MEETING REPORT

Seventh International Nuclear Desalination Advisory Group (INDAG)

held at the IAEA Headquarters, VIC, Vienna
7 to 9 July 2004

CONTENTS

List of Participants

ATTENDING EXPERTS

No.	Name	Country/Organization
1)	Mr. N. Masriera	Argentina/INVAP
2)	Mr. Zong Xin Wu	China/INET
3)	Mr. S.B. Abdel Hamid	Egypt/NPPA
4)	Mr. S. Nisan	France/CEA
5)	Mr. P.K. Tewari	India/BARC
6)	Mr. A. Barak	Israel/IAEC
7)	Mr.A. Minato	Japan/CRIEPI
8)	Mr. Si-Hwan Kim	Korea/KAERI
9)	Mr. B.C. Noh	Korea/KAERI
10)	Mr. S.B. Ghurbal	Libya/REWDRC
11)	Mr. Y. Bouabdallaoui	Morocco/COPSAN
12)	Mr. Y.D. Baranaev	Russia/IPPE
13)	Mr. K.V. Zverev	Russia/MINATOM
14)	Mr. A.I. Al-Marshad	Saudi Arabia/AERI
15)	Mr. N. Reguigui	Tunisia/CNSTN
16)	Mr. R.S. Faibish	United States/ANL
17)	Ms. E. Bertel	OECD/NEA
18)	Mr. A. Omoto	IAEA, DIR-NENP
19)	Mr. J. Kupitz	IAEA, SH-NPTDS
20)	Mr. M. Methnani	IAEA, NPTDS
21)	Mr. B-K Kim	IAEA, DIR-TCPB
22)	Ms. S. Miaw	IAEA, TCPB
23)	Mr. D. Kysela	IAEA, OIOS
24)	Mr. M. Gasparini	NSNI
25)	Ms.M. Szikszaine	NPES

MEETING REPORT

A. General

The seventh meeting of the International Nuclear Desalination Advisory Group (INDAG) was held from 7 to 9 July 2004 at the VIC, Vienna. The meeting was attended by 14 members and two observers (from Korea and Russian Federation) and represented by one International Organization (OECD). Mr. Nisan of the Commissariat a l'Énergie Atomique of France served as the Chairperson.

Mr. Omoto, Director, NENP opened the meeting by briefing on the relevant progress and development in the Agency's activities in the field of nuclear desalination.

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

Since last INDAG meeting Argentina has continued to support the Agency's ongoing programs on nuclear desalination.

In the last Research Coordination Meeting of the CRP "Optimization of the Coupling Nuclear Reactors and Desalination Systems" (February 2003), the participating institution (INVAP) presented the foreseen achievement of developing a flexible modelling tool, DESNU spreadsheet, helpful for evaluating nuclear desalination systems from the safety point of view. DESNU produces RETRAN input files for MED, MSF and RO desalination systems, and the BoP of a small NPP. The scopes of all the models were optimised in order to focus on the "component residence time", as relevant to the convective phenomena over which the contamination is spread, while minimising the input data requirement from the User.

The additional goals set by agreement within the CRP were also achieved, including greater flexibility, review by the participants and a User's Manual. As another expression of support to this CRP, Argentina was one of the two Countries hosting Consultants Meetings: a fruitful collaboration took place around DESNU in the meeting hosted by INVAP in Bariloche. Lately the support continued by giving feedback to every review request for the compilation of the CRP TECDOC.

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 considerable progress has been made according to two of the foreseen goals:

- Assessing potential sites in progressive stages achieving a justified final selection based on energy shortage and population and industrial activity growth, and
- Assessing main technologies of seawater desalination pointing to a selection according to the particular characteristics of the selected site, to world tendencies and to the technological advances of the desalination processes.

Regarding potential sites in Argentina, a single coastal region with meaningful water-stress was identified: the central coast of Argentine Patagonia. Within the site survey stage, several places were considered and after screening the available information the selected site was Puerto Deseado. In a third stage, the relevant parameters of the site have been collected.

Applying a similar selection procedure for Latin America, three regions were identified: the coastal area of Venezuela, the Dry-Pacific hydrographic system, and numerous Caribbean Islands. The selected site was the Dry-Pacific system.

Concerning the second goal the assessment of the seawater desalination technology concluded in selecting RO as the most convenient for Puerto Deseado, and a study of the desalination plant capacity and plant variables was carried out reaching the desalination plant specification. The investments and operative costs were estimated for the desalination plant, for CAREM Nuclear Power Plant and for a combined cycle gas turbine plant.

Beyond the activities on the Co-ordinated Research Projects, a relevant effort on developing Safety Aspects of Nuclear Desalination has been in progress. A well settled practice of Technology Development within INVAP gave the adequate framework for producing clear advances, first in the practical knowledge and understanding of these aspects and then on specific engineering and project management findings. During this last year, specific expertise on Nuclear Desalination Safety has been shared with colleagues of PAEC, BATAN and KAERI with fruitful technical interchanges.

Canada

Over the past year Candesal has evaluated the extension of its advanced RO seawater desalination technology into other applications. Of particular interest has been the application of this technology to the clean-up of salt-contaminated wastewater produced as a result of environmental remediation activities. Environmental remediation of contaminated sites, such as abandoned oil and gas fields, industrial sites, or municipal highway maintenance depots, has become an issue of major concern in Canada, as well as internationally. The remediation of such sites generally results in large volumes of salt-contaminated wastewater that creates a significant disposal problem. RO seawater desalination technology can be applied, with some modification to system flow paths, to reduce the

volume of wastewater by factors ranging from 10 to 20. This leaves only 5-10% of the original volume for disposal, with the balance being fresh, clean water that can be safely returned to the environment or reused in an industrial process.

Candesal participated in a Panel Discussion on nuclear desalination at the ICAPP embedded topical meeting at the ANS Annual Meeting in Pittsburgh in June 2004.

We believe the direction nuclear desalination must take to become truly successful in the future - that is as a part of an Integrated Water Resource Management solution addressing all aspects of energy and fresh water production, use, re-use and recycle.

China

China is a country of shortage of freshwater especially in the east coast areas. The nuclear seawater desalination will be an option of solution for mitigating fresh water shortage in the China's east coast areas. A demonstration project will be significant importance for promoting the development of nuclear desalination. The construction of a nuclear desalination demonstration plant (SNDP) with production capacity of 160.000m3/d in Shandong Peninsulu of China was initialled in 2000. Hao-Zin Investment Co. is the owner and the Institute of Nuclear and New Energy Technology. Tsinghua University is the engineering contractor.

The feasibility study started from 2003 March. The SNDP consists of a NHR/200 coupled to a MED process. The NHR-200 as a nuclear heating reactor with 200 MW capacity has designed with a numbers of advanced features, such as integral arrangement, full natural circulation, self-pressurized, in-vessel CR drive , passive safety systems in order to achieve very high safety margins. The coupling desalination process is based on high temperature MED with vertical tube foamy evaporation.

The feasibility study is expected to be completed before end of 2004. After assessment of feasibility study the SNDP will be decided whether to be built. In pararelly the experiment on vertical tube foamy evaporation is carrying on to investigate the operation behaviour and parameters.

Egypt

NP PA is carrying a number of integrated activities and studies to keep a state of readiness for efficient execution of NPP when the decision is taken. Also NPPA is working to complete the necessary infrastructure, including site development, preparation of the required studies and documents as well as manpower development.

Main motivation for that: the limited primary energy and water resources; and the work to improve the live standard. Egypt is investigating the optimal mix of electricity generation, taking into consideration the environmental aspects and the sustainable development requirements.

With the cooperation of the IAEA, technical and economical feasibility study to use NP for electricity generation and potable water production has been completed. Also, the IAEA is supporting the effort to construct a simulator for ND.

On other hand an experimental facility is under construction at the site. The objective of this facility: to obtain real data on preheating-R technology at the site conditions, which will useful for the future activities.

In brief, NPPA is proceeding with an integrated set of activities to introduce ND.

France

CEA, Nuclear Energy Directorate (DEN), Cadarache Atomic Centre, is involved in several nuclear desalination studies:

- Own studies under the Future Reactor Systems Division, Project No. SF/13.
- Site-specific study for the La Skhira site in Tunisia under the bi-lateral agreement between CEA and CNSTN under the aegis of IAEA's INT/4/134 programme: The TUNDESAL Project.
- Bi-lateral collaboration agreement between CEA and CNESTEN for site-specific studies of the Agadir and Laayoun sites in Morocco: the AMANE project.
- Development of an MED process simulator for the NPPA (Egypt) under an IAEA TC contract N° EGY/4/040
- CEA is also participating in the IAEA CRP: Economic Research on, and Assessment of, Selected Sites and Case Studies.

In the context of TUNDESAL project, 4 Tunisian engineers were detached at CEA, Cadarache to predimension the integrated desalination systems for La Skhira site in Tunisia, to develop appropriate coupling schemes based on the MED and RO processes and to perform economic evaluation of nuclear desalination with well validated codes. Comparison of desalination cost from nuclear systems (PWR, GT-MHR) were also made with that from fossil energy, (Fuel, Pulverised Coal, PC, and Gas Turbine Combined Cycle, CC) based systems, all coupled to MED and RO.

Two more engineers from Tunisia are expected in September-October 2004. A final report of the TUNDESAL project is being prepared for publication in November.

One Moroccan engineer has also completed the pre-dimensioning of the nuclear desalination systems for Agadir and Laayoun and developed a new coupling scheme, utilising waste heat from the GT-MHR.

CEA has recently completed two other important studies:

- Financing of nuclear desalination projects in developing countries: preliminary study of the rate of return of different fossil and nuclear energy based systems.
- Extraction of useful materials from the concentrated brine rejected by the desalination plants.

As its contribution to the CRP2, CEA is playing a leading role in the "DEEP Developers Group" and as such has provided corrected versions of some modules in DEEP (RO systems, hybrid MED-RO systems).

As part of its own activities, CEA is developing a new code system, called COSMOS for Nuclear desalination coupling scheme simulation, interactive modelling and optimisation and cost evaluations. In this context, new analytical models for Ro and MED have been developed.

India

BARC (India) is setting up a 6300 m^3/d combined MSF-RO Nuclear Desalination Demonstration Plant (NDDP) connected to 2 x 170 MWe PHWR units at Kalpakkam with the following objective:

- To gainfully employ the years of experience and expertise in various aspects of desalination activities on laboratory scale/pilot scale
- To demonstrate nuclear desalination technology on large scale
- To demonstrate safe and economic production of good quality water by nuclear desalination of seawater

- To cater the desalted water requirement for the dual needs

Considerable progress has been made in the implementation of the project. SWRO section of NDDP has already been commissioned and operating successfully as per design intent since August 2002. Potable water produced is supplied to nearby areas. MSF is in advanced stage of construction.

The location of desalination plant at an existing nuclear reactor has resulted in many experiences not encountered in coupling to a new nuclear plant. Useful design data from this plant on the coupling of small and medium size reactors (SMR) based on PHWR enable us to design large size plants of 100-300 MLD capacity. India is committed to share the NDDP experience with the Member States. It is planned to organise a Technical Meeting on "Integrated Nuclear Desalination Systems" during December 13-16, 2004 in Chennai (India) including site visit to NDDP.

BARC (India) has an active programme to study the possible utilization of waste heat from the heavy water research reactor and PHWR by coupling low temperature evaporation (LTE) desalination systems for seawater desalination. A 30 m3/d LTE desalination plant earlier established in the Desalination Division, BARC, has been commissioned this year (2004) producing very high quality water from seawater. The successful demonstration of utilisation of nuclear waste heat will open up the possibility of setting up large size seawater nuclear desalination plants utilising low grade/waste heat of PHWR/AHWR/HTR and nuclear research reactors. It is planned to integrate a 500 m3/d nuclear desalination plant with AHWR for seawater desalination.

BARC (India) is also engaged in collaborative efforts through CRPs. In the CRP on "Optimization of Coupling of Nuclear Reactor and Desalination Systems", India has focused on working together with the other participants on common aspects related to the performance evaluation of desalination systems and different types of SMRs for coupling. The CRP has been successfully completed and final report has already been submitted. India is also participating the CRP on "Economic Research on, and Assessment of Selected Nuclear Desalination Projects and Case Studies" and focusing on working together with the other participants on the economic assessment of hybrid nuclear desalination systems.

The development work done at BARC (India) has generated capability to design, fabricate, commission and operate small and large size nuclear desalination plants for large scale deployment and providing opportunities for the socio-economic development of water scarcity areas and coastal arid zones. The road map includes establishing large size nuclear desalination plants (100-300 MLD) coupled to nuclear power plants in coastal regions for both power and water security.

Israel

The revised governmental desalination policy is to install seawater desalting plants up to the accumulative capacity of 315 millions m^3/yr [MCM/Y] within this decade. In addition, quite a few plants of several dozens of MCM/Y from brackish water are already operating, under construction or will be ordered soon. This policy has been determined in view of the existing national water balance deficit and the growing water demands.

The largest plant, SWRO of 100 MCM/Y nominal capacity, located near Ashkelon on the Mediterranean about 60 km south of Tel-Aviv, is already in the midst of its construction. The pumps and RO membranes are now being installed. The first part [50%] of the plant is expected to supply desalted water in mid 2005; the second half is due by the end of 2005. The promised water price at the plant exit is as low as about 50-53 US cents. The required desalted water quality is extremely high – 20 ppm chlorides and low boron content.

56 Mwe will be supplied by a 'dedicated' combined-cycle power plant of 86MWe, the balance of which will be supplied to the national electric grid.

A similar plant is planned for Hadera, on the Mediterranean about 50 km north of Tel-Aviv. The bid will be issued this July.

Another plant of 45 MCM/Y is planned as the next step. Two additional bids for 30 MCM/Y each will be decided upon within 2-3 months. There is yet some uncertainty about these three projects.

Nuclear desalination, however, seems now more remote than ever for Israel. Nevertheless, data and experience – construction as well as O&M - gathered from the two gigantic Ashkelon and Hadera projects might most probably contribute a lot of information as well as ground for decision making regarding future large nuclear desalination projects.

Japan

Japan has no national projects, international projects and inter-regional projects at the present time. Japan is not able to provide any information related to above three projects. However, Japan has nuclear desalination facilities, which are collocated inside the nuclear power plants, in order to supply the fresh water, which is being used inside the plant. The load factor of all desalination facilities is not so high, however, those are being operated without any serious troubles now.

1. Nuclear technology development

R&Ds of some innovative nuclear technologies are being conducted under the contract with MEXT and METI. Those technologies will be incorporated into the future nuclear power plants.

2. Desalination technology development

Two kinds of improved RO system, of which the recovery ratio can be increased from 40 % to 60 % have been developed by Toyobo and Toray. One of system with one stage was installed into the desalination plant (50,000ton/day), which was constructed in Fukuoka. Its construction was finished and the test operation by each unit will be started in the near future. The fresh water will be supplied from the next year (2005). Another new technology related to the intake of seawater was also installed into the Fukuoka desalination plant.

Korea Rep. of

Well-established nuclear energy and desalination technologies pursue their extended applications to resolution of fresh water shortage problem by seawater desalination. The objectives are mainly to develop an integrated desalination plant with SMART (System-integrated Modular Advanced ReacTor) for a dual-purpose application. The programme is being carried out by the Korea Atomic Energy Research Institute (KAERI) as the leading organization with the support of Government and participation of industries The concept of the SMART desalination plant aims to supply forty thousand (40,000) tons of fresh water per day and ninety (90) MW of electricity to an area with approximately a ten thousand (100,000) population or an industrialized complex.

SMART is an advanced integral PWR with designed thermal energy output of approximately 330MWt. Major primary components are arranged within a single pressure vessel, unlike the conventional loop-type reactors. New, innovative and highly advanced features are adopted in the SMART design to enhance the safety, reliability, performance, and operability. The SMART desalination plant consists of 4 units of MED-TVC (Multi Effect Distillation with Thermo Vapor Compression) to produce 40,000 cubic meter of distillate per day and each MED-TVC evaporator consists of 10 effects, 1 final condenser, and 2 flash condensers. SMART is a safety enhanced, economically viable and environmental friendly plant system for power generation and seawater desalination.

Since 1997, Government of Korea has been supporting the development of SMART. Both the conceptual design and basic design of SMART with a desalination system were successfully completed in March of 1999 and in March of 2002, respectively. In 2002, Korean government

launched construction project of the SMART plant with one-fifth scaled power for comprehensive performance verification. Pre-licensing documents were submitted to licensing authority on July 2003. Now, the SMART design verification phase is currently underway to conduct separate effect tests and comprehensive integral tests. A SMART desalination plant currently under construction will be in operation by 2008**.** It is expected that SMART desalination plant can be completely commercialized from 2009.

Inputs from IAEA programmes are: use of DEEP code for economic evaluation of the nuclear desalination plant with SMART, participation in the CRP on "Optimisation of the coupling of nuclear reactors and desalination systems" based on the activity in the SMART project" and on "Economic Evaluation of SMART in Korea", and forum for technical information exchange. From the very beginning, the Korean programme has been open to co-operation from any interested Member States. For this purpose, the SMART project has been brought to the IAEA inter-regional technical co-operation project (INT/4/134) on "Integrated nuclear and desalination system design" which started in 1999. KAERI started at January 2, 2002 the joint study with BATAN and the Agency on "Preliminary Economic Study of Nuclear Desalination in Madura Island, Indonesia as one of Korean contributions to the IAEA Inter-regional TC project.

Libya

Water desalination is a necessity for Libya due to the sharp increase in the demand for water as a result of the increase in population associated with improved living standard. The water deficit gap is increasing and has raised concern on the national level. Desalination was introduced in Libya during early sixties and has grown up dramatically since then. Commercial scale production has started in mid seventies where the total accumulated and operable installed capacity from the three main desalination technologies (MSF, MED, RO) has reached 750000m3/d and about 333000m3/d respectively in 2002. Libya is considered to be the largest operator of desalination plants in North Africa and has a build up experience in the field of operation. Reliance on water desalination for the supply of potable water to some urban cities along the coast necessitate local engagement in the design of desalination plants and manufacturing some of the components comprises such plants so as to minimize the cost of product water.

In view of this Libya has seen the desalination of seawater to be one of the major option to augment national efforts for the supply of potable water and decided to conduct certain activities toward capacity building and cost optimization in this field. Among the activities in this direction are:

1- The establishment of a specialized research center mandate it (as part of its tasks) to be responsible for research and development in technologies for water desalination and wastewater treatment. For the center to achieve the objectives for which it was established a national program to acquire know-how and transfer of technology in the field of seawater desalination was initiated in collaboration with some European companies.
2- Continuing the site-specific studies to assess economic competitiveness of energy options to be coupled with desalination plants using DEEP and other tools.
3- Assistance in the field of nuclear desalination under IAEA Technical Cooperation programme was being considered and a request has been submitted.
4- Establishing cooperation with other countries for feasibility study on nuclear desalination for specific site is being considered so as to promote and deepen the technical and economic investigations for the optimum coupling between energy and desalination systems.

Morocco

Morocco adopted specific law covering all water management aspects, including pricing and environmental issues and creating Basin agencies. In order to address water scarcity in the near term Water Authorities set up and are implementing the 2005-2025 National Water Plan. Nuclear desalinisation is an option among other options. The Government of Morocco strongly believes that existence of effective regulatory infrastructure is a prerequisite for the development of any promotional nuclear activities. Consequently, it is establishing an adequate and sound legal and institutional legislative and regulatory nuclear framework. And is committed to become familiar with all existing and available technologies and expertise in nuclear peaceful activities in general and desalination in particular. This is done and will be further strengthened in co-operation with the IAEA and other countries through multilateral and bilateral arrangements.

With a vision aiming at meeting its water and energy needs in a sustainable manner including desalination, Morocco formulated a strategy with clear responsibilities and coordination mechanisms between all concerned parties (e.g., ONE, ONEP, CNECTEN, etc.).

Given the progress of technologies and the oil price, ONE is updating with the assistance of the Agency, the ONE-FRAMATOME qualified NPP site.

ONEP engaged conventional desalinisation feasibility studies using wind and solar energy to compare the findings with those of the nuclear desalinisation Pilot Project. The later was implemented through the IAEA's TC programme, involving China, INET ONE, ONEP and CNESTEN. Also CNESTEN is being involved in bilateral nuclear desalinisation studies.

As a conclusion Morocco is interested and will use all the findings and results of any desalination related projects and technologies within bilateral and multilateral co-operation programmes.

Pakistan

Did not participate

Russian Federation

The design and licensing activities for the small floating heat and power co-generation plant based on ship propulsion reactor technologies has been finished. Several financing schemes, including using international co-operation channels, are being elaborated for construction of the first station in the North of a European part of Russia. The Nuclear Floating Power Unit (NFPU) equipped with two KLT-40C 150 MWt PWRs, being a part of the station, can be effectively used as energy source for nuclear desalination complex. Russia proposes to implement international nuclear desalination demonstration project based on the above technology and invites interested partners for participation in such a project.

The activities of design and scientific organizations in the field of nuclear desalination is aimed at the analysis of technical and economic problems of utilizing various nuclear reactor as electric power and heat sources for seawater desalination plants. A scientific and technological basis resulting from these activities assumed to be applied for detailed developments and practical implementation of nuclear desalination.

The preliminary design work aimed at the assessment of technical and performance characteristics of nuclear desalination systems has been conducted for prospective Russian medium-sized reactors VVER-640, GT-MGR, BREST-300, VK-300, and small-sized reactors KLT-40C, RUTA, UNITERM, NIKA, SBBR-75/100.

Conceptual document “Nuclear Desalination using Russian Reactors” is under development now. The objective is to identify technical tasks as well as organizational and financing recourses for a short- and medium-term action plan in nuclear desalination.

Russian design and scientific organizations took part in the IAEA CRP-1 on “Optimization of the Coupling of Nuclear Reactors and Desalination Systems” and the CRP-2 on “Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies”.

Saudi Arabia

The Saudi experience during the last quarter 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.

Saudi Arabia's water desalination output exceeded one billion cubic meters in 2002, reported the Saline Water Conversion Corporation (SWCC). Currently, 70 percent of the Kingdom’s drinking needs are provided through desalination, generating 3,600 megawatts of electric power.

Saudi Arabia is the largest desalinated water producer in the world, contributing to 30 percent of global production, according to official statistics. Desalinized seawater currently constitutes Saudi Arabia’s chief source for drinking water. The Saudi government transports its desalinated water via a 2,500 kilometer pipeline network, 21 pumping stations, 131 depots and 10 stations for mixing the desalinated water with underground water.

The government has for some time realized that massive investments are needed to upgrade or replace the existing water desalination plants, water treatment plants and sewage treatment plants and to build new ones to meet the spiraling demand for drinking water and sewage treatment. It is estimated that the total investment in the desalination industry for the next twenty years will reach 16 billions US $.

King Abdulaziz City for Science and Technology has financed a research project in nuclear desalination planning for Saudi Arabia. The outcome of the study showed that nuclear desalination is very promising option, however besides economic issues, safety concerns of water contamination is very important issue need to be investigated for coupled nuclear desalination system.

Tunisia

In 2002, the Tunisian National Centre for Nuclear Sciences and Technologies (CNSTN) and CEA-France signed and under the aegis of IAEA’s Interregional Cooperation Programme INT/4/134 launched a nuclear desalination feasibility studies for the Skhira site in the south of Tunisia, known as the TUNDESAL project. A mixed team of experts from CEA and from CNSTN as well as from the Tunisian electric utility (STEG) and the water utility (SONEDE) was formed. This feasibility study considers the following tasks:

- Pre-dimensioning of the nuclear reactor and desalination processes, compatible with Tunisian electricity needs and required water production capacity at La Skhira site.
- Coupling of the selected nuclear reactor to desalination processes and system optimisation.
- Economic evaluation of the integrated systems elaborated above.
- Safety verification studies of coupled systems.

The first three tasks were completed. The fourth task related to safety and radiological analysis will be finalized in October 2004.

Three scenarios were considered to estimate water deficit in 2020. For the most pessimistic scenario, one would require a water production capacity of about 260,000 m3/day. The second scenario is more realistic and assumes gradual consumption increase. This approach results on a deficit of 148,751 m3 per day for the year 2020. The third scenario takes into account water supply

projects that are under way or planned for the region by the year 2006. Estimations give a deficit of 40,000 m3 per day for the year 2020.

Using the actual data for previsions of the electrical demand, combined with the energy demand for the desalination unit led to the need for a power plant of about 600 MWe in 2020 operating in the co-generation mode. For the purpose of the economic study, five types of solutions were considered for this power range, two are fossil power plants (Fuel and Gas turbine combined cycle) and three nuclear power plants, namely: a SCOR-600, two modules of the GT-MHR and a 900 Mwe PWR as a reference case.

The economical evaluation of the power production systems was performed with the help of the SEMER code, recently developed by the CEA, and the STEG approach that is based on the method adopted by EURELECTRIC (ex UNIPEDE) for the fossil based power plants.

Desalination costs were calculated using a modified version of IAEA's DEEP code with SEMER results as input for three types of desalination processes: MED, RO, and ROph, (RO with preheating of feed water).

United States of America

The U.S. is actively engaged in pursuing solutions for pending domestic as well as international water and energy problems. It is clear that from a thorough examination of future prospects of global water and energy shortages, the challenges for finding solutions are very real and demanding. In the framework of nuclear desalination, the U.S., with the leadership of Argonne National Laboratory (ANL), is actively engaged in assessing the possible contribution of cogeneration of water and power using advanced desalination and power plant combinations for sustainable development. ANL is actively engaged in the IAEA's coordinated research projects (CRP) on site-specific economics and technical feasibility of a possible nuclear desalination facility in the U.S. and in helping upgrading the Agency's relevant software DEEP.

Indeed, a new project in the U.S. State of Texas co-led by Sandia National Lab and sponsored partly by the U.S. Department of Energy (DOE), will examine the technical, economic and socioeconomic feasibility of a nuclear energy/water cogeneration plant along the Texas coast for supplying energy, water and hydrogen for the local petrochemical industry as well as the surrounding population. The nuclear plant will be based on an advanced plant inline with DOE's "Vision 2010" reactor designs. ANL's Nuclear Engineering Division (NED) has been given a leading role in the technical design and economic assessment of this possible future plant. Other nuclear desalination operations such as at the Diablo Canyon Nuclear Powel Plant and co-located membrane desalination plant will also be reexamined to assess future possible expansion of operations and lessons learned from operations thus far.

ANL-NED is also leading a new working group at ANL consisting of experts from 5 separate divisions – the Argonne Integrated Water Resource Management Working Group. This group of experts, along with water professionals around the world, and particularly in developing countries, will lead the assessment of various water needs and related infrastructure requirements, planning, and training that are in the framework of broader Integrated Water Resource Management (IWRM) plan development and implementation efforts. Nuclear Desalination is regarded as one possibility for water capacity building.

OECD

The NEA has no current activity devoted to desalination only by is pursuing a project on "Nuclear energy products" which covers nuclear desalination. The main outcome of project, to be completed by the end of 2004, will be a report focusing on strategic and policy issues (including social and environmental aspects) associated with the development and deployment on non-electrical

applications of nuclear energy. The NEA Secretariat will make the report available to Members of INDAG once it will have been completed and approved by the relevant NEA bodies (likely early in 2005).

Also, in the framework of its activities on economics of nuclear energy, the NEA is interested in computer tools for assessing the economics of nuclear systems and DEEP is one of them. In this connection, the NEA Secretariat will endeavour to provide feedback on the new developments of DEEP and would like to be kept informed on the activities planed by IAEA in this field, in particular any new meeting of the users group.

IAEA Staff

Nuclear Power Technology Development Section

Mr. B.M.Misra, the Scientific Secretary, presented the technical overview including the status of the CRPs, DEEP, the Web Page, participation in the international conferences and the proposed ICTP Workshop and the Technical meeting at Kalpakkam. CDs of the draft TecDoc of CRP1 and the proceedings of the Marrakech Conference were distributed to the INDAG members. He also presented the status of 2004- 05 Activities and Deliverables and the proposed Activities for 2006-07.

Mr. M. Methnani gave an overview of current development work related to the IAEA program DEEP, used for economic evaluation of desalination. The presentation focused on currently known limitations in the code and the efforts underway by the Agency to prepare for the release of a DEEP-3 version. Areas of improvement include thermal and RO performance modeling, cost modeling, as well as the user interface.

Nuclear Power Engineering Section

Ms. M.Szikszaine presented the status of PRIS activities. It was suggested to add one more table to RDS 2 content with list of nuclear power plants, which have non-electrical applications, including nuclear desalination.

Technical Cooperation

The DIR-TCPB and the Project Manager of the Interregional Project on Integrated Nuclear Power and Desalination System Design - INT/4/134 have participated in the meeting. Presentation on the Status of TC projects on Nuclear Desalination was given. Some discussions on the phase out of the INT/4/131 and future assistance from TC were held.

Upon request of the members of INDAG meeting and agreement from Indonesia and Korea, copies of Executive Summary of Preliminary Economic Feasibility Study of Nuclear Desalination in Madura Island were distributed. The main objective is to share the achievements of the agreement (Indonesia, Korea and IAEA) and information with INDAG participants.

Division of Nuclear Installation Safety

Mr. M. Gasparini presented the current activities in the Division of Nuclear Installation Safety that are of interest for the Nuclear Desalination. Although at the present time there are no activities specifically dedicated to safety of nuclear desalination, the work on IAEA Safety Standards and the project on safety of innovative reactors are of immediate application to safety of nuclear desalination. The nuclear power plant coupled with a desalination unit, from a safety point of view, is considered and analysed as an integrated system for which the current safety standards and methods for safety assessment apply. The application of current safety standards and methods to innovative reactors needs to be thoroughly reconsidered at the light of a new technology-neutral and risk-informed safety approach. The presentation summarized the main achievement of the activity on this area.

Office of Internal Oversight Services

Mr. D. Kysela presented the summary of programme evaluation by the Expert Panel. A programme evaluation of the Agency Nuclear Desalination programme was conducted in the first half of 2004 by OIOS with the assistance of an independent external Evaluation Panel. Findings, conclusions and recommendations from the evaluation were presented by OIOS. The evaluation concluded that the IAEA nuclear desalination programme has done a decent job with the available human and financial resources. The evaluators recommended to be more proactive in promotion of the outputs from the regular programme (DEEP, INDAG meetings) and of the results from relevant TC projects, to ensure wider participation of IAEA Member States and to address issues collateral to nuclear desalination such as socio-economic and environmental effects, water transportation and storage, and public acceptance of the nuclear desalination technology.

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 2002. Following activities were specifically reported to INDAG:

- Technical overview including CRPs 1 and 2
- Status of TC projects
- Summary of Programme Evaluation Report
- DEEP developments
- Safety aspects
- PRIS Extension for non-electrical application

D. Technical Topics

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

- Water transport and distribution	A. Hamid (Egypt)
- Financing of nuclear desalination projects	S. Nisan (France)
- Hybrid systems	P.K. Tewari (India)
- Water radiological monitoring as a safety measurement	N. Masriera (Argentina)

E. Findings and Recommendations

1) INDAG stressed the need to address socio-economic and environmental aspects of nuclear desalination. It recommended that a third CRP be launched. Proposed tentative topics: environmental aspects, socio-economic impact on local and national scales (value of water; impact of the deployment of ND systems, employment, infrastructures, public acceptance, etc.).

2) INDAG recommended that the Agency's Nuclear Desalination Unit contact the Nuclear Science and Applications Department and any other relevant Departments for providing information on radiation monitoring systems for product water from a nuclear desalination complex. This issue should be on the agenda of the next meeting.

3) The members felt that when possible, recognised experts from water and nuclear utilities and related international associations be invited as observers to INDAG meetings.

4) INDAG supported the need for continued upgrading and validation of the Agency's software DEEP.

5) INDAG supported the continuation of Agency workshop on nuclear desalination technologies and economics.

6) INDAG proposed the continuation of CRP2 until 2007so that alternate water costing methods such as, the exergy principle and several alternative power credit methods could be considered in economic analyses of nuclear desalination operations.

7) It was proposed by the majority of INDAG members that the definition of nuclear desalination be modified to include the production of water of various grades for various end-users (e.g. potable water, industrial applications, agricultural usages, hydrogen production processes, and other applications).

8) INDAG recommended that, in view of the increased activity in the field of nuclear desalination, the frequency of INDAG meetings be changed from biennial to annual basis.

9) INDAG observed that its Newsletter indeed enhanced its visibility and transparency. Its continued and regular publication is encouraged.

10) INDAG requested that it should be informed of what was being reported to SAGNE and of SAGNE’s decisions.

11) The next meeting of INDAG was proposed to be held in early 2006.