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Nuclear Desalination Newsletter

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Successful Commissioning of Nuclear Desalination Plant in Pakistan

In January 2011, The Pakistan Atomic Energy Commission successfully commissioned the first unit of a nuclear desalination plant in the Karachi Nuclear Power Complex (KANUPP), a single unit CANDU PHWR with a total gross capacity of 137 MW(e). The demonstration plant producing 1600 m^3/day of pure water (TDS below 5 ppm), will provide adequate know-how and experience in design, manufacturing, operation and maintenance for local fabrication of future large scale desalination plants in Karachi and other populated areas along coastal belt. *(Read more on Page 4)*

New IAEA Tools for Desalination

A new version of DEEP, the IAEA's Desalination Economic Evaluation Program was released in February 2011. Users can now experience a more polished version and enhance their prefeasibility reports with the new reporting and analysis tools provided by this version. Along with this release, a new tool named DEsalination Thermodynamic Optimization Program (DE-TOP) has been released. DE-TOP is complimentary to DEEP and helps analyze the thermodynamics of cogeneration systems with emphasis on water desalination. *(Read more on Page 7)*

A Word from the Deputy Director General

The continuing improvement of technologies and decrease of cost, seawater desalination is expected to play an important role in the global economic and social development as well as in the ecological environment, especially for regions having severe water shortages such as China and the Middle East.

Seawater desalination using nuclear energy is not only technically feasible but economically an option in varying site conditions and with a variety of nuclear reactor concepts. In any given country, nuclear desalination will become a viable option if the following two prerequisites exist: lack of potable water and the ability to deploy nuclear energy. In most regions, only one of the two is fulfilled.

Many countries; e.g. China, the Republic of Korea and, even more so, India and Pakistan have both factors present. These countries already account for almost half the world's population, and thus represent a potential long term market for nuclear desalination. The accumulated experience in nuclear desalination will undoubtedly contribute to what many consider as the world wide central issue of the 21st century: the crucial need for new sources of freshwater for sustainable development.

Within its continuing efforts to support Member States through various forums of information exchange, technical cooperation projects, and publications, the IAEA updated and released a new version of Desalination Economic Evaluation Program (DEEP 4.0) in 2011 with new features and easier usability for both newcomers and experts.

The IAEA also released a new tool named DEsalination Thermodynamic Optimization Program (DE-TOP), which complements DEEP and is used to analyze the thermodynamics of cogeneration systems with emphasis on water desalination. The IAEA toolkit on nuclear desalination, intended for Member States considering nuclear power for seawater desalination, provides access to information on nuclear desalination including DEEP and DE-TOP. This tool was further improved in 2010 with updated and expanded information.

I am pleased to be able to inform you that the IAEA intends to continue this support in the forthcoming years.

The IAEA's activities on seawater desalination using nuclear energy have been conducted within the framework of the ***Technical Working Group on Nuclear Desalination (TWG-ND)*** in which countries are represented that have ongoing development programmes and are interested in the deployment of nuclear desalination. This technical working group will also continue to provide advice and guidance for implementation of the IAEA's programmatic activities in the area of nuclear desalination.

I am pleased with the release of this issue of the TWG-ND newsletter highlighting some current activities of the IAEA and its Member States.

A. Bychkov

Deputy Director General

Head, Department of Nuclear Energy, IAEA

For more information about the NE Department please visit: http://www.iaea.org/OurWork/ST/NE

A Word from the Chairman of TWG-ND

Nuclear desalination is an inevitable option for the production of potable water. Increase in fresh water shortage, adverse impact of climate change on quality/quantity of fresh water and ever increasing price of fossil fuels favour the deployment of nuclear desalination. It is anticipated that small, medium and large size nuclear desalination plants will be required in water stressed coastal areas in several parts of the world. Credible prospects for nuclear desalination are foreseen in the next twenty years. Adopting the cogeneration concept along with hybridization of desalination system would help to make the production of desalinated water from seawater affordable and sustainable.

Technological development for nuclear desalination is progressing in many countries. In India, for example two types of nuclear desalination plants have successfully been demonstrated: (i) a 6300 m^3/d Nuclear Desalination Demonstration Plant (NDDP) using hybrid Multistage Flash-Reverse Osmosis (MSF-RO) technology in Kalpakkam coupled with Madras Atomic Power Station (MAPS) and (ii) a Low Temperature Evaporation (LTE) plant coupled with a nuclear research reactor at Trombay.

Useful experience from design, fabrication and operation of the plants has been shared with the TWG-ND members. Fellowship training and scientific visits to NDDP have been organized for interested Member States through the IAEA Technical Cooperation Programme. Pakistan has completed the successful commissioning of Multi-Effect Distillation (MED) type nuclear desalination demonstration plant (1600 m^3/d capacity) in the Karachi Nuclear Power Complex in January 2010.

Small and Medium Reactors (SMRs) are viewed by many in the USA as technologically and economically promising future types of reactors for potential deployment in the USA and around the world. The coupling of desalination systems with SMRs could be advantageous to the overall economics of the nuclear power plant. In addition, the need for fresh water and energy for sustainable economic growth around the world can provide rational for expansion of cogeneration operation of nuclear power plants.

The Technical Working Group on Nuclear Desalination (TWG-ND) is playing an important role as an international forum for information exchange and cooperation in nuclear desalination as well as providing technical advice to interested Member States. The TWG-ND meeting was held in April 2011 at the IAEA, and was attended by 14 Member States. The TWG-ND has demonstrated a successful role in meeting its objectives as specified in the terms of reference. This includes exchange of information on nuclear desalination programmes, reviewing the progress and providing advice and guidance on the IAEA's activities in nuclear desalination, such as coordinated research programmes, technical meetings, providing expert advice on preparatory action by Member States for implementing nuclear desalination demonstration projects.

The TWG-ND endorsed the IAEA work plan on nuclear desalination, which also includes technical cooperation projects, publications on nuclear desalination, upgrade of Desalination Economic Evaluation Program (DEEP) and development of toolkit on nuclear desalination. The successful release of DE-TOP and updated version of DEEP by the IAEA are important milestones. All can be further enriched by involving Member States and renowned experts in defining the specifications, developing and reviewing the software tools at regular intervals so that input data and relevant formulas in both DE-TOP and DEEP can be updated from time to time to reflect present day conditions and analyses.

In light of the Fukushima accident and the apparent need for on-site fresh water for operational purposes, the TWG-ND recommends that the use of nuclear desalination be evaluated as an additional fresh water supply source for nuclear power plants. The scope of TWG-ND may be widened for addressing the challenges related to integrated water resources management for efficient use of water in nuclear facilities. There is a need to enhance communication with the public on nuclear desalination, possibly through increased contact with international desalination workshops/ conferences/ networks.

The IAEA TWG-ND should continue to provide technical advice to interested Member States through CRPs, technical meetings, topical conferences, technical cooperation programmes, computer software and toolkit.

The TWG-ND looks forward to the continuing programatic support from the IAEA for the further development and deployment of nuclear desalination as a major contribution to sustainable socio-economic development.

P.K. Tewari

Chairman, TWG-ND

Recent Activities in Member States

Karachi nuclear desalination demonstration plant

Successful Commissioning of Nuclear Desalination Plant in Pakistan

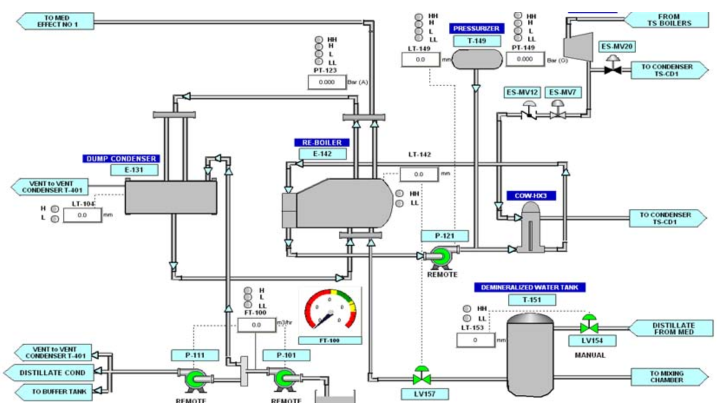
The Pakistan Atomic Energy Commission (PAEC) has successfully commissioned the first unit of a nuclear desalination plant in the Karachi Nuclear Power Complex (KANUPP), a single unit CANDU PHWR with a total gross capacity of 137 MW(e) that has been in commercial operation since 1972 owned and operated by PAEC. The demonstration plant will provide adequate know-how and experience in design, manufacturing, operation and maintenance of nuclear desalination systems as a reliable source of potable water to Karachi and other dense populated areas along the Pakistan coastal belt.

PAEC has been actively engaged in various activities in the field of nuclear desalination since 1965. The Karachi nuclear desalination demonstration plant is the result of a Coordinated Research Project launched by the IAEA in February 2002 entitled Economic Research and Assessment of Coupling Existing 137 MW(e) KANUPP with a Desalination Plant where the size of the plant, coupling arrangement and desalination technology were selected. The chosen technology was low temperature MED (max brine temperature of 59°C). The plant size was established to allow common seawater intake for both nuclear power plant and desalination plant, and to limit plant efficiency drop due to the required steam withdrawal for the desalination process.

The 8 effects MED unit produces 1600 m^3/d pure water below 5 ppm TDS with a gain output ratio of 6:1. The desalination plant is coupled to the secondary side of the reactor through an intermediate coupling loop (ICL) assuring a third physical barrier against radiation. Steam is extracted from the high pressure turbine at 1.7 bar and 116°C and condensed in an intermediate heat exchanger where it heats up the ICL fluid which transfers this heat to the desalination unit in the reboiler. Hence, the ICL consists of a loop with a steam/water intermediate heat exchanger a recirculation pump and a reboiler where the steam needed for the first effect of the desalination plant is produced.

The intermediate coupling loop operates at a higher pressure than the secondary loop of the nuclear power plant, in order to ensure that even in a hypothetical and highly improbable double rupture in the reboiler tubes and intermediate heat exchanger tubes no contamination can migrate into the desalination system.

Results of the Karachi Nuclear Desalination Demonstration Plant project will demonstrate the feasibility of the nuclear desalination option and help gather the necessary know–how for local fabrication of future large scale desalination plants in Pakistan.



Coupling arrangement and Intermediate Cooling Loop in KANUPP

Algeria: The current desalination program, having a 2260000 m^3/d total capacity, is in the phase of realization and reached an appreciable advancement. The current programme is based on natural gas due to the fact that desalination is an energy consuming technology. In 2007, Algeria conducted in collaboration with the IAEA, a techno-economic prefeasibility study of seawater desalination by means of nuclear energy. Several research activities, such as simulation of nuclear desalination plants, are also being analyzed.

China: The nuclear power development goal is to have an installed capacity of nuclear power plants in operation of 40 GW(e) by 2020. By the end of October 2010, China has thirteen nuclear power plants having total capacity of 10.8 GW(e), and 25 units with a capacity of 27.7 GW(e) are under construction. New approvals for nuclear power plants have been suspended due to the Fukushima accident. The rapid development of nuclear power, the lack of water resources, as well as the development of desalination technology is expected to be the drivers for the deployment of nuclear desalination.

SWRO desalination plant in Hongyanhe nuclear power plant

Nuclear desalination is being used in some NPPs to support the plants themselves (e.g during construction) and for the plant's residential use. In June 2010, the first seawater desalination system operating in China's nuclear power plant was officially put into use. It is located in Liaoning Hongyanhe Nuclear Power plant. The seawater desalination facility at Hongyanhe station is able to provide 10080 tonnes of freshwater daily. The SWRO desalination process is used. Fresh water will be used in operating reactors in the Hongyanhe nuclear power plant and for daily life needs.

Egypt: A research programme for the analysis of feed water preheating for RO plants is being conducted. Studies have shown that there is a potentially significant economic and performance benefit through the combined effects of feed water preheating and system design optimization. The Egyptian Nuclear Power Plant Authority (NPPA) constructed an experimental Reverse Osmosis (RO) facility at its site in El-Dabaa to validate the concept of feed water preheating. The experimental programme was developed with IAEA technical assistance in the design stage as well as in the preparation of the technical specifications and tender documents. The commissioning tests started in 2006. The experimental facility has been in operation since 2008. All parameters that affect product water as different feed water temperatures from ambient temperature to 45°C were studied and compared with a parallel system operated at ambient temperature. The experimental results show that the RO desalination performance (product water rates and conductivity) increases with increasing the feed water flow temperature and pressure.

France: The Commission for Atomic Energy (CEA) is developing engineering support systems for nuclear desalination studies. Focus is made on model development (MED RO coupling with nuclear power plants), model validation and recovery of valuable materials present in seawater in collaboration with BARC (India). Other prospects of nuclear desalination, such as its energy needs, environmental concerns and its potential contribution in preventing Fukushima-like accidents, were also presented.

India: Total water market in India is estimated as US$ 14 billion while the industrial water market is US$ 3.5 billion. There is a requirement for large, medium and small size desalination and water purification units in the country as part of the Integrated Water Resource Management. Desalination plants can also help in adaptation and mitigation of the impact of climate change. There are two nuclear desalination plants operating in India: A 6300 m^3/d Nuclear Desalination Demonstration Plant (NDDP) using hybrid Multi-Stage Flash-Reverse Osmosis (MSF-RO) technology in Kalpakkam coupled with Madras Atomic Power Station (MAPS) and a Low Temperature Evaporation (LTE), first of a kind, desalination plant coupled with a research reactor at Trombay. Useful experience from design, fabrication and operation of the plants were shared. Fellowship training and scientific visits to NDDP were organized.

Hybrid nuclear desalination plant in Kalpakkam

With the successful demonstration of nuclear desalination in India, the opportunity may be utilized by the IAEA for providing technical training on nuclear desalination to interested Member States through the IAEA technical cooperation programme. Indo-French bilateral cooperation on nuclear desalination was also deliberated. There are also on-going activities on brine disposal environmental aspects and development and validation of MED-TVC models. The use of different qualities of desalinated water in nuclear facilities was also addressed. It was concluded that nuclear desalination is inevitable (small, medium or large capacity) due to the ever increasing water shortage and climate change.

Saudi Arabia: The desalination programme is considered to be the largest in the world. The main challenges that are driving Saudi Arabia's power and desalination programme are: the rapid increase in population, increase in water demand, high per-capita consumption, and scarce natural water sources and rapid industrialization. Since the end of 2008 there have been 9 desalination plants constructed with a total capacity of 1800000 m^3/d. Therefore, Saudi Arabia is interested in the development and introduction of a nuclear energy programme for both electrical power generation and water desalination.

Jubail II thermal desalination plant in Saudi Arabia

USA: SMRs are viewed by many in the USA as technologically and economically promising future types of reactors for potential deployment in the USA and around the world. The coupling of desalination plants with SMRs could be advantageous to overall economics and benefit nuclear power plant operations. In addition, the need for freshwater and energy for sustainable economic growth around the world can provide rational for expansion of cogeneration operations of nuclear power plants. The USA, through Argonne National Lab, is planning to continue to participate in the CRP on new technologies of nuclear desalination.

Cooperation Through IAEA Fellowship Programme with Indonesia

The IAEA Fellowship Programme has provided training, study, and research opportunities for scientists and engineers since its initiation in 1958. For many countries, scientific fellows have become an important link in the effective transfer of nuclear technologies.

Under the supervision of Dr. I. Khamis, two fellows from the Indonesia's National Nuclear Energy Agency (BATAN), the national institution planning the development of nuclear power infrastructure in Indonesia, Ms. Dewita Erlan and Mr. Deddy Priambodo joined the IAEA through the Fellowship Programme from October 2010 until May 2011. The main objective of their fellowships was to receive training and support on non-electric applications of nuclear power for their contribution on the preparation of pre-feasibility studies for nuclear power plant projects in the country which are now in progress.

Mis. Dewita Erlan and Mr. Deddy Priambodo from BATAN

The fellowship focused on the technical aspects of nuclear power plant pre-feasibility study for Bangka Belitung island, an Indonesian province which already has deficit in electricity and water supply. Several nuclear desalination alternatives were evaluated considering large Pressurized Water Reactors, High Temperature Reactors and SMRs by focusing on economics using the recently released DEEP 4 and thermodynamic optimization of the coupled system using the new IAEA tool DE-TOP.

The Fellows reached significant conclusions on the competitiveness of nuclear desalination plants and the benefits of integrated power and water production. Appreciations are due to I. Khamis, K. Kavvadias, Ignacio Garcia Sanchez-Cervera, and other NPTDS Staff.

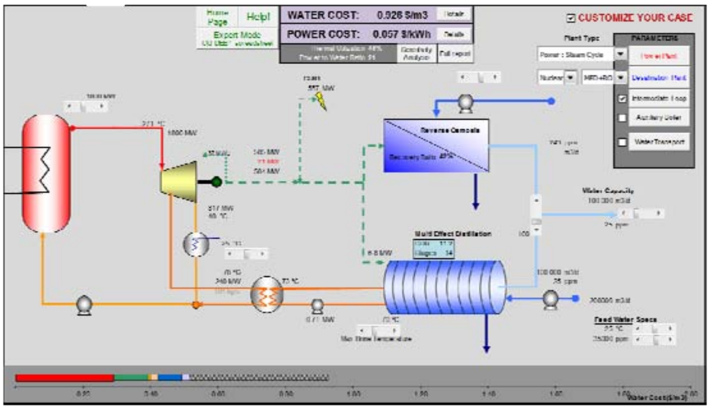
Highlights of IAEA Activities

Release of DEEP 4

The IAEA Desalination Economic Evaluation Program (DEEP) has been under continuous development in the last 10 years. DEEP models have been thoroughly reviewed/ updated and overall validity was examined and found very much accepted worldwide. The main use of DEEP is the quick identification of the lowest cost options for providing specified quantities of desalted water and/or power at a given location. DEEP is mainly used for:

- Preliminary economic evaluation of desalination by a wide range of fossil and nuclear energy sources, coupled to selected desalination technologies;
- Comparison of large number of different configurations and technologies on a consistent basis with common assumptions.

Despite the fact that DEEP is not a design code, it has been used worldwide for the economic evaluation of desalination plants coupled with various energy sources (nuclear or fossil fuelled) and different plant configurations (steam, gas or combined cycle) for site specific project feasibility analysis, what-if analysis or even for conceptual research studies.

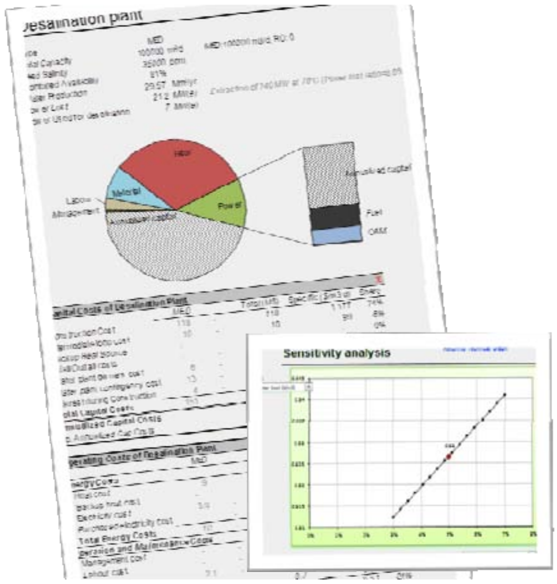


New DEEP 4 graphical interface

TDEEP software was updated constantly. Such updates included the user interface, model structure and the economic models. One of the most salient features of DEEP was the complete modularization of various cases. As the user group enlarged, new ideas as well as criticisms of the DEEP models appeared. Some of them were implemented gradually in different working versions. The previous continuous development culminated in the development of the DEEP 4.0 version, which was recently released in February 2011.

The DEEP main calculation sheet supports both nuclear and fossil power options. It considers heat and power plants as well as heat-only plants, distillation processes MSF and MED and membrane process reverse osmosis.

New features have also been added to DEEP 4.0, emphasizing its user friendliness and intuitiveness. They concern both new users and experts, as they facilitate the understanding of the desalination process, variables interactions and cogeneration benefits. Some of them are summarized below:



New DEEP 4.0 reporting features

- **Intuitive graphical user interface** containing all basic reference coupling schemes in a single unified template. The user interface is enhanced with helpful alert messages and intelligent error checking routines.
- **'On-the-fly' comparison of different technologies and configurations**. All parameters and factors can be modified instantly and users can quickly create their case and customize it step by step understanding the impact of their changes.
- **Versatile sensitivity analysis** to show the effect of important variables various economic and operating variables on the water cost and the performance of the dual power plant.
- **Automatic printable reporting** with enhanced charts, importing/exporting cases etc. Default parameters values have also been reviewed and updated in order to reflect the current state of affairs.

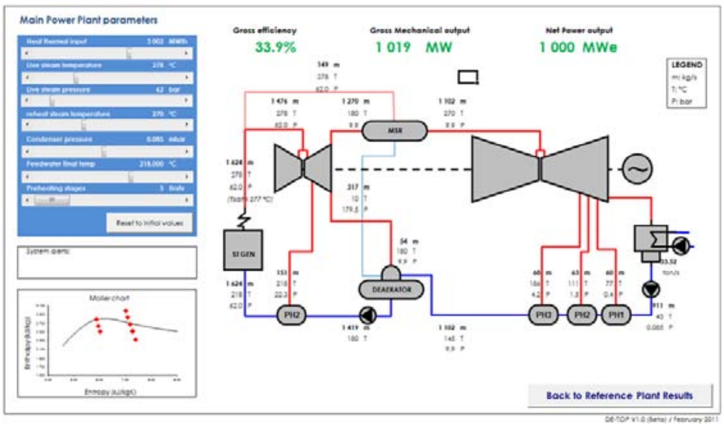
Download from: http:/www.iaea.org/nuclearpower/desalination

DE-TOP: New IAEA Tool for Nuclear Desalination

The coupling configuration between a desalination plant and the nuclear power plant not only entails technical and safety considerations but has a strong influence on the overall economics of a nuclear desalination system, therefore detailed thermodynamic model for the coupled system is of the main importance when assessing nuclear desalination. Addressing this issue, the IAEA recently released the Desalination Thermodynamic Optimization Program (DE-TOP), an excel based powerful tool that models generic water cooled reactors coupled with seawater desalination plants, and compares their performance for different configurations. DE-TOP is intended for educational and research purposes and along with DEEP provides a wider overview of nuclear desalination.

Power plant model and coupling arrangements

DE-TOP models the secondary loop of a nuclear power plant according to fundamental thermodynamic models. In order to simulate various types of power plants, main input parameters are introduced by the user: thermal capacity, live steam conditions, reheat pressure ratio, feedwater preheating conditions, isentropic efficiencies, etc. Site specific data, such as cooling water temperature, is also modelled as an input necessary to show the impact of ambient temperature to the performance of the dual-purpose plant. DE-TOP uses the input data to simulate the thermodynamic model of the power plant, solving all mass and energy flows using thermophysical properties which are calculated based on a built-in databank, such as temperature, pressure, specific enthalpy and entropy.



Graphical User Interface for the power plant model with DE-TOP

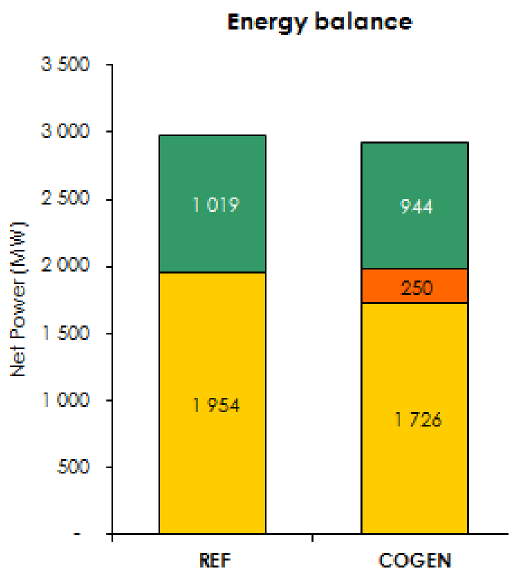
In dual-purpose water and power plants, steam has to be extracted from the power plant to deliver heat for the desalination process. Additional safety measures are required to prevent any potential carryover of the radioactivity from the secondary cycle to the desalination plant. Hence, an isolation loop is modelled between steam extraction and desalination plant.

DE-TOP simulates the following configurations for the coupled nuclear power and sea water desalination plant:

- Steam extraction from the low pressure turbine at the exact steam conditions required for the desalination process;
- Steam extraction from HP/LP crossover pipe and throttle to reach required conditions for desalination;
- Extraction from HP/LP crossover pipe and use of an additional backpressure turbine to reach required conditions for the desalination process;
- Low pressure turbine in backpressure operation mode.

Simulation of the coupled system and complete report

Once the model of the reference power plant is solved, and both the coupling configuration and heat requirements for the desalination process are defined. DE-TOP uses the output from the power plant simulation and the input from the user to estimate the performance of the designed cogeneration system, which is shown in a report with comparative results of the reference power plant and the dual purpose power and water plant.



DE-TOP report of energy flows for the single purpose nuclear power plant (REF) and the dual-purpose power plant and MED 100000 m^3/d desalination plant (COGEN). Waste heat to condenser shown in yellow, electrical output in green, heat to desalination in orange

Results benchmarking and conclusion

The DE-TOP model has been validated with different existing power plant data available in literature. Benchmarking results indicate that the relative error on energy and mass flow calculations do not exceed 2%. Therefore, this comparison shows satisfactory accuracy of DE-TOP and validity of its results for any kind of analysis. Hence, DE-TOP results can be used as an additional tool for improving judgement and overall knowledge of nuclear desalination and its attractiveness.

Download from: http:/www.iaea.org/nuclearpower/desalination

Internships on Non-Electric Applications of Nuclear Energy

Technical Assessment of Coupling Schemes

Under the supervision of Dr. I. Khamis, Sahak Margossian, BSc in nuclear engineering from the USA, is completing the last stages of his 12 month internship on non-electric applications in NENP/NPTDS. His main task was to assess the coupling strategies of nuclear cogeneration facilities. The assessment will likely be presented in the form of a light weight reference tool and documented in a future publication.

The reference tool being developed gives a basic overview of some coupling schemes available for different non-electric applications of nuclear facilities as well as providing some basic trends such applications follow. The information that will be presented in this tool was extrapolated from parameters and design characteristics of existing systems in an effort to bring actual operational experience to the member states interested in such facilities.

Sahak also maintained and updated the IAEA's Advanced Reactor Information System (ARIS)

Thermodynamic Analysis of Nuclear Desalination

Under the supervision of Dr. I. Khamis, Ignacio Garcia Sanchez-Cervera, MSc in mechanical engineering from Spain, has successfully completed his 7 month internship on nuclear desalination in the NENP/ NPTDS. His main tasks focused on analyzing thermodynamics and coupling configurations for nuclear power plants with thermal desalination processes.

The contribution of Mr Garcia Sanchez-Cervera within the Non-electric Applications Group was culminated with the release of DE-TOP, a new nuclear desalination tool already available in the IAEA's website. Along with this software release, Ignacio participated in several conferences and meetings as the CRP on New Technologies for Seawater Desalination Using Nuclear Energy and collaborated with the Indonesia's Fellowship programme, training the participants on the thermodynamic aspects of coupling water reactors with desalination plants.

Ignacio and Sahak acknowledge all NENP / NPTDS staff , especially Dr. Khamis for their continuous support and kindness throughout their Internship period.

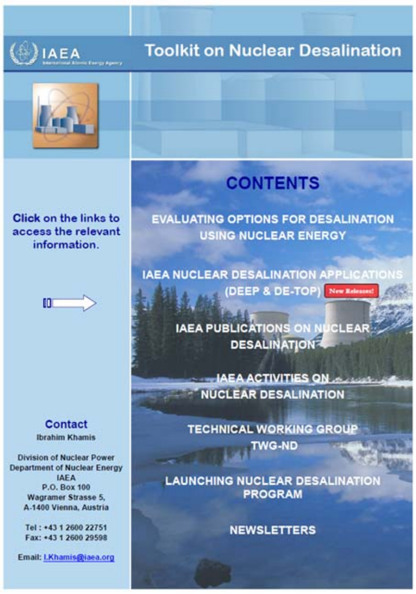
Nuclear Desalination Toolkit 2011

The IAEA Toolkit on Nuclear Desalination is an active document, freely available on the IAEA website, which collects all relevant information on the Agency's activities on nuclear desalination, including:

- DEEP and DE-TOP overview and homepage;
- Updated IAEA publications on nuclear desalination;
- Updated IAEA activities on nuclear desalination;
- Technical Working Group on Nuclear Desalination (TWG-ND, previously INDAG);
- Launching a nuclear desalination programme
- Newsletters on nuclear desalination.

Each page of the toolkit contains hyperlinks to all relevant documents. These documents are either available on the IAEA official website or from the toolkit directory prepared by the subscriber through consultation with the IAEA representative. Once officially released, the updated toolkit can either be downloaded directly from the IAEA website or distributed as a standalone compact disc or other sorts of data storage.

Future updates of the Toolkit may include an important tool for capacity building such as an integrated nuclear desalination simulation package which could combine the efforts of DEEP and DE-TOP with operational information to provide a comprehensive overview as well as some optimizations of various desalination schemes, investigate operational and transient events experienced by the desalination system, and address some safety issues resulting from the coupling of desalination systems to the nuclear power plant.



Latest update of the Nuclear Desalination toolkit

Technology and Economic Assessment of Nuclear Desalination

As the use of nuclear energy for the production of fresh water from seawater is of broad interest for many Member States, the IAEA has been frequently requested, through TC projects, to perform feasibility studies on nuclear desalination systems. Such studies involve the assessment of technology options and economic aspects of current and future systems of nuclear desalination. This support may be best addressed in part through information exchange of a technical forum.

The Technical Meeting on Technology and Economic Assessment of Nuclear Desalination, held on 1st March 2011 provided a forum for information exchange among Member States and the IAEA. On-going activities on important aspects of feasibility studies, technical and economic aspects of various desalination processes and coupling aspects between power and water desalination plants were presented. The meeting discussed some IAEA activities on nuclear desalination especially the IAEA recently released tools e.g. DEEP 4.0 and DE-TOP as well as future activities.

The objectives of the meeting were to exchange information on:

- Up to date technical and economic assessment of current and future nuclear desalination;
- Exchange information on best practices on technology and economic assessment of seawater desalination;
- Establish common criteria on methodology to conduct the technological and economic assessment of nuclear desalination systems;
- Strengthen national and regional infrastructures in interested Member States on nuclear desalination.

The following conclusions and recommendations were done:*

- The development of IAEA tools should be continued and finalized in the form of a complete nuclear desalination simulator.
- Participants recommended that training courses on DEEP4.0 and DE-TOP be organized by the IAEA.
- To maximize the usage of these and other IAEA tools, coordinated research projects or technical cooperation (TC) projects might be envisaged.
- Participants requested the IAEA to provide additional forums for exchange of feedback of experience during the commissioning and operation of Nuclear Desalination Demonstration Plants and collect all relevant data from the Member States involved in nuclear desalination demonstration projects, in particular on the measurements of radioactivity, tritium levels and other relevant information.
- Where possible, results of studies on the diffusivity of tritium across metallic barriers (e.g. SS316L, Inconel etc.) should be compiled.
- Existing or future information on the water for nuclear reactor cooling should be made available to the technical meeting participants.

PRIS: New Features for Non-electric Applications

The Power Reactor Information System (PRIS) is a comprehensive data source on nuclear power reactors worldwide. It includes specification and performance history data of operating reactors as well as reactors under construction or reactors being decommissioned. All operating nuclear power plants participate in the PRIS project and provide data regularly.

The PRIS database currently includes a minimal set of design characteristics for non-electric applications. These design characteristics provide basic insight into the steam extractions utilized or electricity consumption on a very basic level. Additions to these design characteristics are currently being implemented in PRIS to provide a detailed description of those existing reactors that are coupled with non-electric applications. These additions will provide a set of guidelines and basic rules of thumb to Member States considering pursuing a non-electric application for existing or future nuclear power plants.

In 2009, the new reporting system PRIS-STATISTICS was developed and implemented. This feature provides a possibility to easily generate both global and plant specific reports and graphs on nuclear energy status, performance and trends. Accompanying this system, the additional design characteristics which are to be implemented will provide decision makers with a solid foundation to decide what options for nuclear cogeneration may serve their needs best.

The PRIS website (http://www.iaea.org/pris) provides information for the public. It is one of the most frequented IAEA gateways.

* The views and recommendations expressed here are those of the meeting participants, and do not necessarily represent those of the IAEA.

Technical Working Group on Nuclear Desalination

Members of the Technical Working Group on Nuclear Desalination, 2011

The International Nuclear Desalination Advisory Group (INDAG), established by the IAEA in 1996, has contributed to promotion of nuclear desalination activities, and provided a forum for Member States to exchange information on the technological developments, operations, and demonstration of nuclear desalination systems. To enhance its functions, the IAEA has reformed INDAG into a Technical Working Group on Nuclear Desalination (TWG-ND) in 2008. The second meeting of the TWG-ND was held 27-28 April 2011 at the IAEA, in Vienna. The main objectives were to:

- Provide a forum for the exchange of information on nuclear desalination activities in Member States, identify important topics for discussion at SAGNE;
- Review the progress of and provide advice and guidance on the IAEA's activities in nuclear desalination;
- To provide advice on preparatory actions by Member States for implementing nuclear desalination demonstration projects.

The TWG-ND reiterated its support for IAEA activities in nuclear desalination and other non-electric applications. The following conclusions were reached:

- BARC (India) offered to provide training to interested Member States in nuclear desalination under the IAEA technical cooperation programme;
- SMRs are considered a suitable option to Member States with small grids, especially for easy deployment for cogeneration complexes;
- The TWG-ND congratulated the IAEA for the successful release of DEEP and DE-TOP;
- India and Pakistan offer to share their valuable experience in nuclear desalination to Member States.

Recommendations:*

- Emphasize the need to update and reference input data and relevant formulas in both DEEP and DE-TOP to reflect present day conditions and analyses.
- Enhance the scope of TWG-ND to address the challenges related to integrated water resource management in efficient use of water in nuclear facilities, which may involve use of water desalination.
- Organize and/or facilitate the organization of regional workshops and training in nuclear desalination as per request from Member States.
- In light of post Fukushima accident and the apparent need for on site freshwater for operational purposes, the IAEA is recommended to analyze use of nuclear desalination as an additional fresh water supply source for the nuclear power plants.
- Enhance communication with public on nuclear desalination possibly through increased contact with other international desalination workshops, conferences or networks.
- Emphasize the added value of nuclear energy through cogeneration aspects and co-products (e.g. biofuels, hydrogen production, district heating, high value chemicals, oil extraction/enhancement)
- Consider organizing a CRP on recovery of valuables from seawater desalination systems; i.e. discharge brine and seawater feed to enhance the economics and favourable environmental impacts of brine discharge.
- Finally, it was decided that the upcoming meeting of the TWG-ND can be accommodated along with the International Conference on Nuclear Desalination to be held in Barcelona in the 4th Quarter of 2012.

* The views and recommendations expressed here are those of the meeting participants, and do not necessarily represent those of the IAEA.

Selected List of IAEA Publications on Nuclear Desalination

Environmental Impact Assessment of Nuclear Desalination
(*IAEA-TECDOC–1642)*

Economics of Nuclear Desalination: New Developments and Site Specific Studies Final Report of a Coordinated Research Project 2002-2006
(*IAEA-TECDOC–1561)*

Advanced Applications of Water Cooled Nuclear Power Plants
(*IAEA-TECDOC–1584)*

Status of Nuclear Desalination in IAEA Member States
(*IAEA-TECDOC–1524)*

Optimization of the Coupling of Nuclear Reactors and Desalination Systems
(*IAEA-TECDOC–1444)*

Market Potential for Non-electric Applications of Nuclear Energy
(*Technical Reports Series No. 410)*

Design Concepts of Nuclear Desalination Plants
(*IAEA-TECDOC–1326)*

Safety Aspects of Nuclear Plants Coupled with Seawater Desalination Units
(*IAEA-TECDOC–1235)*

Introduction of Nuclear Desalination A Guidebook
(*Technical Reports Series No. 400)*

Examining the economics of seawater desalination using the DEEP code
(*IAEA-TECDOC–1186)*

Floating Nuclear Energy Plants for Seawater Desalination
(*IAEA-TECDOC–940)*

Potential for Nuclear Desalination as a Source of Low Cost Potable Water in North Africa
(*IAEA-TECDOC–917)*

Use of Nuclear Reactors for Seawater Desalination
(*IAEA-TECDOC–574)*

Guide to the Costing of Water from Nuclear Desalination Plants
(*Technical Reports Series No. 151)*

Storage and Transport of Water from Nuclear Desalination Plants
(*IAEA-TECDOC–141)*

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