MEETING REPORT

Eighth International Nuclear Desalination Advisory Group (INDAG)

held at the IAEA Headquarters, VIC, Vienna
6 to 8 February, 2006

CONTENTS

List of Participants

ATTENDING EXPERTS

No.	Name	Country/Organization
1)	Mr. N. Masriera	Argentina/INVAP
2)	Mr. Y. Zhang	China/INET
3)	Mr M.M. Megahed	Egypt/NPPA
4)	Mr. S. Nisan	France/CEA
5)	Mr. P.K. Tewari	India/BARC
6)	Mr. A. Barak	Israel/IAEC
7)	Mr. T. Ishida	Japan/Kobe University
8)	Mr. S.B. Ghurbal	Libya/REWDRC
9)	Mr. Y. Bouabdellaoui	Morocco/COPSAN
10)	Mr. A. Boughriba	Morocco/ONEP
11)	Mr. K. Mahmood	Pakistan/PAEC
12)	Mr. Y.D. Baranaev	Russia/IPPE
13)	Mr. A.I. Al-Marshad	Saudi Arabia/AERI
14)	Mr M. Zaara	Tunisia/SONEDE
15)	Mr. R.S. Faibish	United States/ANL
16)	Mr. K.S. Lee	OECD/NEA
17)	Mr. A. Rao	IAEA, SH-NPTDS
18)	Mr. B.M. Misra	IAEA, NPTDS
19)	Mr. M. Methnani	IAEA, NPTDS
20)	Mr. J. Stuller	IAEA, TCPB
21)	Mr A. Mahjoub	IAEA, TCAF
22)	Mr. J. Mandula	IAEA, NPES

MEETING REPORT

A. General

The eighth meeting of the International Nuclear Desalination Advisory Group (INDAG) was held from 6 to 8 February 2006 at the VIC, Vienna. The meeting was attended by 14 members and one observer from Morocco and represented by one International Organization, NEA/OECD. Mr. Tewari of the Bhabha Atomic Research Centre, India served as the Chairperson.

Mr. Rao, SH-NPTDS welcomed the members and opened the meeting. He mentioned that based on the studies done so far in the Agency and in the Member States, nuclear desalination is viable and a feasible option. He desired that this INDAG meeting discuss means for more visibility of the programme and suggest plans for early establishment of nuclear desalination projects in the interested Member States.

The meeting provided a forum for the exchange of information on the progress of national programmes in this field. INDAG also reviewed and assessed ongoing IAEA activities in the relevant field and future activities being proposed by the Secretariat for the year 2006/2007 and made certain recommendations.

B. Recent Developments in National Programmes & Agency Activities

All participants updated status and prospects of programmes on nuclear desalination in their respective countries.

Argentina

Argentina has continued to support the Agency's ongoing programs on nuclear desalination in two different lines.

A relevant effort within INVAP on developing specific engineering and project management findings out of the well settled IAEA's Safety Approach of Nuclear Desalination. This work has backgrounds on the SAR content survey, and includes:

A technical presentation during INDAG 7th meeting showing a development of the conceptual engineering for the Product Water radiation Monitoring (PWM) as a Safety Feature, using reservoirs with hold up time enabling verification before distribution.

In the TM on Integrated Nuclear Desalination Systems, Chennai, December 2004, the development was on a coupling featuring a barrier in which the pressure configuration is monitored. The NPP side pressure is kept lower than in the DP side, (namely a "pressure reversal", PR) providing a Safety Feature.

A technical presentation during INDAG 8th meeting analyses the "pending issue" of the impact in terms of efficiency of using an Intermediate Loop implementing the Pressure Reversal Safety Feature.

Simultaneously, the Argentine CNEA (Comisión Nacional de Energía Atómica) has been participating in the CRP on "Economic Research on, and Assessment of Selected Nuclear Desalination Projects and Case Studies" and during this last period the foreseen goals were achieved completely.

Within the site survey stage, several places were considered and after screening the available information the selected site was Puerto Deseado, and the selected desalination technology was RO. The site relevant parameters were collected and a study of the DP variables was carried out reaching an optimised specification. The investments and operative costs were estimated for the DP, and for both energy sources (CAREM NPP and a combined cycle gas turbine plant).

Two economical assessment methodologies were used in parallel, DEEP and IPEE (Chemical Plants Economic Evaluation, CNEA). Beyond a base case, a sensitivity study was performed on the product cost with the fossil fuel price, the interest rate, and the Plant capacity. It was concluded that the use of a CAREM NPP coupled to an RO plant provides an attractive, economic and feasible option for electricity and freshwater production in Puerto Deseado.

China

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 in Aug.2005.

Based on the R&D over more than forty years, for the capacity more than 500 m3/d each unit, 12 seawater desalting plants have been established in China with a total capacity of 40,000m^3/d, and the capacity under construction has exceeded 50,000t/d.

There are several targets to be achieved in the "National Sub-plan for Seawater Utilization". The key materials and unit should be 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; single 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, 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

Several projects related to nuclear desalination have been going on with technical assistance from the Agency. These include:

- Development of an Integrated Economic and Financial Assessment Tool for Power/Desalination Systems (EGY-11973/RO)

- Simulation of Nuclear Desalination Plant (EGY/4/046)

- Human Resources Development for Nuclear Power Plant Project Preparation and Project Management (EGY/4/045)

- Safety and Environmental Impact Assessment for El-Dabaa Nuclear Power Plant (EGY/4/049)

An important progress in the construction of El-Dabaa Experimental RO Desalination Facility was delayed for reasons beyond the control of NPPA. The project is expected to be completed in 6-8 weeks. NPPA offered international cooperation with other Member States through:

- Making the results of the experimental programme available to Member States

- Participation of Member States' experts in NPPA experimental programme to validate thermal coupling of SWRO system with nuclear power plants, particularly in the following fields:

- Data collection, normalization and analysis
- Compilation of reports and joint publications
- Development of new experiments utilizing the test facility
- Others, to be mutually agreed upon

France

Nuclear Desalination Studies at CEA, France – being carried out under CEA's own R&D programme – are increasingly becoming inter-regional.

In addition to collaboration within the EU, in particular with Germany, a collaboration agreement has already been signed between CEA and BARC, India, for specific nuclear desalination activities. The agreement between CEA and REWDC (Libya) is expected to be signed in March 2006. Similar agreement is under negotiation with South Korea.

These collaborations would cover the following aspects:

- Modelling of divers integrated nuclear desalination systems and economic evaluation methods.

- Experimental validation of these models.

- Techno-economic feasibility studies, including the application of new cost evaluation method based on the exergy principle.

- Development of specific SMRs most adapted to nuclear desalination with the lowest possible costs.

CEA is also preparing a proposal for a nuclear desalination demonstration project with the Materials Testing Reactor at Cadarache Research Centre. The proposal will be submitted to the regional authorities by the end of 2006.

India

As a part of the national programme for better quality of life for its population by systematic induction of nuclear energy, BARC (India) has developed several desalination and allied technologies. It is also engaged in coordinating a nation wide activity on preparing position paper on desalination activities, which include nuclear desalination.

BARC (India) has active programme on utilization of nuclear waste heat for seawater desalination. The 30,000 litres/day LTE desalination which was integrated to CIRUS nuclear research reactor for utilizing waste heat for seawater desalination has completed two years of successful operation producing high quality distilled water which meets the entire requirement of make up water of the reactor. The successful demonstration has opened up the possibility of setting up large size seawater nuclear desalination plants utilizing low grade/waste heat of nuclear reactor. It is planned to integrate 500,000 litres/day nuclear desalination plant with AHWR for seawater desalination.

SWRO Section of Nuclear Desalination Demonstration Project (NDDP) at Kalpakkam has completed three years of successful operation as per design intent since its commissioning in 2002. Potable water produced is supplied to nearby areas. MSF is under construction. The road map includes establishing

large size nuclear desalination plants. The vision is nuclear power plant producing electricity, desalinated water and hydrogen.

An IAEA Technical Meeting (TM) was organized on “Integrated Nuclear Desalination Systems” at Chennai (December 13-16, 2004) which included a visit to NDDP (Kalpakkam).

BARC (India) is also engaged in collaborative efforts through CRPs. BARC (India) and CEA (France) have recently signed a cooperative agreement on integrated nuclear desalination systems.

Israel

No nuclear desalination activity has developed but the vast non-nuclear desalination developed might have a significant contribution to nuclear desalination.

The SWRO plant in Ashkelon (100 M m3/year) was commissioned. The first 50 M m3/year unit started preliminary operation in May 2005 and regularly operated in August 2005. The second twin unit followed 2 months later. The production rate and quality positively exceed the nominal values. The maximum daily measured production per hour was 7200 t/hour/unit equivalent to 115 M m3/year. The chlorides concentration is about 12 ppm, compared to the guaranteed level of 20. The boron level varies between 0.2-0.4 ppm, close to 0.2 vs the guaranteed value of 0.4. The overall plant specific energy is 3.6-3.8 kWh/m3 vs the expected 3.9-4.0. The overall efficiency of the pressure energy recovery system is very high, 93-96 %, compared to the equivalent approximate value of 80 % with the conventional water-turbine/pump coupling.

Total manpower is 40 (keeping the labour cost component as low as 1-1.5 c/m3). Electricity is supplied from the grid but will soon be replaced by local, plant own gas operated power unit.

The price of the water (which was the basis for the BOOT bid) increased from about 50 c/m3 to 56-59 t/m3, following the partial contracted linkage between the desalted water price to the fossil fuel escalating prices.

Two near future large SWRO plants are now underway. The first 30 M m3/year will be ready during 2007, being now in the installation phase. The second (100 Mm3/y) is now in the midst of bid procedures that will conclude in September 2006. The plant is planned to be commissioned in 2009.

Japan

Japan has continuously operated some nuclear desalination facilities to use the water inside the plants without any serious troubles. Although there are not any exclusive nuclear desalination for supplying potable water to residents, potential needs exist especially in the west parts of Japan. Fukuoka district, a local autonomous body of the northern part of Kyushu recently commenced supplying the potable water 50,000 m3/day produced by non-nuclear seawater desalination, followed by Okinawa City 40,000 m3/d. 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 %.

R&D on innovative nuclear technologies is conducted under the contract with MITI. Concept design studies on small reactors generating power of 350 to 450 MW such as IMR by MHI and CCR by Toshiba are continued. These small reactors can be used also as energy source for desalination like SMART, if necessary.

Libya

Water desalination is a necessity for Libya because of the water shortage problem. The water deficit gap is increasing and has raised concern on the national level. Desalination was introduced in Libya during the early sixties and has grown up dramatically since then. Commercial scale production has

started in the mid seventies where the total accumulated installed capacity from thermal (MSF and MED) and membrane (ED and RO) desalination technologies has reached about 800,0000m3/d while the capacity in operation now amounts to about 380,000m3/d. Libya is considered to be the largest operator of desalination plants in North Africa and has gained experience in this field.

Water shortage problem and the experience and expertise gained in the field of desalination and nuclear were among the motives to pursue ND related activities, with view to have low cost potable water. The related activities are:

- A TC Project with the agency on Simulation of ND of seawater (LIB/4/010) was launched with view to build local capabilities in modelling of ND systems.
- A programme of capacity building in the field of desalination technologies was launched, with view to increase the level of local participation in the construction and O&M of desalination plants, so as to reduce product water cost.
- Foreseen cooperation project with other MSs to carry out site specific feasibility studies, and also considering the possibility of setting up an experimental facility to utilize the generated heat from our 10 MW research reactor to demonstrate nuclear desalination (still to be proposed).
- Carrying out economic studies using DEEP3 to assess economic competitiveness of nuclear desalination in Libya.

Morocco

Morocco adopted many years ago Integrated Water Resources Management Process. As a part of implementation of this process, the country has established with the help of Agency a Nuclear law covering both, nuclear, radiation and safety. In parallel with this, Morocco adopted liability law together with an implementation decree. The above legislation has been set up with a view to meeting International requirements and obligations.
To deal with the water scarcity and demand energy challenges, Morocco is considering introducing the nuclear desalination. This fact resulted from the 2006 water resource assessment.
The National Electricity Utility (ONE) is updating its NPP project with IAEA's assistance.
The National Water Potable Utility (ONEP) is pursuing its program on water and seawater desalination through international cooperation. The preliminary findings lead to Agadir as proposed site for nuclear desalination.
Morocco is also seeking:

a. Assistance from the agency in term of expertise, software and exchange of information
b. Bilateral co-operation to continue implementing the nuclear desalination program

Pakistan

A Nuclear Desalination Demonstration Project (NDDP) of 1600 m3/day capacity (MED type) is being established at Karachi Nuclear Power Complex (KNPC) utilizing the heat from Karachi Nuclear Power Plant (KANUPP), which is a PHWR of 137 MWe. After completing the soil investigations and design of Intermediate Coupling Loop (ICL) and of MED plant, the Civil Work at site is starting in March 2006. The procurement of raw materials is in progress and manufacturing of MED plant will start in May 2006. Procurement of pipes, fittings valves and pump of ICL is also in progress. Safety evaluation report of the project has been completed and is ready for submission to the regulatory authority (PNRA). Pakistan is also considering seriously to couple large-scale seawater desalination plants with future nuclear power plants along the coastal regions.

Russian Federation

The Federal Energy for Atomic Agency (ROSATOM) has made a decision to start in 2006 construction of a small floating barge-mounted heat and power co-generation nuclear plant based on state-of-the-art ship propulsion reactor KLT-40C (150 MWt PWR). Severodvinsk-city (Arkhangelsk Region) in the Russian North-West is selected as location site for the first unit. Detailed design of the plant is completed and site is licensed. It is planned to construct and commission the plant within four year period.

Demonstration of this nuclear technology is thought to allow its larger scale application in remote regions over Russia and abroad for electricity and heat production and also for seawater desalination.

The pre-project work aimed at the assessment of technical and economic characteristics of integrated nuclear desalination systems based on prospective Russian small and medium-sized reactors (VVER-640, GT-MGR, VBER-300, KLT-40C, RUTA, ABV, UNITERM, SVBR-75/100 etc) reactors is carried out in ROSATOM design and scientific organizations. The emphasis is given to development of desalination complexes based on floating reactor concepts. An output of these activities is assumed to be applicable for practical implementation of nuclear desalination projects. "The Concept of ROSATOM Activities in Nuclear Desalination using Russian Small and Medium Size Reactors" has been prepared and is being discussed now in the ROSATOM. The document determines short and medium term objectives of ROSATOM in nuclear desalination.

Saudi Arabia

The Saudi experience during the last decades of this century proved that the Saline Water Conversion is one of the most important available options for extra sources to supplement the natural water sources. It has been undoubtedly proved that this industry is dependable to guarantee the satisfaction of the population needs of this vital element. In spite of the costs of this technology, it is important to extend it and approve it as a supplementary to the natural sources.

Saudi Arabia is the largest seawater desalination producer in the world, contributing to 17 % of global seawater desalination production, and on national scale 60% of the fresh water and 19% of the electricity are produced from desalination plants. Water desalination production exceeded one billion cubic meters (along with 21831 million megawatt-hour of electricity) in 2004 produced in 30 plants and transported via 3000 km (diameter 300-2000 mm), 27 pumping stations, 17 blending stations and 147 water storage tanks with a total capacity 8,340,000 cubic meters. From 2003 a decision was made by the Saudi government to give the lead to the private sector to invest in the desalination industry, to construct, own and operate the new desalination plants (BOO). In addition, a national water saving program has been adopted and carried out very effectively nation wide.

Nowadays, one can see a reasonable experience in the field of nuclear desalination. The demonstration facilities have been built in Kazakhstan, Japan, and India etc. have proven the technical viability of the technology and provided good experiences in coupling nuclear energy source with desalination plant, besides this experience many countries have shown interest in nuclear desalination through several designs and studies. Never the less, an effort has to be made to go for commercial nuclear desalination plant to prove the economical side of the nuclear desalination coupling. The IAEA may take the lead to bring up together vendors from nuclear and desalination industries to explore the emerging business opportunities in this direction.

Tunisia

Tunisia began desalination since the 80s with brackish water desalination in order to reinforce water resources for drinking water and also to improve the quality. The total capacity installed until now is about 100,000 m3/day.

This capacity will reach 200,000 m3/day in the next few years and 300,000 m3/day before 2015 – the new plants will be mainly seawater desalination plants. The biggest one is Sfax plant with capacity of about 150,000 m3/day.

Tunisia has already been active in interregional study in the feasibility study of economic nuclear seawater desalination since the 90s. Also, TUNDESAL project feasibility studies show the interest of Tunisian Government for viable and proven nuclear desalination. We believe that for large-scale project studies Sfax plant (150,000 m3/day) will be a big opportunity to undertake a nuclear desalination project.

At the same time, we believe that manpower development for these new fields, desalination and nuclear power, is an important issue in which IAEA already have made a lot of effort. It is very important that each Member State has to consider this issue at local level. Tunisia already plans to implement a training centre for desalination technologies with a goal to make it an international centre.

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United States of America

The U.S. has been continuously supporting the IAEA's work on nuclear desalination prior and since the last INDAG meeting. Since the last meeting, the U.S., through work at Argonne National Lab (ANL), participating in the IAEA's CRP on economics of site-specific nuclear desalination projects (also known as CRP2), input into the upgrade of the IAEA's software DEEP (version 3.0), and participating in consultancies and technical meetings at the Agency on various aspects of nuclear desalination.
The sense in the U.S. is that the links between nuclear desalination, hydrogen production, and other related non-electrical applications should be investigated more rigorously in order to demonstrate the potential additional importance and need for nuclear desalination activities in the future. To that end, ANL is planning to investigate and quantify the interdependencies between energy and water production and planning, especially when future hydrogen production for a hydrogen economy scenario is considered.

U.S. expertise in the areas of hybrid desalination and membrane technologies were also utilized since the previous INDAG meeting. These were specifically applied to the upgrade of DEEP and to the on-going development of the CRP2 Technical Document.

ANL remains committed to helping the Agency in its nuclear desalination activities and in the planning and organization of an IAEA-led international symposium on "Process Heat Applications of Nuclear Power" in the summer of 2007, which will include sessions on nuclear desalination, hydrogen production, and related water-nuclear energy issues.

OECD

OECD/NEA participated in the meeting as observer. Although there are no ongoing activities on nuclear desalination right now, it maintains high interest in non-electricity application of nuclear energy including nuclear desalination. The NEA expressed its wish to continue close cooperation with the IAEA in this regards.

IAEA Staff

Nuclear Power Technology Development Section

Mr. B.M. Misra, the Scientific Secretary, presented the technical overview including the status of CRPs, DEEP, nuclear desalination Web Page, ICTP Training Course on Desalination System Modelling-Technology & Economics and the Agency's participation at the international conferences. He also presented the implementation status of 2005 activities and the activities and deliverables for P&B 2006-07.

Mr. M. Methnani has updated INDAG members on the planned IAEA international conference on "Non-Electric Applications of Nuclear Power", preliminary scheduled for June 10-14, 2007 in OARAI, Japan. The conference will update the state of R&D work on process heat applications of nuclear power, in particular hydrogen and desalination. INDAG members are encouraged to act as focal points, disseminating conference information to potential participants in their area and contributing with technical papers to the conference on significant nuclear desalination related work. Information sheets will be mailed to all interested parties, once the dates and venue of the conference are confirmed."

Nuclear Power Engineering Section

Mr. J.Mandula

Technical Cooperation

Mr J. Stuller

Mr A. Mahjoub

C. Progress Review of Nuclear Desalination Activities

INDAG reviewed the progress of the Agency's nuclear desalination activities implemented since the last INDAG meeting in July 2004. Following activities were specifically reported to INDAG:

- Technical overview including CRPs 1 and 2, DEEP
- Status of TC projects
- PRIS Extension for non-electrical application
- Low tritium measurement at the Agency's Isotope Hydrology Laboratory

D. Technical Topics

INDAG elaborated on the latest technological review on the following topics. Members took active part in the discussions in this session. .

- Hybrid Systems R.Faibish (USA)
- Waste heat utilization S. Nisan (France)
- Socio-economic & Environmental Aspects P.K. Tewari (India)
- Safety Features vs nuclear desalination efficiency N. Masriera (Argentina)

E. Findings and Recommendations

Findings and Recommendations

1. INDAG noted the full implementation of all the activities regarding Program & Budget (P&B) 2005.

2. INDAG reviewed and approved the proposed activities of P&B 2006-07 of the project A.5.01 "Support for the demonstration of nuclear seawater desalination".

3. INDAG took note of the progress of technical developments including the CRPs, DEEP 3.0, nuclear desalination Web Page, ICTP Training Course on Desalination System Modelling-Technology & Economics and the Agency's participation in international conferences. It recommends continuation of the training course and participation in the conferences. INDAG reiterates the suggestion to examine the possibility of inviting leading experts from industry to future INDAG meetings.

4. INDAG was informed of past and recently-completed TC-supported inter-regional and national nuclear desalination projects and of the possibility of launching similar new projects, depending on the availability of IAEA-TC funds and interest by MSs.

5. INDAG recommends for continuing the publication of INDAG Newsletter highlighting the latest status in the MSs and in the Agency.

6. INDAG members agree to participate and to present research papers on nuclear desalination at Agency's forthcoming International Symposium on "Process heat applications of nuclear power". In this context it is suggested to organise the next INDAG meeting at the same location either just before or after the Symposium.

7. INDAG was informed about initiation in the near future of the preparation of P&B for the two bienniums 2008-09 and 2010-11. INDAG recommends the launching of a new CRP on "Advances in nuclear desalination technology" including:

- Advanced reactors and desalination technologies,
- Cost reduction strategies, and
- Socio-economic and environmental aspects.

8. INDAG deliberated in length the factors requiring immediate attention for the deployment of nuclear desalination in the interested Member States and recommends enhanced synergy between the actively.involved countries.

9. The successful completion of several TC supported projects and other national nuclear desalination projects have clearly demonstrated the techno-economic interest and viability of nuclear desalination. INDAG recommended that the Agency issues a Position Statement on this non-electrical nuclear energy application.

10. To continue the considerable momentum generated by the various inter-regional and national projects, INDAG recommends that specific consultancies be organised by the Agency to review the practical aspects and challenges in deploying nuclear desalination systems (infrastructure, financing, human resource development, etc.).

11. INDAG encourages the Agency to maintain and update all IAEA nuclear desalination-related documents.

12. INDAG encourages the Agency to consider launching a comprehensive global study on links between energy and water future needs (i.e., energy-water nexus) and their influence on trends in nuclear desalination.

13. INDAG recommends that the Agency make use of the expertise in its various sections and elaborate the guidelines on the monitoring of radioactivity in the water circuits of nuclear desalination systems.