IAEA
International Atomic Energy Agency

Place of Meeting: Vienna, Austria

Date of Meeting: 9 – 10 December 2014

Scientific Secretary: Mr Ibrahim Khamis

ATTENDING EXPERTS

Name	Country/Organization	Date
M.Chocron	ARG/CNEA	9 – 10.12.
J.F. Zuñiga Santana	CUB/CUBAENERGIA	-"-
G. Zakrzewska-Koltuniewicz	POL/INCT	-"-
S. Shivayyanamath	IND/BARC	-"-
A. Przybyszewska	POL/NCNR	_'_

1. Background

Seawater desalination using nuclear energy could be seen as an attractive, non-conventional water resource to meet the rising water demands. The nexus between seawater desalination and nuclear power plants seems inevitable. Future nuclear power plant could be made more economical through cogeneration or waste heat recovery if coupled to a desalination plant, and the later could well become more accident proof through the introduction of low temperature on-site desalination systems. The newly advanced technologies of low temperature desalination, specifically the distillation processes with utilization of waste heat from turbines allow producing necessary quantities of fresh water on site with low cost and secured from extern threats. The benefit of using low temperature thermal desalination for NPPs has been demonstrated on small scale in India, Pakistan, and Kazakhstan where waste heat has been harnessed to provide quality water needed to NPPs. Meanwhile, making water available on site and increasing the overall thermal efficiency of NPPs will help bringing better recognition of nuclear energy and wider acceptance of nuclear energy for daily applications in various sectors.

Countries embarking on nuclear power could exploit prospects of co-generation and the use of waste heat from a nuclear power plant to increase the NPP overall efficiency and make better energy utilization. Simultaneously, NPPs vulnerability due to water shortage can be further enhanced in case of an accident or terrorist attacks through the introduction of advanced technologies of low temperature desalination, specifically the distillation processes with utilization of waste heat from turbines which allows producing necessary quantities of fresh water to meet on site NPP requirements with low cost and secured from extern threats.

This is the first RCM for the CRP of advanced low temperature desalination technologies to support NPPs and non-electric applications.

2. Objectives of the meeting

The purpose of the meeting is to:

- Review, discuss, and suggest modification if any for individual CSI's preliminary work plan to align with the CRP objectives;

- Discuss expected outcome from individual CSIs and overall outcome of the CRP;
- Develop a detailed overall work plan of the CRP including scheduling of activities; and
- Harmonize and integrate individual plans within the overall work-plan of the CRP.

3. **Agenda:** see Annex I

4. Summary of the Work done and results achieved

The IAEA (Scientific Secretary) presented an overview of the CRP: motivations, objectives, expected outcomes, schedule, and other administrative issues and approaches related to the overall management of the CRP. Drivers for the CRP include the quest for advances in technologies which may lead to more efficient and economical desalination systems, promoting R&D on new technologies to enable nuclear desalination systems to be a viable option, coordinate efforts of Member States (MSs) on ND, establish platform for information exchange between MSs, and compliment other CRP on nuclear desalination (Coupling Optimization… & Economic Assessment…). The CRP is expected to result in the publication of an IAEA technical report summarizing and discussing the CRP's results and additional scientific publications by CRP participants.

Argentina (Mr. Chocron) presented his work plan in the field of innovative technologies which integrates well with the overall objective of CRP. The goals of Argentina during this CRP is to: 1) design and construct a rig for testing both a MED (plate heat exchanger type) operating in a thermal mode, and an independent RO system, and MED + RO in a hybrid system; 2) analysis the coupling to a Small Size Reactor (SSR) for the production of quality water for both the reactor and the secondary circuit taking into consideration the provision of water and removal of waste heat under different operating conditions as well as a provision to produce potable water to the NPPs on-site staff. The plan of the first year includes the followings:

- Construction of the rig
- Theoretical design of the MED device. Preliminary mechanical design
- Conceptual alternatives for coupling to the SSR under several operative conditions.
- Considerations on the release of concentrated water solutions.

In the second and third years of the CRP, the plan will include activities relating to the improvement of the overall efficiency of the NPPs (by operation in co-generation) i.e. potable water, industrial water and steam, reactor quality water, replace cooling towers; efficient removal of waste heat and its use for the above mentioned purposes (identify waste heat sources); reuse of relatively new devices such as heat pumps, intermediate organic cycles, heat transfer materials. Regarding RO, filtration, etc., and production of different qualities of water, will be considered in the future as part of the plant in case of decontamination need; replacement of the ion exchange plants and reduce use of chemicals; assessing all economy improvements; provide cases relating to cogeneration and use of waste heat to IAEA for benefit of other countries (make use of free software like DEEP and MESSAGE); for countries that still do not have NPPs but are considering the construction; carry out a survey of thermal plants, consumption of water, comparison against NPPS; and technical and economical assessment.

Cuba (Mr Santana) presented his work plan which does not integrate well with the overall objective of CRP (the proposed workplan of his research has already been presented by Mr Santana as a completed work in 2009). He presented a detailed overview of water and energy status in Cuba with emphasis on the use of small capacity desalination systems based on renewable energy and the exclusion of nuclear energy till 2030. He stated that the overall objective of the project is to assess a set of options of advanced Low temperature Desalination Systems to support existing energy

technologies in the country and the water supply to the population, with focus on capacity building for economic evaluation of desalination. He also stated the main expected outcomes as follows:

- Improved and updated the existing database in the country on desalination.
- Assimilated and applied to desalination plants in operation the latest version of DEEP (Desalination Economic Evaluation Program) developed by IAEA.
- Developed the economic evaluation of desalination plants using the latest version of the DEEP.
- Identified the costs of existing desalination technologies in the country.
- Made a comparative analysis of desalination technologies.
- Establishment of desalination strategies for the Cuban energy sector.
- Dissemination of results and strengthening of the technical knowledge in new desalination technologies for decision-making of government institutions related to energy and water resources.

He also presented the workplan for the first year as follows:

- Collection of technical data for an existing nuclear desalination plant as a reference plant.
- Perform economic assessment of the reference plant using DEEP.
- Performing various scenario analysis for different desalination processes and technologies using the same technical data of the reference plant.
- Present cost comparative assessment and submitting reports of results.

India (Mr.Shivyyanamath) presented his work plan in the field of innovative technologies which integrates well with the overall objective of CRP. He pointed out that India proposal aims at exploring the possibilities of utilizing low quality waste heat (40-50^{o}C) from NPP for desalination (condenser/low pressure and temperaure (LPT)) outlet, and developing an advanced low temperature desalination (ALTD) process which utilieses nuclear waste heat either from warm seawater from condenser (< 40^{o}C) or exhaust steam from low pressure (LP) turbine (~ 45^{o}C). He explained that technical feasibility, coupling aspects and modeling & simulation of proposed schemes shall be carried out during this research. In addition, India will investigate the utilization of low cost material for such system. The major expected outcomes from this research are: feasibility report on nuclear desalination utilizing low quality waste heat (40-50^{o}C), Design basis report of a typical ALTD plant coupled to NPP, and Techno-economic feasibility report of ALTD process

Poland (Ms Zakrzewska) presented her work plan in the field of innovative technologies which integrates well with the overall objective of CRP. The presentation concerned application of membrane-based systems in nuclear desalination. Two potential membrane processes will be considered: Reverse osmosis (RO), which is well-developed technology, applied also for desalination: separately or as a component of hybrid systems in combination with thermal processes; driven by the electricity produced in the NPP, it can enhance its performance by using the waste heat for heating up feed water; and membrane distillation, which however known from many years, was not applied for desalination purposes yet; because of relatively low operational temperatures it can be directly driven by waste heat.

Both processes were studied by Institute of Nuclear Chemistry and Technology in Warsaw; RO was implemented at Radioactive Waste Management Plant (ZUOP) for liquid low and intermediate-level radioactive waste treatment. In scope of the project the comparative assessment of two processes will be done. The advantages and constraints of both methods will be analysed taking into account different conditions of specific applications. For Poland developing nuclear energy, the research on

economic aspects of nuclear reactors, as well as safety issues are very important. Practical facets of nuclear power plants operation with the appropriate water management within the NPP are also necessary to be solved before the successful launch of the first power unit in Poland. The relevance of the project to the present CRP is seen in :

- The research focused on cogeneration: Combined Heat and Power;
- Development of the system which uses waste heat either works at low temperatures;
- The increase of overall energy efficiency of nuclear reactor by utilization of heat produced.

The project is consistent with the strategy of the State and with the Program of Polish Nuclear Energy, which requires development of suitable associated technologies that will make it technically successful and acceptable by the public. The membrane system associated with nuclear reactor will be used for: Desalination of water, Recycling of water within the plant - it can be used for make-up water preparation, Decontamination of water in emergency situations, and Treatment of liquid low-level radioactive waste in the site.

The project creates the opportunity to initiate the more structured discussion on cogeneration in Poland, which is an economic solution, reduces harmful emissions to the environment, and leads to a reduction in energy dependence of the country on imported raw materials. The expected outcomes of the project are as follows:

- A set of experimental data enabling evaluation of the low-temperature system based on membrane processes, and selected for desalination, which could be coupled with nuclear reactor supplying the process heat;
- Comparison of different membrane processes and technological evaluation of the feasibility to apply them in nuclear desalination;
- Assessment of hybrid arrangements based on membrane processes.
- Recommendation for future cogeneration possibilities in the country.

5. Conclusions

- Discussions were held for promoting synergy and interaction between CSIs in the important fields of studies of the CRP
- Work plans by participating CSIs will be modified to reflect future work in accordance with the discussion made during the 1RCM.
- It was agreed that all proposed modifications on the workplan should reach IAEA by end of 31 Jan 2015.
- ***For own reasons, participants from Hungary, Jordan, and Syria were unable to attend this meeting.*** Hence, it was rather difficult for other participants to see an overall picture of what will other participants contribute to the CRP.

6. Recommendations

I- It was recommended that all modified work plan be harmonized to fall under the overall objectives of the CRP. The following CSIs agreed to modify workplan as follows:

CSI	***Suggestions to be included in the workplan***
Cuba	The entire workplan should be revised to address a specific research topic relating to the CRP.
Poland	An additional task is to address the use of desalination Membrane technologies as a measure for decontamination in case of an event in NPP

II- Results of this collaboration shall be discussed in the next RCM.

Next RCM Meeting

Since the CRP has suddenly suffered a major drawback by having three CSIs not participating in the 1RCM (Jordan, Hungary, and Syria), one refused to sign the contract due to low financial support by IAEA (Kazakhstan), and one has to completely modify workplan (Cuba). Therefore, ***the scientific secretary suggests freezing this CRP for one year to allow for better coordination among participants, and to encourage more participation to the CRP from other MSs.*** If during the upcoming few months, more proposals have been received and the above CSIs commit themselves to continue with active participation, then the next RCM will be planned to be held in Vienna during 1st week of Dec 2015.

ANNEX I

AGENDA

1st RCM on CRP Application of Advanced Low Temperature Desalination Systems to Support Nuclear Power Plants and Non-electric Applications"

Room MOE16

09-10 December 2014

Vienna, Austria

Tuesday, 09 December 2014

Opening Session		
09:30	Welcoming and opening remarks	Khamis, IAEA Koshy, IAEA
09:45	Introduction of participants, adoption of Agenda, Selection of Chairperson	All participants
10:00	An overview of the CRP	Khamis, IAEA
10:15	*Coffee Break*	
10:30	Presentation 1: Design and construction of a modular MED desalination system and a hybrid (thermal and RO) testing rig	Mr Chocron, Argentina
11:15	Presentation 2: Application of advanced low temperature desalination systems to support NPPs and other energy technologies	Mr Zuñiga Santana, Cuba
12:00	*Lunch Break*	
13:30	Presentation 3: Technical and economic examination of various NPP-desalination plant hybrid systems	Mr Aszodi, Hungary
14:15	Presentation 4: Nuclear desalination in Jordan	Mr Al-Rawajfeh, Jordan
15:00	*Coffee Break*	
15:15	Presentation 5: Development of advanced low temperature desalination process coupled to NPPs	Mr Shivayyanamath, India
16:00	Presentation 6: Application of advanced membrane systems in nuclear desalination	Ms Zakrzewska, Poland
16:45	Open Discussion	
17:30	Wrap up of Day 1	

Wednesday, 10 December 2014

09:30	Discussion on: (1) Plan for next year: common issues (2) Specific work plans of each CSI (3) Modifications to work plans	All participants
11:00	Discussion on: - Conclusion and recommendations - Future RCM	All participants
11:30	Discussion on: Finalization of RCM report	All participants

12:00	*Closing Remarks*	All participants
12:15	End of the Meeting	