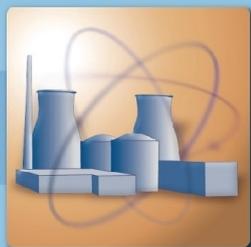




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Toolkit on Nuclear Desalination



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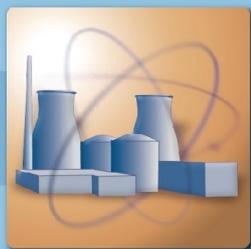
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**Ibrahim Khamis
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EVALUATING OPTIONS FOR DESALINATION USING NUCLEAR ENERGY

Options of Nuclear Energy For Seawater Desalination

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Desalination is an energy intensive process. Selection of the most appropriate desalination process depends on various factors including:

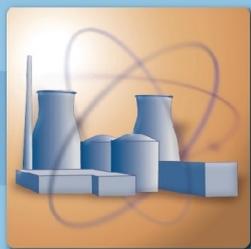
- Available water resources in terms of quantity and quality,
- Available energy resources including cost of energy (e.g. residual steam, waste heat, electricity),
- Optimum co-generation scheme with technical and economical considerations,
- Overall cost of distribution, cost for water transport and co-location,
- Plant capacity and expected availability,
- Siting of the plant including co-location option with nuclear power plant,
- Technology assessment including selection of materials for construction, equipment, plant life time, etc.,
- Safety of coupling and quality of product water, and
- Environmental impact assessment of the nuclear desalination plant.

Steps to launch a nuclear desalination project is more complicated than launching a typical desalination project, yet, in both cases, the above steps should be considered in details as they are prime elements of the technical and economic feasibility report.

To assist Member States on evaluating options for seawater desalination using nuclear power, the IAEA has released its DEEP and DE-TOP programs to enable performing economic, thermodynamic, and optimization analyses of different power resources coupled to various desalination processes. The IAEA also published several reports to highlight technical information on aspects of optimum coupling including some safety considerations, and has also published an environmental impact assessment of the process.

Current and future IAEA activities will focus on:

- ⇒ The assessment of new technologies which makes desalination using nuclear energy more attractive such as heat pipes as heat exchangers, low temperature desalination processes, and harvesting waste heat. This is made through the approved CRP on Application of Advanced Low Temperature Desalination Systems to Support Nuclear Power Plants and Non-electric Applications
- ⇒ Publish technical reports on important issues such as:
 - Cogeneration options for new nuclear installation
 - Technology assessment of seawater desalination using nuclear energy
 - Criteria and standards for the assessment of environmental impacts of seawater desalination using nuclear energy
 - Water management for efficient use in water cooled reactors
 - Continue the development of DEEP and other tools through various activities (please see [DEEP](#) and [DE-TOP](#) page).



IAEA Desalination Economic Evaluation Program (DEEP)



[Download DEEP](#)

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IAEA TOOLS ON NUCLEAR DESALINATION

DEEP software has been under continuing improvements through the last 15 years to respond to the need of performing a scoping analysis and economic comparisons and sensitivity analysis of various envisioned desalination systems using nuclear and conventional energy sources. DEEP 5.1, early 2015, adds some new features that enhance the economic analysis of desalination plants



- 2017 Release of DEEP 5.13
- 2016 Release of DEEP 5.12
- 2015 Release of DEEP 5.1 ([User's Manual](#))
- 2013 Release of DEEP 5
- 2011 Release of DEEP 4
- 2009 Review of Economic model in DEEP 3.2 ([Report, Paper](#))
- 2009 Benchmarking of DEEP 3.2 ([Expert's report](#)), (1 & 2)
- 2008 Update of DEEP 3.1 with Rankin cycle ([Expert's report](#))
- 2007 Update for DEEP 3.1 with water transport (1 & 2)
- 2006 DEEP 3.1 ([Draft Version of the DEEP 3.1 User's Manual](#))
- 2005 DEEP 3 ([Computer Manual Series No. 19: DEEP3.0 User's Manual](#))
- 2000 DEEP 2 ([DEEP 2 User Manual-Update](#))
- 2000 Examining the economics of seawater desalination using the DEEP code ([IAEA-TECDOC-1186](#))
- 2000 DEEP 1 ([Computer Manual Series No. 14: DEEP User's Manual](#))



IAEA PUBLICATIONS ON NUCLEAR DESALINATION

IAEA Publications on Nuclear Desalination

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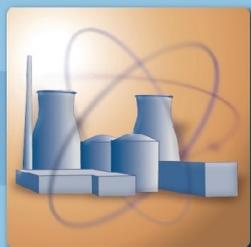
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The IAEA has published a long list of publications related to nuclear desalination including the following:

- ⇒ [New Technologies for Seawater Desalination Using Nuclear Energy \(IAEA-TECDOC-1753\)](#)
- ⇒ [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 \(Technical Reports-410\)](#)
- ⇒ [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 \(Technical Reports-400\)](#)
- ⇒ [Examining the economics of seawater desalination using the DEEP code \(IAEA-TECDOC-1186\)](#)
- ⇒ [Thermodynamic and economic evaluation of co-production plants for electricity and potable water \(IAEA-TECDOC-942\)](#)
- ⇒ [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 \(Technical Reports-151\)](#)



IAEA ACTIVITIES ON NUCLEAR DESALINATION (Coordinated Research Projects)

Coordinated Research Projects (CRPs) on Nuclear Desalination

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The IAEA has initiated several research coordinated projects CRP in the area of nuclear desalination which include:

Application of Advanced Low Temperature Desalination Systems to Support Nuclear Power Plants and Non-electric Applications ([1st Meeting Report](#)) ([2nd Meeting Report](#)) ([3rd Meeting Report](#))

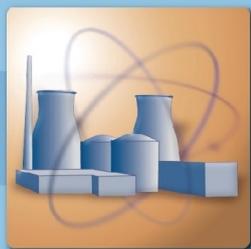
This CRP was concluded in 2017. It was planned on the basis of extensive feedback from many participants in Technical Meetings on non-electric applications and desalination technologies, and was further recommended by the Technical Working Group on Nuclear Desalination. The activities of the CRP was conducted over the years of 2014 to 2016 with successful outcomes as documented in the meeting reports. The participants to this CRP agreed that future nuclear power plants (NPPs) could be made more economical through cogeneration and waste heat recovery, as well as more accident proof through the introduction of low temperature (i.e. 40–50°C in some cases requiring a temperature gradient of 10°C) on-site desalination systems. Countries embarking on nuclear power could exploit the prospects of cogeneration and the use of waste heat from an NPP to increase the plant's overall efficiency and achieve better energy utilization. Simultaneously, NPPs' vulnerability to water shortage (e.g. in case of an accident or terrorist attacks) can be further reduced through the introduction of advanced technologies for low temperature desalination, specifically the distillation processes with utilization of waste heat or any other innovative means which allow for the production of necessary quantities of fresh water to meet on-site NPP requirements and make the plant more secure against external threats.

New Technologies for Seawater Desalination Using Nuclear Energy ([IAEA-TECDOC-1753](#))

The focus of this CRP was on introducing the innovative technologies which may help making nuclear desalination more safe and economical. The new technologies are expected to enhance harvesting nuclear reactors waste heat (i.e. waste heat from the condenser of water cooled reactors, or from the pre-cooler and inter-cooler of High Temperature Gas Reactors HTGR) and utilize it for sea water desalination. New technologies may involve technologies related to the desalination processes such as Low Temperature-Horizontal Tube Multi-Effect Distillation *LT-HT MED*, others related to the efficient and maximizing heat recovery systems such as *heat pipes*, or the optimization of *coupling configuration* between nuclear reactors and desalination systems. Additional dimensions of the CRP are to analyze the *economics* of cogeneration systems (i.e. electricity and water production), and improve the IAEA *DEEP* software. The results help R&D in nuclear desalination, and assist developing countries interested in nuclear programmes to master applications of nuclear energy for desalination and cogeneration.

Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies ([IAEA-TECDOC-1561](#))

The scope of this CRP was to enable Member States to dispose of precise and well validated methods for desalination cost evaluations and to contribute to the IAEA's efforts to enhance prospects of demonstration and eventually for the successful implementation of nuclear desalination plants in Member States. Techno-economic feasibility studies were carried out for specific sites in the nine Member States participating in this CRP. Some of the new developments, aiming to reduce desalted water costs, have also been discussed. Results achieved were site specific and dependent on several factors and the economic assumptions used.



TECHNICAL WORKING GROUP ON NUCLEAR DESALINATION

Technical Working Group on Nuclear Desalination

TWG-ND

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In line with the efforts to unify and update the [Terms of Reference](#) for the Technical Working Groups in the Department of Nuclear Energy at the IAEA, 'International Nuclear Desalination Advisory Group' (INDAG) was renamed to the 'Technical Working Group on Nuclear Desalination' (TWG-ND).

The functions of the TWG-ND are listed below:

- Provide advice and guidance, and to marshal support in their countries for implementation of the IAEA's programmatic activities in the area of nuclear seawater desalination;
- Provide a forum for information and knowledge sharing on national and international programmes development in the area of nuclear desalination;
- Act as a link between the IAEA's activities in specific areas and national scientific communities, delivering information to and from national communities;
- Provide advice on preparatory actions in Member States and the IAEA's activities in planning and implementing coordinated research programmes, collaborative assessments and other activities as well as the review of the results on nuclear desalination demonstration projects;
- Develop and/or review selected documents from the Nuclear Energy Series, assess existing gaps and advise on preparation of new ones, in the scope of their field of activity;
- Identify important topics for discussion at SAGNE and contribute to status reports, technical meetings and topical conferences in the field of nuclear desalination;
- Encourage participation of young professionals, as appropriate, in IAEA activities.

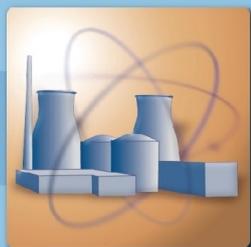
The TWG-ND normally meets every 16~18 months at IAEA Headquarters. It may meet from time to time away from IAEA Headquarters to familiarize itself with activities in a Member State. Special arrangements will be made to provide secretariat services for such a meeting in cooperation with the host Member State.

The Deputy Director General may invite international or regional organizations that have an interest in the field of this TWG to be represented at meetings of the TWG or at particular sessions during such meetings. Meetings will be conducted in English only.



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TWG-ND MEETING REPORTS

Technical Working Group on Nuclear Desalination

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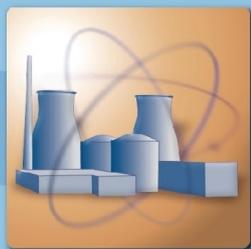
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TWG-ND Membership

Members of the TWG on Nuclear Desalination shall be appointed by the Deputy Director General, Department of Nuclear Energy, following consultation with the respective national authorities or organizations.

Members of the TWG-ND:

- Shall be recognized experts in nuclear seawater desalination having extensive links with national technical communities;
- Are to serve for a standard length of four years;
- Shall participate in the Group in their personal capacity and shall provide as appropriate views on national policies and strategies in the technical field;
- May bring experts to provide additional information and share experience in the meetings of the TWG-ND if appropriate.



LAUNCHING NUCLEAR DESALINATION PROGRAMME

Towards Launching New Nuclear Energy Based Desalination Programme

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Launching a nuclear desalination programme is similar to a nuclear power plant programme. It is an undertaking that requires careful planning, preparation and investment in a sustainable programme.

The implementation of a nuclear desalination programme involves several complex and interrelated activities. The IAEA has published various publications to assist Member States on how to proceed with such a nuclear power programme. Some of these publications can be tracked in other IAEA web sites (see links below).

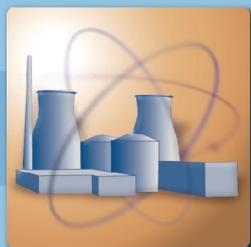
Some publications of interest to launching a nuclear desalination programme are:

- ⇒ Basic Infrastructure for a Nuclear Power Project ([IAEA-TECDOC-1513](#))
- ⇒ Milestones in the Development of a National Infrastructure for Nuclear Power ([IAEA Nuclear Energy Series No. NG-G-3.1, IAEA, Vienna \(2007\)](#))
- ⇒ Managing the First Nuclear Power Plant Project ([IAEA-TECDOC-1555](#))
- ⇒ Evaluation of the Status of National Nuclear Infrastructure Development ([IAEA Nuclear Energy-NG-T-3.2](#))
- ⇒ Site Survey for Nuclear Power Plants ([Safety-50-SG-S9](#))
- ⇒ Commissioning of Nuclear Power Plants: Training and Human Resource Considerations ([IAEA Nuclear Energy-NG-T-2.2](#))
- ⇒ Construction and Commissioning Experience of Evolutionary Water Cooled Nuclear Power Plants ([IAEA-TECDOC-390](#))
- ⇒ Safety Aspects of Nuclear Plants Coupled with Seawater Desalination Units ([IAEA-TECDOC-1235](#))
- ⇒ Technical Report Series ([Access](#))



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NUCLEAR DESALINATION NEWSLETTER

[Newsletter](#)

The TWG-ND publishes regular newsletters on global desalination activities using Nuclear Power.

Issues of the Nuclear Desalination Newsletter starting from 2001 to 2011 and the updated Latest News since 2011 can be accessed through the following list:

[Nuclear Desalination Newsletter No. 2, Sept. 2011](#)

[Nuclear Desalination Newsletter No. 2, Sept. 2010](#)

[Nuclear Desalination Newsletter No. 1, Sept. 2009](#)

[INDAG Newsletter No. 8, September 2008](#)

[INDAG Newsletter No. 7, September 2007](#)

[INDAG Newsletter No. 6, September 2006](#)

[INDAG Newsletter No. 5, September 2005](#)

[INDAG Newsletter No. 4, September 2004](#)

[INDAG Newsletter No. 3, September 2003](#)

[INDAG Newsletter No. 2, September 2002](#)

[INDAG Newsletter No. 1, September 2001](#)

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