

**IAEA**

International Atomic Energy Agency

Interoffice Memorandum

To: D. Hahn,
DIR-NENP**From:** I. Khamis,
NPTDS**Through:****Clearance:** S. Monti,
SH-NPTDS**Reference:** TM-55103_EVT1700257**Date:** 2017-12-04**Subject:** Meeting Report of the Technical Working Group on Nuclear Desalination (TWG-ND)

Place of Meeting: IAEA Headquarters, Vienna

Date of Meeting: 20-22 November 2017

PTAEO Code: 1000155.2016.04.RBF-MP1-2017.613222.NENP-Nuclear Power
Technology Development Section

Scientific Secretary: Mr Ibrahim Khamis

Chairperson: Mr Ron Faibish, USA

1. Participants

Name	Country/Organization	E-Mail Address
Ms M. Conti	Argentina/ Comisión Nacional de Energía Atómica	mconti@cnea.gov.ar
Mr P. Berquó de Sampaio	Brazil/ IEN/CNEN	sampaio@ien.gov.br
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File

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Mr A. S. Al-Arifi	Saudi Arabia/ Saline Water Conversion Corp	aalarifi@swcc.gov.sa
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Mr R. Faibish	USA/ General Atomics	ron.faibish@ga.com

2. Background

The International Atomic Energy Agency (IAEA) established the former International Nuclear Desalination Advisory Group (INDAG) in 1996. INDAG played an active role in the years that followed, contributing to the promotion and stimulation of nuclear desalination activities, and providing a forum for Member States to exchange information on relevant technological developments and on the demonstration and operation of integrated nuclear desalination systems. To enhance its functions, the IAEA restructured INDAG to form the Technical Working Group on Nuclear Desalination (TWG-ND) in 2008.

The TWG-ND operates within the framework of the IAEA Nuclear Energy Department, with the role to assist the IAEA in identifying and initiating activities enabling Member States in the process of preparatory actions for nuclear desalination demonstration projects, and actively contribute to the promotion and stimulation of nuclear desalination activities in Member States. The scope of the TWG-ND has been enhanced to encompass integrated water resources management and more specifically the efficient use of water in nuclear facilities.

The TWG-ND normally meets every sixteen to eighteen months at IAEA Headquarters. It may meet from time to time away from IAEA Headquarters to familiarize itself with activities in a Member State. Special arrangements will be made to provide secretariat services for such a meeting in cooperation with the host Member State. This meeting is the sixth meeting of the TWG-ND.

3. Objectives of the meeting

The purpose of the meeting was to:

- Review activities undertaken by the IAEA Secretariat and Member States in the fields of nuclear desalination and integrated water resources management (IWRM) at nuclear facilities;
- Conduct an objective assessment on the future of nuclear desalination including: near-term deployment, responsibilities of users and vendors, capacity building, localization, socio-economic and environmental aspects, and the potential deployment of nuclear desalination projects as a measure for climate change mitigation;
- Provide a forum for sharing information and knowledge on latest developments on national and international programs in the areas of nuclear desalination and IWRM; and
- Provide advice and guidance on future IAEA activities relating to nuclear desalination and IWRM.

4. Agenda

see Annex 1 attached.

5. Summary of the work done, and results achieved

Mr. S. Monti (SH-NPTDS) welcomed the new members to the TWG-ND as he delivered the opening remarks of the meeting where he emphasised that seawater desalination using nuclear energy has already been demonstrated in several countries; China, India, Japan, Kazakhstan, Pakistan, and USA, and has so far operational experience of over 250 reactor-years. Several other Member States expressed their interest in the deployment of nuclear desalination, and that the experience and information exchange play a crucial role in expanding nuclear desalination in Member States, as well as in achieving efficient water management in nuclear power plants. He pointed out that the issues to be discussed in the meeting of the TWG-ND are of importance to many countries considering nuclear desalination as an option, mainly the discussions on the future of nuclear desalination, including: near-term deployment, responsibilities of users and vendors, capacity building, and the potential of nuclear desalination projects as a measure for climate change mitigation. At the end, Mr. Monti encouraged the members of the TWG-ND to provide their advice, guidance, and support for mapping the future IAEA activities on nuclear desalination and integrated water management in nuclear facilities, as well as identifying the important topics to be share with SAGNE

Mr. I. Khamis (IAEA Scientific Secretary) delivered an introductory presentation explaining the Terms of Reference, scope, functions, chairmanship, methods of work and expected deliverables of the TWG-ND as related to the IAEA Programme on nuclear seawater desalination. He also delivered another presentation on the previously conducted IAEA activities on non-electric applications, and the ongoing activities including status of Coordinated Research Programs (CRPs) in the area of the project, the status of the several publications expected for release in future, updates on the tools of Desalination Economic Evaluation Programme DEEP, DE-TOP, WAMP, the nuclear desalination toolkit, and Budget & Planning (B&P). At the end of his presentation, Mr. Khamis highlighted the main planned activities of the project for 2018 and encouraged member of the TWG-ND to participate in these activities.

Mr. H. Subki (IAEA) presented on the Small Modular Reactors and their applicability for cogeneration and synergy with renewables. He highlighted the status of SMRs for immediate and near term deployment and the main design characteristics, challenges, and considerations of these reactors. He also presented the prospects of these designs for non-electric applications as well as to be utilized in hybrid nuclear-renewable energy systems.

In the following, the input of some participating Member States is presented:

Argentina (Ms. Conti). Argentina has established a solid Nuclear Desalination and Integrated Water Management programme in the frame of the IAEA activities. Studies related with the coupling of RO and low-temperature multi-effect evaporation (LT-MEE) plants to SMR have been achieved. For the design of modular plate evaporator in a LT-MEE technology, the interaction between R&D/technical groups and engineering companies was required. A global water management programme is well accepted by NPP engineering authorities. In that sense, the recovery of the Steam Generator Blow Down is under analysis for NPP under operation (Atucha I) and future project as well (CANDU 4th NPP, 800 MWe). Also, discussions with NPP authorities/operators show that the reduction in water cost, chemicals consumption, and features of plant availability and life management are taken into account for the selection of the technology for the Demineralized Water Plant. The hybrid RO+ Electrodeionization (EDI) is still seen as not fully reliable for the production of demineralized water. The future activities for ND and WM programme are focus in i) reinforce connections with local companies and international engineering companies (that hired for support NPPS in life management) for ND and WM divulgation, ii) establish a legal framework between engineering companies and designer institutions in the technology transfer. ii) continue encourage engineering authorities from CNEA projects and NPPs in the importance of ND and WM implementation.

Brazil (Mr. de Sampaio). The national development of a small PWR for cogeneration of water and electricity can improve the country capacity to address water shortage issues. Therefore, studies have been initiated aiming to adapt and improve a previously Brazilian designed small PWR in order to

optimize it for cogeneration of water and electricity: the DES-SAL reactor. The DES-SAL reactor will meet Generation III and post-Fukushima requirements. Design innovations for the system are sought both in the desalination process and in the coupling of the secondary reactor circuit and the desalination unit. The concept adopted in the project is based on shortening the steam expansion in the turbine, thus stopping the expansion at atmospheric pressure rather than at the very low pressures usually adopted in PWR systems designed for electricity generation only. In the proposed system, steam condensation occurs at 100 C, a temperature sufficiently high to provide the heating required to operate a Membrane Distillation unit. From the 75 MWth generated in DES-SAL, 17 MWe of electricity will be produced and the remainder 58 MWth will be available for the Membrane Distillation process. A prototype of a Membrane Distillation unit will be built at the Instituto de Engenharia Nuclear/CNEN in order to study and optimize the Membrane Distillation process that will be employed in DES-SAL.

Egypt (Mr. Motyaser). Egypt was one of the countries that realized the importance of nuclear power to secure the supply of electricity and fresh water. Several attempts haven't been materialized in the last 3 decades due to different factors. Recently, Egypt has reconsidered the nuclear power as an option to supply electricity and signed cooperation agreement with Russia in the field of establishing and operating nuclear power plant in Egypt. The country intended to develop Seawater desalination modules with total capacity up to 170 000 m³/day using hybrid MED/RO technology for each nuclear power plant block. The proposal for new seawater desalination modules connected with the new nuclear power plants units was cancelled because of the possibility to cause delays in the construction of the nuclear power plants due to the required modifications on the design, as well as not being licensed in the supplier country.

India (Mr. Adak) In the delivered presentation, an overview on the seawater desalination programmes already undertaken in nuclear complexes in India was presented. Some of the developments which have been demonstrated and achieved the design intent along with the new nuclear desalination plants to be coupled to new or planned nuclear reactors are discussed. It was mentioned that the Indian Nuclear Desalination Demonstration Plants (NDDPs) have generated enough data and proved the long term feasibility of production of fresh water from seawater utilizing heat from nuclear reactors. Almost 10 years of operation of Kalpakkam Nuclear desalination plant, it is concluded the technical viability for coupling desalination plant with Nuclear Power Plant. Seawater desalination systems are to be intensively set up in the future in view of the large water and electricity shortages. It has been emphasized that India is continuously supporting the nuclear desalination activities under Agency's Technical Cooperation Program along with their member states and will continue to promote nuclear desalination through symposium/ coordinated research programs/ workshops at various National & International forums.

Pakistan (Mr. Khan) Pakistan Atomic Energy Commission (PAEC) has completed 8 years successful operation of their 1600 m³/day Nuclear Desalination Demonstration Plant (NDDP) coupled with nuclear power plant of 137MWe, KANUPP in 2009. Two more Nuclear power plants PWR, ACP1000, 1100 MWe each at coastal area of Karachi are under construction phase. So there is a promising opportunity that Pakistan could exploit prospects of co-generation and the use of waste heat to increase the NPP overall efficiency and make better energy utilization. With successful demonstration of nuclear desalination in Pakistan, PAEC is now capable of providing training to interested Member States in nuclear desalination, particularly in the field of Installation, commissioning, operation & maintenance under the IAEA Technical Cooperation Program. IAEA may initiate organizing technical meetings and training program in nuclear desalination on international level. Pakistan is willing to share important data, exchange experiences, and best practices regarding building the confidence for contamination-free water, ND safe and efficient operation which may be supportive in gaining widespread acceptability and appreciation in the field of nuclear desalination. It is extremely important that IAEA continue to play the encouraging role as facilitating agency to strengthen International cooperation through technical visits and CRPs amongst interested countries using nuclear energy in the field of desalination.

Saudi Arabia (Mr. Al-Arifi, and Mr. Al-Sharif) In the Kingdom of Saudi Arabia (KSA), there are also great challenges in the water sector. To fulfil the demand for water, more and more countries are becoming dependent intensively on seawater desalination. Desalination in the Kingdom of Saudi Arabia has become a strategic choice. Today, KSA tops in the production of desalinated water which is about 16.14% of world production. The presented overview showed the current trends in the desalination industry sector in the world and in KSA. Trends in current desalination technologies used were presented. The challenges faced by the water sector in KSA were also covered, highlighting some facts and figures about the government organization responsible for seawater desalination in KSA "Saline water conversion corporation (SWCC)". The future seawater desalination projects in KSA (2016-2030) were also presented. The presentation also covered the SWCC's strategy of diversifying its fuel portfolio, especially the option of utilizing alternative energy (solar and nuclear energy) sources for seawater desalination and the future plans for that. The elements of the Saudi national atomic energy project were also presented and discussed and the future of nuclear desalination in KSA was discussed.

USA (Mr. Faibish) On-site nuclear desalination experience in the US is still quite limited (e.g., the reverse osmosis membrane filtration system for make-up water and on-site general use at the Diablo Canyon nuclear power station is a long-standing example of this). This could very well change in the coming years with the expected deployment of advanced light water small modular reactors (SMRs). The promise of the advanced reactor systems (i.e., non-light water reactors [LWRs] and advanced SMRs) is also seen as gaining momentum, with the current development of several US reactor designs, including fast high temperature gas-cooled, sodium-cooled, molten salt, and others. The general interest in cogeneration and non-electrical applications of nuclear power is also catalysing the specific interest in nuclear power-enabled water production and treatment applications. The US Department of Energy, its national labs and industry (several reactor vendors and utilities) are actively exploring the use of nuclear fission energy beyond the electricity sector, i.e., as hybridized nuclear energy systems. The economic case for any of these applications needs to be demonstrated, and initial indications are that this could be achievable for several of the advanced SMR designs that could potentially be deployed in the next 10 to 25-year timeframe.

6. Conclusions

1. The members of the TWG-ND expressed their satisfaction with the IAEA's conducted activities on non-electric applications and on nuclear desalination specifically and also expressed their will to participate in the revision of the upcoming documents, mainly on nuclear desalination and water management in nuclear power plants.
2. The TWG-ND agreed that nuclear desalination activities present an important and impactful opportunity for nuclear power applications in the future, especially as new nuclear reactors come on line. Advanced HTR type reactors as well advanced SMRs, may provide unique features and operating parameters for electricity generation (e.g., higher temperatures and thermodynamic efficiencies) which could also enable greater deployment of coupled desalination operations. Coupling of the desalination plant (e.g., thermal, mechanical separation, or hybrid operations) should be considered either with extracted heat directly from the power cycle or rejected heat.
3. Nuclear desalination should be considered as an important carbon-free generation option for augmenting water resources.
4. The members of the TWG-ND agree to proactively engage the IAEA and specifically on nuclear desalination with ideas and concepts for future implementation by the Agency.
5. Existing nuclear desalination experience to-date has demonstrated the benefits of nuclear energy beyond electricity production and provides some of the technical basis required for future expansion of similar activities.
6. Some of the Members of the TWG showed interest of their MSs to embark on new nuclear desalination installations incorporating existing and emerging desalination technologies.

7. Recommendations

The TWG-ND recommends the IAEA to:

1. Consider initiating a new CRP to examine the specific benefits of SMRs (and particularly the advanced HTR) for nuclear desalination and other non-electric applications.
2. Consider including select-topics on non-electric nuclear power applications such as industrial heat, hydrogen production, and district heating, in the scope of future TWG-ND meetings.
3. Update the relevant data and experience relative to the coupling of nuclear power plants with various desalination systems and their operation and maintenance.
4. Conduct technical and information sharing workshops in MSs with relevant experience in nuclear desalination.
5. Regularly communicate new and updated relevant IAEA publications, technical studies, and MSs input to the members of the TWG-ND.
6. Disseminate nuclear desalination related information in relevant international fora.
7. Highlight the benefits of providing fresh water specifically using nuclear energy as a clean and sustainable source of energy to the public.
8. Encourage sustained and constructive interaction between vendors, utilities, and various end users in sharing relevant technical information and licensing considerations.
9. Assess the importance of licensing issues and related gaps relevant to the coupling of nuclear and water production systems and explore interlinks between comprehensive integrated water resources management and nuclear desalination practices.
10. Update the IAEA nuclear desalination guidebook with the latest relevant information and continue updating software tools, such as DEEP, DE-TOP, ND Toolkit as needed.

Annex.1:
IAEA's Meeting of the
Technical Working Group on Nuclear Desalination
VIC, Vienna

13-15 November 2017

Room: M0E03

Meeting Agenda

DAY 1: Monday, 13 November 2017		
09:30	Welcoming Remarks	Mr. I. Khamis, IAEA Mr. S. Monti, SH-NPTDS
09:40	<ul style="list-style-type: none"> ▪ Introduction of the TWG-ND members ▪ Selection of Chairperson to the TWG-ND ▪ Adoption of the meeting Agenda 	All participants
09:50	Opening Remarks	Chairperson
10:00	Roles & Responsibilities of TWG-ND Goals & Objectives of this Meeting Nuclear Desalination Activities of the Project on Non-Electric Applications	Mr. I. Khamis, IAEA
10:30	<i>Coffee Break</i>	
11:00	Brief on National Program & Identification of Important Topics in The Field of Nuclear Desalination	Mr. G. Ejje, Belgium
11:30	Open Discussion on the IAEA conducted Activities on Nuclear Desalination and Water Management	All participants
12:30	<i>Lunch Break</i>	
14:00	Brief on National Program & Identification of Important Topics in The Field of Nuclear Desalination	Ms. M. Conti, Argentina
14:30		Mr. P. de Sampaio, Brazil
15:00		Mr. A. K. Adak, India
15:30	<i>Coffee Break</i>	
16:00	Open Discussion on the IAEA Role to support MSs in Nuclear Desalination in light of Paris Agreement for Climate Change Mitigation	All participants
17:30	<i>Wrap up of Day 1</i>	

DAY 2: Tuesday, 14 November 2017		
09:00	Brief on National Program & Identification of Important Topics in The Field of Nuclear Desalination	Mr. R. Faibish, USA
09:30		Mr. S. Motyaser, Egypt
10:00		Mr. K. Kim, Korea, Rep. of
10:30	<i>Coffee Break</i>	
11:00	Small Modular Reactors: Applicability for Cogeneration & Synergy with Renewables	Mr. H. Subki, IAEA
11:30	Brainstorming Session The Role of SMR for Advancing Nuclear Desalination	All participants
12:30	<i>Lunch Break</i>	
14:00	Brief on National Program & Identification of Important Topics in The Field of Nuclear Desalination	Mr. A. Al-Arifi, KSA
14:30	Brainstorming Session on the Responsibilities of Vendors and Users in Nuclear Desalination Projects	All participants
15:30	<i>Coffee Break</i>	
16:00	Brief on National Program & Identification of Important Topics in The Field of Nuclear Desalination	Mr. A. Khan, Pakistan
16:30	Open Discussion on the Roadmap of Nuclear Desalination Technologies	All participants
17:00	<i>Wrap up of Day 2</i>	

DAY 3: Wednesday, 15 November 2017		
09:00	<ul style="list-style-type: none"> ▪ Conclusions & Recommendations ▪ Identification of important topics to SAGNE 	All participants
10:30	<i>Coffee Break</i>	
11:00	Finalizing the meeting report	All participants
12:30	Closing Remarks	Chairperson
12:45	<i>End of the Meeting</i>	