrying out a site specific techno-economic feasibility studies to use nuclear reactors for desalination and electricity production and demonstration of nuclear desalination using Tajoura research reactor, LIBNDP1 in collaboration with France.

The advances in the on going technical activities are as follow:

- The aim of the programme of the capacity building in the field of desalination technologies has already been successfully realized with varying level of success in different areas.
- Regarding the TC Project on Simulation of ND of seawater (LIB/4/010),

The APROS version 5.08 has already been installed, the working team in the project have started to utilize this software.

- The task concerning the first work package (WP1) of the feasibility study, for the Pre-dimensioning of the Nuclear Reactors and Desalination Systems from site-specific data, has already been realized. The work involved :

  - Collection of all pertinent data related to the selected Libyan site (electricity for the entire Libyan grid and water for Tripoli agglomeration).

  - Evaluation of Water and electricity needs up to year 2020.

  - Detailed analysis of key design parameters of an integrated nuclear desalination system. The analyses have led to the conclusion that, around 2020, the Libyan grid would require a nuclear reactor of about 1400 MWe and a desalting capacity to the selected site of between 600,000 and 1000,000 m3/d.

Such demands could be satisfied by:

- One unit of the EPR reactor producing 1400 MWe and providing thermal energy to 4 desalination plants of 100 000 m3/d capacity per unit.
- Two units of the French PWR-900 providing in total 1830 MWe and coupled to two desalination plants of 100 000 m3/d capacity each.

In the particular case of HTRs

- Five units of the GT-MHR providing 1425 MWe and 96 800 m3/d of desalted water at very low costs because of the waste heat utilisation.
- Ten units of the PBMR, providing 1038 MWe and 85 206 m3/d of desalted water.

In all cases the water capacity can be increased at the expense of electricity generation or to utilize the RO technology which is electrically driven. With regard to the advances in the demonstration part of the project:

- Technical aspects regarding the extracting point of an intermediate circuit has already been envisaged.

- Conceptual studies of the required coupling schemes based on the utilization of hybrid MED/RO systems have already been made.
- The dimensioning of the various components is underway.

MOROCCO (Mr Yahia BOUABDELLAOUI)

As part of its infrastructure continuous improvement, Morocco adopted specific law covering all water management aspects, including pricing and environmental issues and creating Basin agencies. In order to address water scarcity in the near term, Water Authorities set up and are implementing the 2005-2025 National Water Plan. Nuclear desalinisation is an important option among other options. The Government of Morocco strongly believes that existence of effective legal and regulatory infrastructure is a prerequisite for the development of any promotional nuclear activities. Consequently, it has started establishing an adequate and sound legal and institutional legislative and regulatory nuclear framework. Morocco is committed to become familiar with all existing and available technologies and experience in nuclear peaceful activities in general and desalination in particular. National nuclear infrastructure is being further strengthened in co-operation with the IAEA and other countries through multilateral and bilateral arrangements. In line with its vision, aiming at meeting its water and energy needs in a sustainable manner including desalination, Morocco is formulating a strategy with clear roles and responsibilities and strengthen coordination mechanisms between all stakeholders and partners (e.g., ONE, ONEP, CNECTEN, OCP …etc.). In this context, a new Ministry dealing with mining, energy, water and environment has been established. The legal framework is being adopted opening the production and distribution of energy to private sector. Specific progress so far achieved consists of the followings:

i) ONE-Given the progress in technologies and the increased oil price, ONE is updating with the assistance of the Agency, the ONE-FRAMATOME qualified NPP site. Last November, a high level delegation, chaired by its DG, visited the Agency and discussed all steps and activities to be undertaken. The newly established Ministry, has recently declared that introduction of nuclear power is scheduled for 2017 due to: (a) continuously increased demand in electricity (8%), (b) high oil price (ten times in one decade), (c) low and embryonic share of renewable energy. In addition, Morocco is to meet Kyoto obligations and promoting CDM.

ii) OCP-The Office is being restructured to become opened to national and international shareholders. In addition, a joint venture with AREVA has been signed for extraction of uranium. OCP has gained strong experience in desalination for its industrial processes.

iii) ONEP- They conducted conventional desalinisation feasibility studies using wind and solar energy to compare the findings with those of the nuclear desalinisation Pilot Project. The later was implemented through the IAEA's TC programme, involving China, INET ONE, ONEP and CNESTEN. In addition, CNESTEN has been involved in bilateral nuclear desalinisation studies with France.

Morocco has always been counting on international cooperation in general and with the Agency in particular in promoting peaceful nuclear activities. It has benefited from: Assistance from the agency in term of expertise, training, software and exchange of knowledge and experience, bilateral co-operation to continue implementing the nuclear desalination program. With all above achievements, Morocco has demonstrated its commitments to further promote the introduction of nuclear power for electricity production

and desalination. Morocco is fully aware of international legal obligations derived from conventions and instruments it has signed and ratified and making every effort to meet them.

PAKISTAN (Mr S. Ayub)

Pakistan Atomic Energy Commission (PAEC) has primarily focussed on installation of a 1600 cu-m/day capacity MED type Nuclear Desalination Demonstration Plant (NDDP) at Karachi Nuclear Power Plant (KANUPP). Over the last years the following milestones of the NDDP project have been completed;

- Design Engineering of the main MED plant equipment has been completed, drawings have been released for construction at a facility within Pakistan. Raw material for fabrication has been received at works and the fabrication work is at an advance stage, nearly 50% of the equipment construction has been completed.
- Final design of the Intermediate Coupling Loop (ICL) hooking up the desalination plant with the NPP has been completed and submitted to the National Regulators for approval which has been received and now site fabrication and installation work is in progress.
- Seawater supply and discharge circuit design has been completed. Required FRP piping has been developed and manufactured by a local vendor industry. The piping system is presently being installed at site and expected to be tested and commissioned by early March 2008.

The commissioning of the NDDP project is now scheduled by mid of year 2008. The demonstration plant at KANUPP will help PAEC to evaluate the most feasible options for developing future nuclear desalination facilities along the coastal areas of Pakistan thus contributing to the socio-economic development of these areas.

RUSSIAN FEDERATION (Mr Yury BARANAEV)

Small reactors development and implementation programme is in progress in Russian Federation. Motivation for the programme is very high electricity and heat cost produced by of conventional power stations in decentralised power supply areas of the country. Technologies of several types of small reactors are available (proven) and ready for implementation. Prospects for non-electric application of nuclear energy, including nuclear desalination, broaden the area for small reactor at the future internal and international market.

The Russian Federal Agency for Atomic Energy (ROSATOM) continues construction of a floating barge-mounted heat and power co-generation nuclear plant based on state-of-the-art ship propulsion reactor KLT-40S of PWR-type. The basic construction contract with navy yard «Production Association «Northern machine–building enterprise» («PO «Sevmash») was signed on June 14, 2006 in Severodvinsk-city (Arkhangelsk Region, North-West of Russia). Severodvinsk is also a location site for the first unit of the floating NPP. Announced construction cost amounts to 9.1 billion Russian Rub. It is planned to put the plant into operation in 2010. The FNPP is mounted to a barge having the following dimensions: length – 144 m, width – 30 m, draft – 5.6 m and displacement – 21500 t. Two KLT-40C reactors are housed into separate steel containments. The floating NPP can produce up to 70 MWt of electric power and about 150Gkal/h of heat for district heating. Life time of the plant is 40 years, continuous operation period before dockyard repair is 12 years. Total operating staff numbers 69 persons. “Rosenergoatom” who is utility of the floating NPP has preliminary agreements to construct at the «PO «Sevmash» several units for deployment in remote regions over Russia. Demonstration of this nuclear technology is considered to allow its larger scale application inside the country and abroad for electricity and heat production and also for seawater desalination. Prospective location site in the North and North-East of the county are defined.

Development of a smaller floating nuclear power plants with ABV-6 reactor has been also started. The objective of the project is to match energy demand of isolated consumers in the remote areas of the country and thus to broaden application market. A barge where two reactors ABV-6 of 38 MWt is mounted has the following dimensions: length – 108 m, width – 14 m, draft – 2.6 m and displacement – 3700 t. Road map of implementation of small floating NPP with KLT-40S and ABV-6 in the period 2008 – 2016 comprises 15 units.

SAUDIA ARABIA (Mr A. ALMARSHAD)

The rising demand for energy and water has prompted the GCC countries to consider exploring the nuclear option for power generation. Saudi Arabia and other GCC Countries namely: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates, have decided to carry out a joint study by the GCC members with the help of IAEA to forge a joint programme in the field of nuclear technology for peaceful purposes according to international criteria and systems. It is more important to identify the necessary steps on infrastructure requirements and other related issues in the event of a decision to introduce nuclear power for electricity generation and desalination for the GCC region. With the focus on cooperation among GCC countries, the recommended steps to follow are:

- Formation by GCC countries of a Nuclear Energy Programme Implementation Organization.
- Evaluation of benefits and weaknesses/threats.
- Collection of examples and lessons learned from case studies.
- Initiation of a preliminary siting study, focusing on the nuclear power plant, waste storage and disposal, interface with the electricity grid, etc.).
- Evaluation of attractive opportunities and modalities of sharing. For the GCC countries the decision on where to site the first nuclear power plant would need to be considered. It would be possible to concentrate all nuclear power development in a single country or, alternately, to identify and develop several sites for nuclear power plants in different Gulf States.
- Development of multilateral agreements on such issues as liability, transport of fuel/spent fuel/waste, long term power off-take, funding for decommissioning, waste disposal; ownership of the nuclear power plant, spent fuel, waste and physical facilities/components; cost sharing; penalty for withdrawal, transfer of title, etc.

TUNISIA (Mr Mohammed ZAARA)

Did not send any contribution, or even attend the meeting

UNITED STATES OF AMERICA (Mr Ron FAIBISH)

The U.S. has engaged the IAEA on nuclear desalination issues through INDAG and other IAEA related activities for several years now. Recent indications have been that non-electrical applications of nuclear energy and nuclear desalination in particular are important incentives for future growth of safe, proliferation-resistant, and cost-effective civil nuclear power operations around the world. Indeed, the production of water using nuclear power is one of the proposed missions of U.S. DOE's newly launched Global Nuclear Energy Partnership (GNEP)'s Grid Appropriate Reactor (GAR) campaign.
ANL's presentation to the January 2008 meeting of the INDAG focuses on the important factors that should be considered in aiding future development and possible deployment of

nuclear desalination and related systems. The discussion highlights the special significance of site-specific considerations, general infrastructure issues, and a suggested roadmap for IAEA's future related activities.

The IAEA and its Member States (MSs) have conducted numerous studies to examine issues primarily relating to technology and economics of nuclear desalination systems. The need still exists for assessment of immediate and near-term needs for water and power cogeneration in the form of country-specific and global analyses. These analyses could include:

- The generation of realistic values of possible proportions of energy and water production of nuclear nature;
- Assessment of cross-cutting issues, such as reactor of choice, infrastructure needs, and regulatory considerations in a given country/region and identify gaps and path forward in bridging these gaps;
- Active engagement of MSs and especially those with very young or no nuclear infrastructure to assess the overall feasibility of such systems.

A specific strategy/roadmap could be laid out as follows:

- The strategy/roadmap should be planned for a period of 3–5 years; revisited and updated if needed
- Elements of the strategy:
    - Knowledge preservation
        - *Establish databases*
        - *Provide active and effective web-based interface*
    - Maintenance, development and updating
        - *DEEP periodic and regular update*
        - *Update of relevant technical documents*
        - *Update and tracking of "real" data and experience*
    - Creation of a "toolkit" of the most relevant materials that would be available to MSs interested in nuclear desalination activities. The information in this kit should be updated periodically.
    - Continued engagement through meetings and information exchange forums

The overall view is that the IAEA can and should play a leading role in any future possible plans for large scale deployment of nuclear-based power and water cogeneration systems around the world. Argonne National Laboratory as the official U.S. representative to the INDAG will do its best to assist in these activities as necessary and within the available resources to do so.

5. Recommendations

1. INDAG took note of the progress of technical developments including DEEP 3.11 with water transport cost model, the update of nuclear desalination Web Page, the cancellation of the ICTP Training Course on Desalination System Modelling-Technology & Economics and the Agency's participation in international conferences. INDAG recommends that the revised version of DEEP should be updated, validated and documented on a regular basis to meet changing technologies and variation in bench-marking data.

2. INDAG noted the full implementation of all the activities regarding Program & Budget (P&B) 2007. INDAG recommends that the IAEA adopt a roadmap on its nuclear desalination activities (an example proposed roadmap is included in Appendix 1). INDAG members can advise the Agency during its regular meetings on possible modifications to the roadmap.

3. In the context of the proposed road map, the IAEA should create a "nuclear desalination toolkit", which can include the latest version of DEEP and a set of documents that provide

recommended guidelines and information on launching a nuclear desalination program in Member States. This toolkit should be updated periodically. To provide the IAEA with input on the contents of the toolkit, it is also recommended that a consultancy meeting be arranged sometime in 2008.

4. INDAG reviewed the IAEA proposed activities of P&B 2008 of the project A.5.01 "Support for the demonstration of nuclear seawater desalination". INDAG was informed of past and on-going TC-supported inter-regional and national nuclear desalination projects, the launching of new CRP on Advances in Nuclear Power on Process Heat Applications, and the possibility of new CRP on Advances on Integrated Nuclear Desalination Systems. Workshops and symposia on nuclear desalination should be organized at regular intervals for enhancing awareness on IAEA's related activities.
    - Workshops should address issues on advances on nuclear desalination-related technology, DEEP development, safety and environmental issues, infrastructure and financial aspects.
    - The symposia should be directed at relevant decision and policy makers in Member States.
5. Future CRPs should consist of clearly defined work packages (i.e. each work package should include clear tasks for a group of participants in an integrated manner) that promote synergy and constructive collaborative work between participants.
6. It is recommended that the IAEA launch assessment studies on world-wide ND plants, prospective short, mid and long term demands, capacities, and value of desalinated water.
7. INDAG recommends for continuing the publication of INDAG Newsletter highlighting the latest status in the MSs and in the IAEA.
8. The proposed date for the next INDAG meeting is June 2009.

6. Concluding remarks

Nuclear desalination is an inevitable option as the increase in water shortage, climate change and oil price would have a greater impact. There would be need for small, medium and large size nuclear desalination plants in the coastal areas which would be governed by the demand and quality of desalinated water requirement. Excellent prospects are foreseen in next 10-20 years as long as the interested Member States (the majority of which currently have no access to required nuclear power technology) will be able to safely and economically generate nuclear power in the near future. The IAEA and INDAG are playing an important role in facilitating and providing advice on nuclear desalination activities in Member States.

Agenda for IAEA's Technical Meeting
of the International Nuclear Desalination Advisory Group (INDAG)
Vienna, Austria
7-9 January 2008

Monday, 7 January 2008

09:30	Welcoming Remarks	A. Rao, IAEA
09:40	Introduction of participants and adoption of Agenda	all participants
10:00	IAEA Programme on INDAG	I. Khamis, IAEA
11:20	China Nuclear Desalination Activities	Y. Zhang, China
11:40	An overview of Egyptian activities for electricity generation and seawater desalination by nuclear energy	M. Megahed, Egypt
12:00	Discussion on the presentations	all participants
12:30	*Lunch Break*	
14:00	CEA Roadmap for Nuclear Desalination CEA Studies in Nuclear Desalination	S. Nisan, France
14:20	Nuclear desalination in India	P.K. Tewari, India
14:40	Operations of nuclear desalination in Japan	T. Ishida, Japan
15:00	Discussion on the presentations	all participants
15:30	*Coffee Break*	
16:00	Activities on Nuclear Desalination in Korea	M. H. Chang, Republic of Korea
16:20	Discussion on the presentations	all participants
18.00	Wine & Cheese Party, Function Room A, F-Building, Ground Floor	all participants

Tuesday, 8 January 2008

09:00	Vision and national programme for nuclear desalination	S.M. Ghurbal, Libyan Arab Jamahiriya
09:20	Current progress on Nuclear Desalination in Morocco	Y. Bouabdellaoui, Morocco
09:40	Discussion on the presentations	all participants
10.30	*Coffee Break*	
11:00	Status of Nuclear Desalination in Pakistan – Present & Future	M.S. Ayub, Pakistan
11:20	Small reactors development and implementation programme in Russia	Y. Baranaev, Russian Federation
11:40	An Overview of Nuclear Power for Electricity Generation and Desalination in the GCC Region	A. Almarshad, Saudi Arabia
12:15	*Lunch Break*	
14:00	Future of Nuclear Desalination: A U.S. Perspective	R. Faibish, USA
14:20	Discussion on the presentations	all participants
15:30	*Coffee Break*	
16:00	General Discussions and Draft Meeting Report	all participants

Wednesday, 9 January 2008

09:00	General Discussions and Draft Meeting Report and Recommendations	all participants
10:30	*Coffee Break*	
11:00	Finalization of Meeting Report and Recommendations	all participants
12:00	Adjourn Technical Meeting	all participants

LIST OF PARTICIPANTS

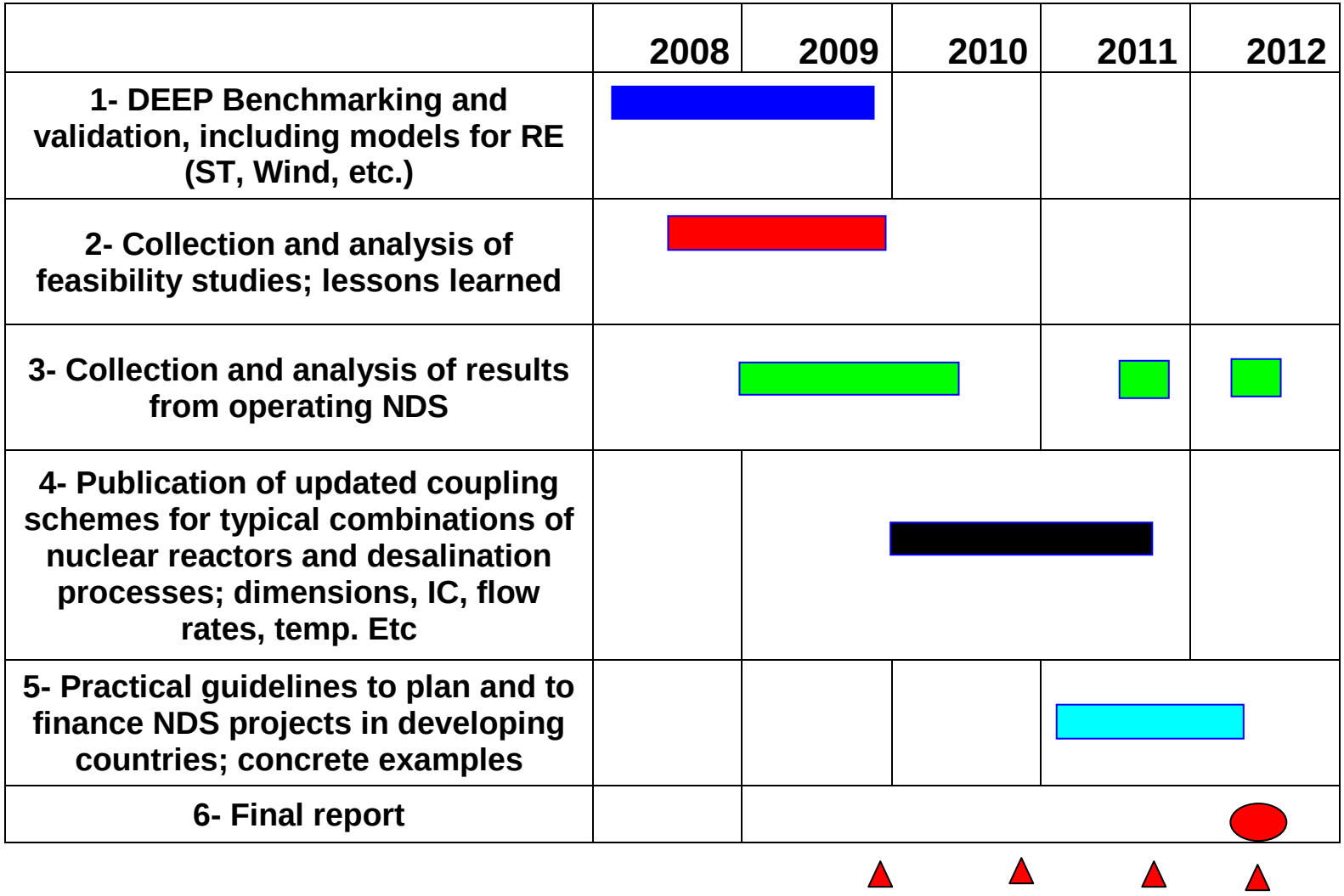
Algeria	Mr	Belkaid Abderrahmane	Commissariat à l'énergie atomique (COMENA); Centre de recherche nucléaire de Birine (CRNB) B.P. 180 17200 Birine, Djelfa Algeria Tel: 00213 27 821154 Fax: 00213 27874280 Email: abbelkaid@yahoo.fr
China	Mr	Zhang Yajun	Institute of Nuclear and New Energy Technology Tsinghua University Beijing 100084 People's Repubic of China Tel: +86 10 62772011 Fax: +86 10 6277 1150 Email: yajun61@mail.tsinghua.edu.cn
Egypt	Mr	Megahed Mohamed Mounir	Vice Chairman for Studies and Nuclear Affairs Nuclear Power Plants Authority 4 El-Nasr Avenue, Nasr City P.O. Box 8191 Cairo 11371 Egypt Tel: +202 2261 6272 Fax: +202 261 6476 Email: MMegahed@hotmail.com
France	Mr	Nisan Simon	Commissariat a l'énergie atomique (CEA); Centre d'études nucléaires de Cadarache (CEN); Direction des réacteurs nucléaires 13108 St. Paul lez Durance France Tel: 0033 4 42254628 Fax: 0033 4 42 25 36 35 Email: simon.nisan@cea.fr

India	Mr	Tewari Pradip K.	Bhabha Atomic Research Centre (BARC); Desalination Division Trombay Mumbai, Maharashtra 400 085 India Tel: 0091 22 25594619 Fax: 0091 22 25505151 Email: pktewari@barc.gov.in
Japan	Mr	Ishida Toshihisa	Kobe University Fukae. Higashinada, Kobe Hyogo-ken 658-0022 Japan Fax: +81 78 431 62 94 E-mail: t-ishida@maritime.kobe-u.ac.jp
Korea, Republic of	Mr	Chang Moon-Hee	Korea Atomic Energy Research Institute (KAERI) 150 Deokjin-dong, Yuseong P.O. Box 105 Daejon 305-353 Korea, Republic of Tel: 0082 42 8682818 Fax: 0082 42 868 8990 Email: mhchang@kaeri.re.kr
Libyan Arab Jamahiriya	Mr	Ghurbal Salem, Mohamed	Renewable Energies and Water Desalination Research Centre (REWDRC) P.O. Box 30878 Tajoura Libyan Arab Jamahiriya Tel: +218 21 3614135/3601109 Fax: + 218 21 3614142 0r +218 21 3699322 Email: ghurbal55@yahoo.com

Morocco	Mr	Bouabdellaoui Yahia	Standing Commission in charge of nuclear affairs (COPSAN) D7, Residence Annakhil Av. A1 Fillao - Riad Rabat Morocco Tel: +212 61211589 Fax: +212 37671401 Email: y.bouabdellaoui@iav.ac.ma
Pakistan	Mr	Ayub Muhammad Saleem	Deputy Chief Engineer Pakistan Atomic Energy Commission (PAEC) Karachi Nuclear Power Plant (KANUPP) Design and Development Division P.O. Box 3183 Karachi 75400 Pakistan Tel: 0092 21 9202222 Fax: 0092 21 9202240 Email: knpc@khi.comsats.net.pk
Russian Federation	Mr	Baranaev Yury	Institute for Physics and Power Engineering Bondarenko Sq. 1 Kalushskaya obl. Obninsk 249030 Russian Federation Tel: +74843998266 Fax: +74843994529 Email: baranaev@ippe.ru
Saudi Arabia	Mr	Almarshad Abdullah I.	Atomic Energy Research Institute King Abdulaziz City for Science and Technology PO Box 6086 Riyadh 11442 Saudi Arabia Tel: +966 1 481 34 44 Fax: +966 1 481 3887 Email: amarshad@kacst.edu.sa

United States of America	Mr	Faibish Ron	ANL Argonne National Laboratory International Energy Resource Cooperation Bldg. 208, Rm E224 Argonne, IL 60439 USA Tel: +1 630 252 8355 Fax: +1 630 252 5161 Email: r.faibish@anl.gov
Observer France	Mr	Noyes Jean-Eric	CEA Cadarache Tel: +33 44 2253706 E-mail: jean.eric.noyes@cea.fr

IAEA ROADMAP TO PROMOTE THE IMPLEMENTATION OF INTEGRATED NUCLEAR DESALINATION SYSTEMS IN MS



FOLLOW-UP CONSULTANCIES