International Nuclear Desalination Advisory Group
to the International Atomic Energy Agency

INDAG NEWSLETTER

No.2 – September 2002

A WORD FROM THE DEPUTY DIRECTOR GENERAL

On the occasion of launching the second term of the International Nuclear Desalination Advisory Group (INDAG) last year, INDAG issued its first NEWSLETTER. It showed the presence of INDAG to and facilitated communications with the people outside IAEA.

I am pleased to notice the status of nuclear desalination demonstration being implemented in some Member States. This will certainly spur other countries to this option for alleviating the freshwater issue in the near future. On the basis of generic studies, the focus of the IAEA activities on nuclear desalination is being shifted to country-specific projects such as Coordinated Research Projects and Technical Cooperation projects. Nuclear desalination is not necessarily a challenge in the next generation. It is also a viable option in the near term deployment. It is time for us to think how to facilitate early deployment of nuclear desalination.

I hope INDAG continues its influence on stimulating nuclear desalination activities in IAEA Member States and contributing to the peaceful use of nuclear technology.

V.M.Mourogov
Deputy Director General
Department of Nuclear Energy, IAEA

To Our Readers

In this second issue, you cannot fail to notice the "winds of change": changes in the individual programmes of the Member States who, as Mr. Mourogov has rightly pointed out, are now progressively moving from paper studies to realistic site specific investigations; changes in the very orientation of INDAG, in which the accent is now more and more on technical issues and discussions; and changes in the Newsletter itself - in this issue you have not one but three technical notes (see the insert: INDAG Technical Brief), summarising the presentations made during the last INDAG Meeting held from 10 to 12 July, 2002. Reflecting these changes, INDAG has recommended the organisation of Technical Meetings to take place in alternate years between INDAG meetings.

Yet another domain where noticeable changes are apparent is the area of International collaborations, which have become realities from just ideas. The EURODESAL project is well underway. This is also the case for the collaboration between South Korea and Indonesia, between France and Tunisia and between France and Morocco, all three dealing with site-specific studies with a view to furnish technical and economic specifications for eventual, integrated nuclear desalination plants. The collaboration between Russia and Canada on a floating nuclear desalination facility continues at an advanced stage.

Happy (and informative) reading!

Chairman, INDAG

INDAG is an Advisory Body to DDG-NE established in 1997.
(See page 3 for Terms of Reference and page 4 for current members)
The next INDAG meeting will be planned for 2004.

Recent Activities in Nuclear Desalination in Member States (Highlights from the last INDAG meeting in July 2002)

Argentina:

The CAREM concept has been submitted to the *Generation-IV International Forum* (GIF) for evaluation.

INVAP actively participates in the IAEA ongoing CRP-1 and the new CRP-2 (*).

(*) CRP-1: Optimization of the Coupling of Nuclear Reactors and Desalination Systems

CRP-2: Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies

Canada:

An experimental program demonstrated the validity of the CANDESAL design methodology of an advanced RO desalination.

Its application to industrial projects is being sought through international collaboration (see page 3).

China:

A pre-project study of a nuclear desalination plant using NHR-200 was carried out for the Shandong area.

A test system set up in INET is validating the thermal-hydraulic parameters of VTE- MED process selected.

Egypt:

A feasibility study for a nuclear plant at El-Dabaa to co-generate potable water and electricity is completed.

A test facility to study the characteristics of SWRO with preheat is under construction.

France:

France is coordinating the EU project EURODESAL, grouping 5 EU and Canadian industrials and two R&D organisations (page 3).

India:

The RO section of the demonstration plant at Kalpakkam was installed. Pre-commissioning trials of the RO is underway. Commissioning of the MSF section is foreseen in 2003.

Israel:

Technical and economical information on low cost desalination technologies and their application within 3 years to large-scale desalination plants can contribute to nuclear desalination evaluation.

Korea Rep. of:

Basic design of SMART is completed. In parallel with out-pile tests a one-fifth scale pilot plant SMART-P is being planned to construct.

A joint study with BATAN, Indonesia, started on economic feasibility of a nuclear desalination plant on Madura Island (page 3).

Libya:

In the framework of CRP's, working groups are studying and investigating viability and competitiveness of nuclear energy for seawater desalination in the country.

Morocco:

A standing commission (COPSAN) was established in order to formulate an adequate and sound legal and institutional framework. It is to prepare a unique nuclear safety law, which will create an independent nuclear safety regulatory authority under the prime minister.

Pakistan:

Feasibility is being evaluated for coupling a desalination plant (4500 m3/d) with the existing PHWR (137 MWe) at Karachi Nuclear Power Plant for demonstration.

A study is being planned to assess the use of a large dual-purpose NPP to meet the water and power needs in the Karachi region.

Russian Federation:

R&Ds for applying Russian small reactors KLT-40C, NIKA and RUTA to nuclear desalination continued.

Construction of a Floating Power Unit (FPU) pilot plant with KLT-40C reactors is planned for 2006. The co-generation plant will be sited at the shipyard in the western North Sea area where the FPU is being manufactured.

United States:

The Generation IV roadmap report will include a detailed discussion of potential nuclear energy products, recognizing the important role that future nuclear energy systems must play in producing fresh water.

In the framework of CRP-2 existing nuclear desalination experience at the Diablo Canyon Nuclear Power Plant will be documented.

Major International Collaboration underway

- **Indonesia and Korea, Rep. of**
  Korea Atomic Energy Research Institute (KAERI) and National Atomic Energy Agency of Indonesia (BATAN) jointly evaluate economic feasibility of a nuclear desalination plant on Madura Island using SMART. It envisions the plant operation in 2015 producing 4000 m^3/d of fresh water.
- **Tunisia and France**
  CEA (France) and CNSTN (Tunisia) signed a collaboration agreement on January 15, 2002 for a technical and economic evaluation of Nuclear Desalination for the site of La Skhira. Preliminary studies on two of the four initial work packages (pre-dimensioning and optimised coupling schemes) have already been completed.
- **Pakistan**
  In proceeding with engineering details of coupling a thermal desalination unit with KANUPP, PAEC is receiving technical assistance through IAEA from international experts including from Argentina and Germany. PAEC plans to start the project work after completing the design related studies during 2003."
- **Morocco and France**
  An agreement, similar to France and Tunisia has also been made (March 2002) between CEA and CNESTEN (Morocco). The project, called AMANE, will study the feasibility of nuclear desalination for two sites: Agadir and Laayoun. Data collection for the water and electricity needs, as well as for the specific sites has started.
- **Russia and Canada**
  Russia (Minatom/Rosenergoatom/Malaya Energetika) and Canada (CANDESAL) have agreed to jointly develop a floating nuclear desalination system based on Russian KLT-40C reactor technology and CANDESAL's advanced RO desalination technology. The project is moving forward, with the next project coordination meeting scheduled for late 2002.
- **EURODESAL**
  France is coordinating a preparation of a follow-up project, EURODESAL DEMO, for proposal under the 6th Frame Work Programme of the European Commission. This project is designed to realistically demonstrate the technical and economic interest of nuclear desalination with a new-generation prototype reactor at Cadarache Atomic Centre (France).

Highlights of the International Symposium (16-18 October 2002, Marrakesh, Morocco)
Advances in Nuclear Desalination: Options and Challenges

The Agency is cooperating with the two NGOs (WONUC and AIGAM) who are organizing the conference. The IAEA session will cover design, coupling and costing aspects of nuclear desalination plants, as well as a panel on national and inter-regional projects.

More information on the overall conference program can be found at www.wonuc.org.

INDAG has been created with a view (excerpts from the INDAG terms of reference):

1. To provide advice and guidance on the Agency's activities in nuclear desalination;
2. To identify important topics for CRPs, etc. in the field of nuclear desalination;
3. To provide a forum for the exchange of information in this field; and
4. To provide advice on preparatory action by Member States for implementing nuclear desalination demonstration projects.

Highlights of on-going and future activities at IAEA (2002/2003)

CRP-1 on "Optimization of the Coupling of Nuclear Reactors and Desalination Systems" is in the concluding stage towards its completion in 2003. Libya and Morocco newly joined. The third RCM was held in October 2001. The final RCM is planned for February 2003.

CRP-2 on "Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies" has been launched early 2002 with participating institutes from 13 Member States. The first RCM was held in July 2002.

The web-based DEEP Users Group (DUG) has been launched as a forum for free and open exchange of information, working experience, and suggestions for future software improvements. DUG is open to all DEEP users.

The Power Reactor Information System (PRIS) is being extended to accommodate relevant information of non-electric applications at NPPs: design characteristics and operating performance. Data collection on the INTERNET will start in 2003 with the initiative of NPES.

The International Project on Innovative Reactors and Fuel Cycles (INPRO) is coming to the end of its first phase (1A) identifying global user requirements in six key technical areas and establishing criteria and methodologies for the comparison of various concepts.

New activities recommended for 2004/2005

Noting that 2002-2003 activities are continuing as planned, INDAG has recommended:

- To launch and co-ordinate a new CRP on "Potable water production at co-generation nuclear plants with special reference to HTGRs (provisional title)".
- To organise Technical Meetings or symposia on specific topics of interest in nuclear desalination in the years in which INDAG meetings are not held, with the first in 2003.

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For further information, visit our web site at http://www.iaea.org/nucleardesalination

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Utilisation of the Waste Heat in a GT-MHR and/or a PWR

S. Nisan, CEA, France

Two types of nuclear reactors have been considered for nuclear desalination in the context of the on-going EURODESAL project: the GT-MHR and the PWRs.

In the GT-MHR, the design requires the cooling of helium gas before the two compression stages. This cooling is achieved through the two helium-water exchangers known as the pre-cooler and Inter-cooler. GT-MHR is therefore an intrinsic source of hot water with temperatures of 80-105°C. According to CEA/FRAMATOME studies, a GT-MHR used in the conventional base case scheme (only one line MED, with, e.g., hot water entering at 80°C and coming out at 50°C) could produce about 25,700 m^3/d from the reject heat, virtually "free of charge". In an innovative "Heat Run-out scheme (Fig.1) in which the condensate from the first effect of the first line (say at 70°C) is fed to a second line in parallel and that from this second line to an eventual third one, the water production could be as high as about 42,500 m^3/d.

For PWRS, several coupling schemes have been investigated. The first is the "conventional" scheme, utilising steam bleeding from the turbine stages. Other innovative coupling schemes are based on the utilisation of a higher temperature output steam going via the condenser, or utilising the mixture of different flows going to various feed-water-heaters (for the steam generator). Detailed thermodynamic analyses show that, compared to the conventional steam bleeding, these second options lead to a higher water production but also lead to relatively higher electrical power production losses because of the reduction of the net turbine efficiency. For example, in the conventional coupling scheme, and for a PWR900 reactor, coupled to an MED plant producing about 260,000 m^3/d, the turbine efficiency is reduced by 2 points to about 31 %. With the scheme using the mixing of flows to various pre-heaters, the loss of efficiency is higher by about 4 points.

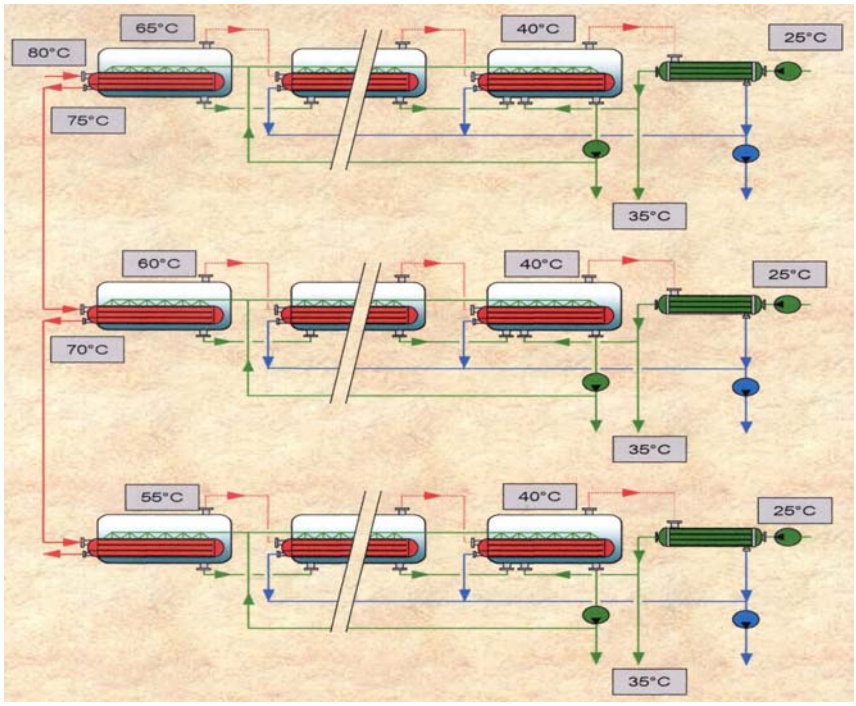


Fig.1: Heat Run-out scheme using the waste heat from a GT-MHR

Table1: Water production in the GT-MHR Base and Heat-Run-out schemes

Hot Water Flow rate (kg/s)	Hot Water Inlet (°C)	Hot Water Outlet (°C)	T (°C) Condenser	Effect Δt (°C)	Brine re-heat Coefficient	Effect Number	Production (t/day)
1210	80	50	35	3	0.9	5	25 700
1210	80	70	35	3	0.9	12	20 000
	70	60				8	14 000
	60	50				5	8 500

Total Heat Run-out = 42500 t/day

Advanced RO Technology for Application in Nuclear installations

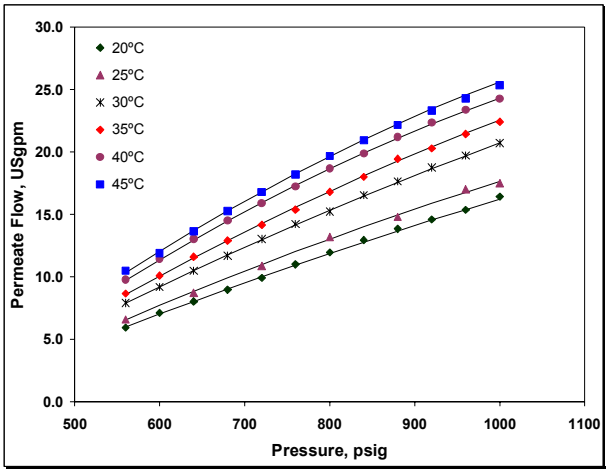
J.R. Humphries, CANDESAL Technologies, Canada

To address the growing water shortage problem, CANDESAL Technologies has developed an advanced reverse osmosis (RO) desalination technology that emphasizes a non-traditional approach to system design and operation, and makes use of a sophisticated design optimization process that can lead to highly optimized design configurations and operating regimes. The technology can be coupled with a nuclear generating station (NGS) to provide an integrated facility for the co-generation of both water and electricity. Waste heat from the NGS allows feedwater into the RO system to be "preheated" above the ambient seawater temperature, thereby improving the efficiency of the RO process and reducing the cost of water production. Analyses of nuclear desalination systems employing this advanced RO technology, under a variety of seawater feed conditions, have consistently shown that the cost of potable water production can be reduced by as much as 20% relative to systems designed in a more traditional manner. Because waste heat, rather than process heat, is used the desalination system can be readily coupled to any existing or advanced reactor technology with little or no impact on reactor design and operation and without introducing additional reactor safety considerations.

With the cooperation of Canada's National Research Council and Babcock & Wilcox Canada, an advanced RO technology seawater desalination demonstration project was undertaken. The objective was to experimentally verify the advanced RO system design and operating methodology. Demonstration testing was carried out using a trailer-mounted system producing up to 150 m^3/d of potable water. The facility was commissioned and the experimental data on performance characteristics under varying conditions of temperature and pressure were obtained in 2001. The project was completed early in 2002.

The experimental program addressed feedwater temperatures over the range from 20ºC to 45ºC and feedwater pressures as high as 69 bars (1,000 psig). Feedwater flow was maintained constant at 47.4 gallons per minute (USgpm). Permeate production over this range of seawater conditions ranged from a low of 5 to a high of about 25 USgpm.

Experimental results from the demonstration testing behaved as expected



based on analytical performance models. Validation of theoretical design models confirms that the performance improvements indicated by the analyses can be achieved in operating systems. In fact, the potable water production achieved at high pressures and temperatures exceeded that predicted by analytical simulation. We believe this is because membrane vendors' performance codes are tuned to provide their best results for traditional RO system design conditions and configurations. Further testing will be carried out to validate this assertion.

The next phase of demonstration testing will be conducted using a full-size containerized system with a nominal production capacity of 1000 m^3/d. The design of the system, which will serve as a pre-production prototype, is underway. Possible sites for the test program include the EURODESAL Demo program at Cadarache.

Potential Application of Waste Heat for Desalination in PHWR

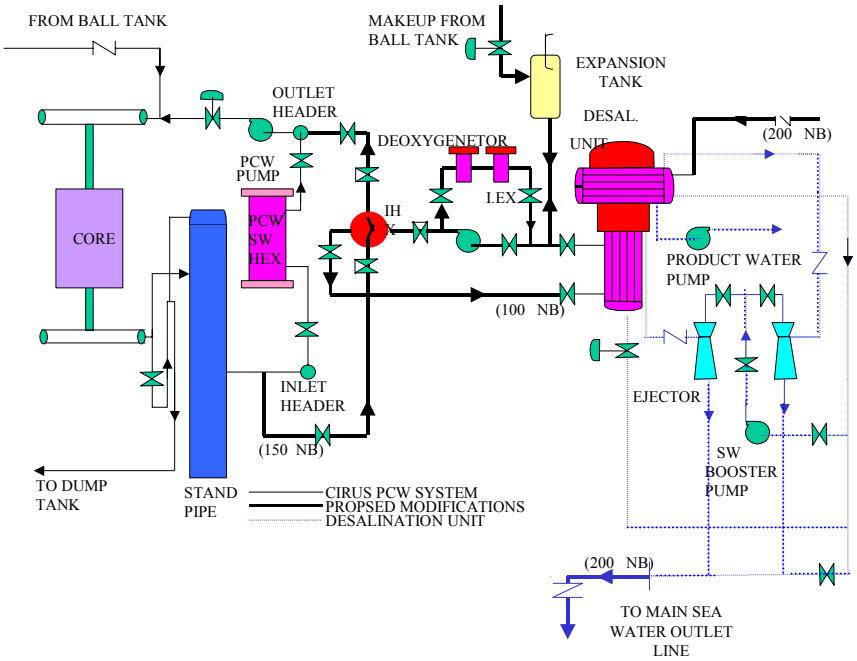
P. K. Tewari, BARC, India

As the energy cost contributes about one third of the total water cost in desalination plants, efforts are directed towards the utilization of waste heat which is available free of cost. BARC has an active programme to study the possibility of use of waste heat of PHWRs and nuclear research reactors for seawater desalination using Low Temperature Evaporation (LTE) and Multi-Effect Distillation (MED) technologies.

Mainstay of Indian nuclear reactors is the PHWR type using natural uranium oxide as fuel and heavy water (D_2O) as moderator and coolant. About 40 MW(th) and 100 MW(th) low temperature waste heat is available in the moderator systems of the 220 MW(e) and 500 MW(e) PHWRs, respectively. A significant part of this waste heat can be utilized for seawater desalination.

The feasibility of LTE technology was demonstrated through a 30m^3/d plant in Desalination Division using low temperature waste heat from a conventional source. The plant has been connected to the CIRUS reactor for demonstration of coupling of an LTE desalination plant to a nuclear research reactor and the feasibility of using low quality nuclear waste heat for seawater desalination. Some of the attractive features of the LTE technology are (i) use of chemicals is minimal in feed water treatment and (ii) less environmental pollution. The plant will be commissioned in the current year 2002. The data from this plant will be useful for the design of larger size LTE seawater desalination plants for the production of demineralised water (DMW) and process water. The design of such plants of larger capacity for Advanced Heavy Water Reactor (AHWR) program has also been taken up. Studies are undertaken towards utilizing low grade and waste heat from the steam and feed water system of AHWR for producing DMW from high salinity water or sea water.

Studies are being conducted on the use of waste heat to generate motive steam for utilization in Horizontal Tube Thin Film (HTTF) evaporators of MED for seawater desalination. Efforts are also directed towards utilizing waste steam from the last stage of turbine of the plant for seawater desalination in a HTTF evaporator producing high quality DMW. Such studies will be of immense use for cost effective seawater desalination.



SCHEMATIC DIAGRAM OF THE LTE DESALINATION PLANT COUPLED TO NUCLEAR REACTOR (CIRUS)

TECHNICAL BRIEFS

Recent IAEA Publications relevant to nuclear desalination

Safety aspects of nuclear plants coupled with seawater desalination units, IAEA-TECDOC-1235

The purpose of this publication is to address the specific safety and licensing aspects of nuclear plants for use in heat utilization applications and to establish the basis for safety assessment of such plants.

This publication also proposes a general approach for the preparation of safety requirements for reactors with special safety features or of a smaller size compared with nuclear power plants. This approach (top-down approach) is aimed at generating the safety design requirements for any kind of nuclear reactor starting from those for nuclear power plants, which are covered by the IAEA's well established corpus of safety standards.

(The responsible IAEA officer was M. Gasparini of the Division of Nuclear Safety)

Status of Design concepts of nuclear desalination plants, IAEA-TECDOC- (to be published in 2002)

Various studies have been considered by Member States with the aim of assessing the feasibility of using nuclear energy for desalination applications under specific conditions. In order to facilitate information exchange on the subject area, the IAEA has been active regularly in compiling related technical documents.

This document presents working material on the current status of nuclear desalination activities and preliminary design concepts of nuclear desalination plants, as made available to the Agency by various Member States. It is aimed at planners, designers and potential end-users in those Member States interested in further assessment of nuclear desalination.

(The responsible IAEA officers were Mr. M. Methnani and Mr. R. Faibish from the Division of Nuclear Power)

Market potential for non-electric applications of nuclear energy, TRS-410

Nuclear energy is known to have a much wider potential than solely for electricity generation. Ideas and technical solutions for non-electric nuclear applications have been developed, although, for various reasons, they have not yet reached the dame industrial maturity as for electricity generation.

Therefore, the IAEA has prepared this report, with contribution of outside experts that concentrates on the market potential and the economics of the nuclear option in district heating, supply of process heat, water desalination, ship propulsion, and outer space applications. In addition, there is an overview of innovative but promising areas such as fuel synthesis (including hydrogen production), oil extraction and some others.

The document is intended primarily for senior experts in governmental organizations, research institutes, industries, and utilities, who have influence in decisions related to the support of research and development for non-electric applications of nuclear energy.

(The responsible IAEA officer was Mr. S. Kononov of the Planning and Economic Studies Session)

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E-mail: sales.publications@iaea.org, Web site: http://www.iaea.org/worldatom/Books/

All recent TECDOCs since 1995 in the field of nuclear desalination are downloadable from the web at http://www.iaea.org/nucleardesalination.

IAEA Presence at International Conferences

Scientific papers have been presented at the following international conferences over the past year. Papers and lectures were also presented at a couple of other national and regional meetings.

1) Market Potential for Non-Electric Applications of Nuclear Energy, International Congress on Advanced Nuclear Power Plants (ICAPP), ANS2002, USA.
2) Application of Nuclear Energy for Seawater Desalination --- Design Concepts of Nuclear Desalination Plants ---, ICONE-10, USA
3) Using Nuclear Energy for the Production of Potable Water: Nuclear Desalination, International Youth Nuclear Congress, Republic of Korea
4) Energy and Water for Developing Countries: Nuclear Solutions for the 21st Century, IDA World Congress on Desalination and Water Reuse, Bahrain