IAEA
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Interoffice Memorandum

To: J.K. Park, DIR-NENP

From: I. Khamis, NPTDS

Through:

Clearance: T. Koshy, for SH-NPTDS

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Subject: Meeting Report on the Technical working Group on Nuclear Desalination (TWG-NG)

Place of Meeting:	IAEA Headquarters, Vienna
Date of Meeting:	23 to 25 January 2013
Program code:	1000025/2012.11.01(TWG-ND 552103) /
	RBF-MP1-2013/613222-NHR-TRV-Non-Staff Other, NENP-NPTDS
Scientific Secretary:	Mr Ibrahim Khamis
Chairman:	Mr P.K. Tewari

ATTENDING EXPERTS

Name	Country/Organization	Date
Belkaid, A.	ALG – COMENA – CRNB	23-25 Jan
Chocron, M.	ARG – CNEA	23-25 Jan
Shen, S.	CPR – Dalian Univ. of Technology	-"-
Tewari, P.K.	IND – DAE – BARC	-"-
Muralev, Y.	KAZ – MAEC	-"-
Asif, M.	PAK -	-"-
Al-Arifi, A.	SAU – R&D Technologies Dept.	-"-
Waite, M.	Westinghouse	-"-
Gillespie, M. (for R. Faibish)	PM USA, Vienna	-"-

1. Background

The International Nuclear Desalination Advisory Group (INDAG) was established by the IAEA in 1996. INDAG played an active role in the past years, contributed to promotion and stimulation of nuclear desalination activities, and provided a forum for Member States to exchange information on the technological developments, operations, and demonstration of integrated nuclear desalination systems. To enhance its functions, the IAEA has reformed INDAG into a Technical Working Group on Nuclear Desalination (TWG-ND) in 2008.

The meeting was held from 23-25 Jan 2013 at the VIC, Vienna, and attended by 9 members. Mr I. Khamis acted as the Scientific Secretary and Mr P.K. Tewari of India served as the Chairperson.

2. Objectives of the meetings

The purpose of the meeting was to:

- Review the progress of the IAEA's activities in nuclear desalination and provide advice and guidance on future activities;
- Provide a forum for the exchange of information on nuclear desalination activities in Member States and identify important topics for discussion at the Standing Advisory Group on Nuclear Energy (SAGNE); and
- Provide advice on preparatory action by Member States for implementing nuclear desalination demonstration projects.

3. Agenda

See attachment ANNEX 1

4. Summary of the work done and results achieved

Mr. I. Khamis (IAEA Scientific Secretary) presented as an introduction to the Terms of Reference of the TWG-ND and discussed its scope, functions, chairmanship, methods of work and deliverables as related to the IAEA Programme on nuclear seawater desalination. Then, he presented a summary of the IAEA activities (those already implemented as well as those foreseen in the future) in the areas of:

- Coordinated Research Programme (CRP)
- Technical Cooperation (TC)
- Forums for information exchange
- Publications on Nuclear desalination
- Upgrade of Desalination Economic Evaluation Programme DEEP
- Development of a toolkit on nuclear desalination
- Budget & Planning (B&P)

The IAEA tools on nuclear desalination tools i.e. the upgraded DEEP-4, DE-TOP, toolkit on nuclear desalination, and the newly released water management programme WAMP were presented. A live demonstration of the applications followed. The TWG-ND expressed their satisfaction with the IAEA Workplan on nuclear desalination and the successful upgrade of IAEA tools, through the supporting recommendations presented in the report.

Algeria (Mr. Belkaid)

The policy makers of Algeria reached a common conviction, that no sustainable development can take place without the control of water. The importance of water from the economic, social, cultural and strategic viewpoints is thus unquestionable. A national strategy was implemented to deal with the water concerns of Algeria which is semi-arid and arid country. The seawater desalination is a key point in this strategy and it represents a large program with total capacity that can reach 2.5 million m3/day at the end of 2015. For this raison, the current status of national desalination program was introduced and also experience gained. Consequently, the desalination of seawater will become in the next years an expanding industry. As this virtually unlimited water resource consumes a huge amount of energy, and because the power in Algeria derives from fossil origin source, a diversification of the energy sources is foreseen for the future. For this purpose, nuclear power energy is one alternative that is considered in the government energy policy to increase the electricity production nationwide. Therefore, the Algerian government launched a study to assess the potentialities of the introduction of nuclear energy for the production of electricity and potable water. Recent activities in the field of nuclear desalination have been introduced in the presentation. In addition, the status and mobilization of water resources in Algeria are also introduced.

Argentina (Mr. Chocron)

Argentina has participated almost since the beginning of the activities connected to ND developed in IAEA. First with the evaluation of safety of coupling a reactor to a NDP and later applying DEEP to assess a RO plant coupled to the CAREM Reactor (SMR Reactor developed in Argentina). In more recent years Argentina-National Atomic Energy Commission (C.N.E.A.) staff joined the created TWG in ND and participated in the last two Meetings. Since May 2011, and considering the CAREM is close to be licenced for construction, after getting experience from the participants and having taken advantage of the abundant published technical literature by IAEA and other sources, C.N.E.A. has decided to set up a permanent group whose tasks involve: (i) The study of the optimal configuration for coupling a ND thermal plant in co-generation with the reactor BoP through an intermediate circuit. Preliminary figures have shown that the ratio electricity/water produced would be suitable for a population of 70.000 people, representing a small city, like several present in Argentina. The plant thermal efficiency would be reduced in 5-7% in terms of electricity generated. (ii) Given environmental considerations for traditional provision of demineralized water, it is under consideration also a co-generation with RO+EDI or RO+Thermal in a hybrid mode. This could provide water for drinking purposes and for the reactor circuits as well. (iii) Reactor Dynamics C.N.E.A. group will collaborate on the study of transients while the ND plant is connected/disconnected from operation. (iv) Economy aspects for the configurations mentioned above will be assessed considering different sites in the country. This will be done in collaboration with the Energy Prospect C.N.E.A. group. (v) A group with experience in determination and recovery of low concentration elements (Analytical Chemistry) and in environmental impact of waste (Chemistry of Natural Water and Soils) , i.e. brine, of C.N.E.A., have been approached for participation.(vi) A bench scale experimental rig for thermal ND is under design. As a summary, the C.N.E.A.-Argentina, has been tried to profit of the nomination to participate in the TWG-ND and to wider the concept that undoubtedly can strengthen nuclear activities in the country, train new professionals, help acceptation and deployment, help small communities by improving level of life. The Argentina ratifies its participation and support of the IAEA ND and related programs in the future.

China (Mr. Shen)

Up to the end of 2010, the capacity of desalination in China is 660,000 m3/d. As planned, the capacity of desalination will reach 2,200,000 m3/d. China's desalination is in a fast development period. More than 10 nuclear power plants are in building in China. The ND should be promoted. But until now only a RO desalination plant was built in Hongyanhe Nuclear plant. We should have more influence on nuclear power plant authorities. Dalian University of Technology performed an intensive research on MED desalination, including

the analysis method of MED system, the falling film evaporation, the condensing in horizontal tube, the spray nozzle, the demister, the anti-corrosion measures, ...etc.

India (Mr. Tewari)

An overview of the seawater desalination programme was highlighted with an emphasis on the nuclear desalination programme, which has already been demonstrated and is in regular operation round the clock. In India, there is a requirement for large, medium and small size desalination and water purification units as part of the Integrated Water Resource Management. Desalination plants help in adaptation and mitigation of the adverse impact of climate change. The 6300 m^3/d (6.3 MLD) Nuclear Desalination Demonstration Plant (NDDP) using hybrid Multi-Stage Flash-Reverse Osmosis (MSF-RO) technology in Kalpakkam is coupled to Madras Atomic Power Station (MAPS). High quality distilled water produced from MSF section is supplied to MAPS for high end applications. Rest of it, is supplied to water reservoir along with potable water produced from RO section for augmenting the water supply. Earlier, a Low temperature desalination plant coupled to a nuclear research reactor at Trombay was demonstrated. With this, India has the experience with different types of coupling mechanisms and isolation loops for nuclear desalination plants. It is planned to integrate a 3x800 m^3/d Multi-Effect Distillation Thermal Vapour Compression (MED-TVC) nuclear desalination plant with Advanced Heavy Water Reactor (AHWR). It is also planned to set up a Hybrid sea water desalination plant based on indigenous RO-MED technology in one of the sites of Department of Atomic Energy (DAE). With the successful demonstration of nuclear desalination in India, the opportunity may be utilized in providing technical training on nuclear desalination to interested Member States through IAEA Technical Cooperation Program. There are on-going research activities on environmental aspects as well as Zero Liquid Discharge (ZLD) concepts. The use of different qualities of desalinated water in nuclear facilities was also addressed. It was concluded that nuclear desalination is inevitable (small, medium or large capacity) due to ever increasing water shortage and adverse impact of climate change.

Kazakhstan (Mr. Muralev)

According to the WHO estimation, the water scarcity affects one in three people on every continent of the globe. The situation is getting worse as needs for water rise along with population growth, urbanization and increases in household and industrial uses. The past five years has seen a 57% increase in the capacity of desalination plants on-line. One of the desalination options is Nuclear Desalination. First official publication of IAEA on ND "Panel on the Value of High-Quality Water from Nuclear Desalting in Agriculture, Vienna, 1967" issued in 1969. Yet, after dozens of conferences and symposiums, meetings and trainings, hundreds of technical documents, thousands of scientific articles published, after nearly 50 years away in this direction; nuclear desalination remains at the stage of demonstration plants. The reasons could vary from public non-acceptance to the absence of design standard solutions. It would be useful to analyse these reasons at the base of questionnaires distributed between decision makers of national nuclear authorities and nuclear engineering companies. The next options could be taken into consideration for planning of ND activities in further:

- Concentrate all efforts on the development of cost effective advanced condensation system (ACS) for NPPs;
- Organize IAEA missions on ND into leading nuclear power engineering companies, developing new NPP projects;

- Develop self-contained nuclear desalination units of small capacity.

IAEA should more aggressive promote nuclear desalination to engineering companies and customers at the stage of technical requirements and technical offers preparation. Renewal of real interest to nuclear desalination could begin after developing of the advanced condensation systems for NPPs, capable to produce distillate for feed water replenishment and search of new options, like application of radioisotope thermoelectric generators for creation of self-contained nuclear desalination plants of small capacity.

Pakistan (Mr. Asif)

A 1600 m3/d capacity nuclear desalination demonstration plant coupled with Karachi nuclear power plant was commissioned on 31st January 2010. The safe operation of nuclear desalination demonstration plant has paved way for larger desalination plant coupled with nuclear power plant. Recent re-mineralization of product water and its use for drinking purpose has further strengthened the claim of safe operation of nuclear desalination. The tools developed by IAEA i.e DE TOP and DEEP give results which compare quite well with the real data. Integration of DE TOP and DEEP in one package may be considered as an option. Based on the experience gained by coupling of desalination plant with nuclear power plant, suppliers/ designers of nuclear power plant may be asked to incorporate desalination plant in the power plant design to fight looming water crises. In countries like Pakistan, the annual per capita availability of water has been decreasing at very alarming rate. It was 1672 m3 in 1990 and it is forecasted that in 2025 it will be only 837 m3. Below 1000 m3 chronic water stress is experienced. Large scale desalination plants are the only solution to fight this menace. Product water cost is an impediment to supply of desalinated water to large segments of population in the third world countries like Pakistan. With better planning this problem could also be overcome.

Saudi Arabia (Mr. Al-Arifi)

The current status of seawater desalination in Saudi Arabia was presented. The growth of desalination program in Saudi Arabia was highlighted. Saudi Arabia now is the world leader in desalination (18% of the world capacity). Currently operating seawater desalination projects, projects under construction and the future plants were presented. Main challenges that are driving Saudi Arabia's desalination program are the following: Rapid increase in population, increase in water demand and high per-capita consumption, scarce natural water sources and rapid industrialization. The total water demand versus planned supply sources was presented. The required future investment for the desalination program was given. The desalination technology transfer in Saudi Arabia was highlighted and the role of King Abdullah City for Atomic and Renewable energy (K.A.CARE) was presented with the future role of nuclear energy program for electrical power generation and water desalination.

USA (Mr. Faibish represented by Ms Gillespie, PM USA Vienna)

Argonne National Laboratory (ANL) has been engaging the IAEA on all nuclear desalination and non-electrical nuclear energy cogeneration issues. In 2012, ANL completed a study on the financial feasibility of nuclear desalination using a Microsoft Excel based analysis tool, and the associated report was submitted to the IAEA as part of an ongoing CRP in this area. ANL is also the official representative of the U.S. to the IAEA on all nuclear desalination issues, including the standing Technical Working Group on Nuclear Desalination and plans to continue in this capacity. In addition to the above ongoing activities, the U.S. through its Department of Energy continues to strongly support design and licensing of SMRs. This type

of reactors could very well catalyse the deployment of future co-located desalination and other cogeneration facilities with nuclear power plants. The smaller generation capacity of SMRs is considered by many as ideal for nuclear desalination operations, especially in remote, off-grid locations and small regions. This does not preclude nuclear desalination and other cogeneration activities with larger reactors.

UK (Invited Observer: Mr Waite)

Westinghouse has two nuclear power plants that it is evaluating for compatibility with cogeneration options and in particular, desalination. The AP1000® is a 1100MWe large reactor and the Westinghouse SMR, a 225MWe small reactor. Typical of most reactors, the thermal output is approximately three times higher than the electrical output, so there is great potential for desalination with thermal processes. In order to efficiently integrate desalination equipment with either reactor, cooperation with end users and desalination equipment manufacturers would be beneficial. It is also recognised that there will be many site specific and market specific considerations to be addressed, such as whether dedicated desalination or flexible cogeneration is required. Optimum utilisation of the capital equipment will also, require close cooperation with end users.

5. Conclusions

1. The TWG-ND reiterates its support for IAEA activities in nuclear desalination, water management, cogeneration (i.e. electricity and desalination).
2. There is an increased interest in SMRs, which may present a suitable option to MSs with small grids, hence easy deployment in some cases. Yet, the economics should be reassessed for both SMRs and large NPPs based on single and cogeneration systems.
3. The TWG-ND commends the IAEA for the successful release of updated versions of DEEP, DE-TOP, and the new water management software WAMP.
4. There is an obvious need to reach out to the young scientists and youth in general on aspects of nuclear desalination through interactive/online discussions, conferences,etc.

5. There is a need to collaborate with nuclear industry to integrate desalination opportunities at design stage to optimize the efficiency of NPPs.

6. Recommendations

1. Enhance the scope of TWG-ND to address the challenges related to integrated water resources management in nuclear facilities.
2. Enhance public perception on nuclear desalination possibly through increased contact with appropriate international workshops/conferences/networks, especially important is to highlight IAEA activities (tools e.g. DEEP, DE-TOP, toolkit and oversight). A flyer on nuclear desalination in several languages would be helpful.
3. Update of IAEA Technical Reports Series No. 400 to reflect lessons learned from desalination projects especially the retrofitting of nuclear desalination demonstration plants in India and Pakistan.
4. Emphasize the added value of nuclear desalination through cogeneration aspects and co-products (notably the advantages that cogeneration could provide in the important

areas of biofuels, hydrogen production, district heating, and industrial applications of nuclear energy)

5. Encourage IAEA to launch a CRP on Application of advanced low temperature desalination systems to support NPPs. The CRP includes the development of cost effective advanced condensation system for NPPs; and self-contained nuclear desalination units of small capacity.
6. Reassess the economics of SMRs and large NPPs for single or cogeneration nuclear desalination.
7. In an effort to reach out to young scientists, the IAEA KM and NEMS schools should include more presentations on non-electric applications with emphasis on nuclear desalination.
8. Date/venue/duration of the upcoming TWG-ND: April 2014

ANNEX 1

Agenda for Technical Meeting of the Technical Working Group on Nuclear Desalination (TWG-ND)

Vienna, Austria

ROOM M05

23-25 January 2013

Wednesday, 23 Jan 2013

1. Opening Session		
09:30	Welcoming and opening remarks	I. Khamis, IAEA
09:35	Finalization of the Agenda	Participants/Chair person
09:45	Opening remarks by the TWG-ND Chairperson	P.K. Tewari, India
10:00	Roles and responsibilities of TWG: Goals of this meeting	I. Khamis, IAEA
10:30	IAEA Project on Nuclear Desalination	I. Khamis, IAEA
11:00	***Coffee Break***	
2. Status of National & International Programs		
11:30		Y.Muralev, Kazakhstan
12:00	***Invited Lunch (VIC)***	
14:00	Nuclear desalination in India	P.K. Tewari, IND
14:30	MED Desalination and ND Activities in China	S.Shen, China
15:00	Current activities related to non-electric applications of nuclear energy in Argentina	M.Chocron, Argentina
15:30	***Coffee Break***	
16:00	Overview of Desalination Activities in Algeria	A. Belkaid, Algeria
17:00	***Adjourn Day 1***	

Thursday, 24 Jan 2013

3. Status of National & International Programs-Continue		
09:30	Safe Operation of Nuclear Desalination Demonstration Plant in Pakistan	M.Asif, Pakistan

10:00	U.S. Update and Support of Nuclear Desalination and Cogeneration Options	M.Gillespie, USA
10:30	***Coffee Break***	
11:00	Westinghouse reactor technology desalination opportunities	M.Waite, Westinghouse
11:30	Desalination in the Kingdom of Saudi Arabia: An Overview	A.Al-Arifi, Saudi Arabia
12:00	***Lunch Break***	
4. Demonstration of latest versions of IAEA tools on Nuclear Desalination		
14:00	IAEA DE-TOP	I. S. Garcias, IAEA
14:30	IAEA DEEP	K. Kavvadias, IAEA
15:00	IAEA WAMP and Nuclear Desalination Toolkits	I. Khamis, IAEA
15:30	***Coffee Break***	
16:00		All participants
17:00	***Adjourn Day 2***	

Friday, 25 Jan 2013

5. Conclusion, Recommendations and Open Discussion on Nuclear Desalination		
09:30	Open discussion: Future of Nuclear Desalination	All participants
10:00	Summary of the Chairperson	
11:00	Finalize meeting report; Conclusions and recommendations	All participants
12:30	***Adjourn Day 3***	All participants