IAEA Activities on Nuclear Desalination

I. Khamis

Department of Nuclear Energy, IAEA

Contents

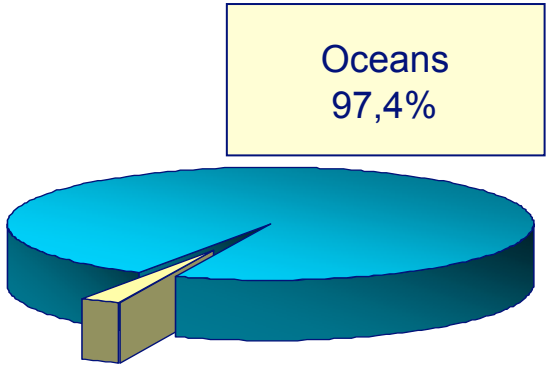
- Introduction to nuclear desalination
- Summary of IAEA activities
- Nuclear desalination in Member States
- Conclusion

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities
- Nuclear desalination in Member States
- Conclusion

Water resources

- **Water covers the planet: water resources: 1,3 x 10^{18} m^3**
- **Only 0,007% of all water on earth is available to drink**
- **Water resources are unevenly distributed**
  (60% in less than 10 countries)
- **By mid-century 3 billions of people will not have adequate water for consumption**
- **Sustainable solution: SEAWATER DESALINATION**



Seawater desalination

- There are about 20 000 desalination plants in the world, producing about 50 million m^3 of water daily, enough to supply over 250 million people

- Desalination plants:
  - Large consumers of energy
  - Discharge large amounts of carbon dioxide into the atmosphere

Nuclear desalination

can be a sustainable alternative

- Waste heat and electricity produced by nuclear plants are ideal for energy-intensive desalination processes.
- "Clean" energy and minimal waste.
- Economically competitive with conventional co-production plants, especially when a strong national grid exists and interest rates are low.
- Many years of successful operation have proved technical feasibility and reliability.

Nuclear desalination

The production of potable water from seawater (or brackish water) in a facility in which a nuclear reactor is used as the source of energy for the desalination process.

Nuclear desalination

Can accommodate/use:

- ***All desalination technologies*** **(currently in use for desalination require significant amounts of energy, either as low-temperature process heat or electricity)**

- ***All nuclear power plants*** **to provide residual heat, low temperature steam, and electricity**

Main advantages of nuclear desalination

- Sustainability: Nuclear is more compatible with sustainable development than fossil fuel.
- Easy adaptation for various desalination processes: Nuclear reactors provide heat at various temperatures.
- Could be for “free”: Some nuclear reactors produce waste heat at ideal temperatures for desalination.

Prospects for Nuclear desalination

- Economic competitiveness especially *in areas without water or fossil*
- Diversification of energy supply
- Fossil fuels resource preservation
- Environmental protection, preventing polluting and greenhouse gases emissions
- Synergetic effects of nuclear technology for industrial developments

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities
  - TWG-ND
- Nuclear desalination in Member States
- Conclusion

IAEA & nuclear desalination (ND)

- In 1989, Member States expressed their interest in nuclear energy for seawater desalination at the IAEA General Conference.

- This interest is continuously emphasized by Member States.

Objective of IAEA:

Capacity building and information exchange on nuclear desalination.

Advices to IAEA on ND : **TWG-ND (INDAG)**

Technical Working Group on Nuclear Desalination (TWG-ND)

- 1997 : In order to provide the IAEA with advice and guidance for fulfilling General Conference resolutions on activities in nuclear seawater desalination, the **International Nuclear Desalination Advisory Group** (INDAG) was established.

- 2009: TWG-ND

Current TWG-ND members

ALGERIA	INDIA	SPAIN
ARGENTINA	INONESIA	SOUTH AFRICA
CHINA	KUWAIT	USA
CUBA	LIBYAN ARAB AMAHIRIYA	
EGYPT	MOROCCO	
FRANCE	PAKISTAN	
GERMANY	RUSSIAN FEDERATION	IAEA (Scientific Secretary): *I. Khamis , NENP*
	SAUDI ARABIA	

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities:
  - CRPs
- Nuclear desalination in Member States
- Conclusion

IAEA Coordinated Research Projects (CRP)

CRP: **Optimization of the Coupling of Nuclear Reactors and Desalination Systems**. 1998-2003.

- It encompassed research and development programmes in the interested Member States pursuing coupling of nuclear reactors with desalination systems in the following fields:
- Nuclear reactor design,
- Optimization of thermal coupling,
- Performance improvement of desalination systems
- Prospects of advanced desalination technologies for the application of nuclear desalination.
- The results of this CRP were published as IAEA-TECDOC-1444 (2005)

Coordinated Research Projects

CRP: **Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies**"

- Launched in 2002 on and completed in 2006
- It is to contribute to the IAEA's efforts to enhance prospects for the demonstration, and eventually, for the successful implementation of nuclear desalination in Member States.
- The objective of the CRP is;
  - To evaluate economic aspects and to investigate the competitiveness of nuclear desalination under specific conditions
  - To identify innovative techniques leading to further cost reduction of nuclear desalination and to refine economic assessment methods and tools.
- The results of this CRP were published as IAEA-TECDOC-1561 (2007)

Coordinated Research Projects

CRP: **Advances in Nuclear Process Heat Applications**"

- It is to contribute to the IAEA's efforts to investigate the prospects of using waste heat generated in High Temperature Reactors.
- The objective of the CRP is;
  - To evaluate the potential of all advanced reactor designs in process heat applications.
- The CRP is launched in 2007, expected to be completed in 2009

Coordinated Research Projects

A new CRP in 2009 on

"New Technologies for Seawater Desalination using Nuclear Energy"

- The CRP will help support R&D in nuclear desalination technologies with the aim of producing large amounts of desalted water at the lowest possible cost and in a sustainable manner, and assist developing countries interested in nuclear programmes to master applications of nuclear energy for seawater desalination and cogeneration option.

- The objective of the CRP is;
  - To introduce innovative technologies which may help making nuclear desalination more safe and economical.
- The first meeting CRP will be 27-28 Oct 2009

Coordinated Research Programme by IAEA

New technologies for seawater desalination using nuclear energy

- For more information on the CRP, please visit: http://www-crp.iaea.org/html/rifa-show-approvedcrp.asp

- To apply, submit your proposal is available on: http://www-crp.iaea.org/html/forms.html

Countries Participating in previous CRPs

CRP Code	CRP Title	Period	Participating Countries
I3 5001	Optimization of the Coupling of Nuclear Reactors and Desalination Systems	1998-2003	Argentina, Canada, China, Egypt, India, Indonesia, Rep. of Korea, Libya, Morocco, Russian Federation and Tunisia.
I3 5002	Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies	2002-2006	Argentina, Canada, China, Egypt, France, India, Rep. of Korea, Pakistan, Russian Federation, Syria, USA.

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities:
  - Technical cooperation (TC)
- Nuclear desalination in Member States
- Conclusion

Technical Cooperation (TC)
Projects on Nuclear Desalination 1997-2004

Project Code	Project Title	Year of Approval	Total Budget (USD)	Status
MOR/4012	Pre-Project Study for Nuclear Desalination	1995	214,381	Completed 2000
EGY/4040	Feasibility of Nuclear Power & Desalination on El-Debaa Site	1999	153,084	Completed 2002
RAF/4013	Sea Water Desalination Using Nuclear Energy	1997	83,325	Completed 2000
INT/4134	Integrated Nuclear Power and Desalination System Design	1999	510,406	Completed 2004
EGY/4046	Simulation of Nuclear Desalination Plant	2001	162,850	Completed 2005

ALG/4046	Feasibility study	2006		
EGY/4051	Simulator for ND plant	2007		
JOR/4005	Feasibility study	2007		
LIB/4010	Simulation	2005		
PAK/4045	Training on ND	2005		
UAE/4002	Feasibility study	2005		

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities:
  - Establish Forums for information exchange
- Nuclear desalination in Member States
- Conclusion

ICTP Workshops on Nuclear Desalination and Economics

- **Workshop on "Technologies for Desalination" and "Desalination Economic Evaluation Programme (DEEP)" from 23 April to 4 May 2001, at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy.**

- **Workshop on "Nuclear Desalination Technology and Economics" (Part I – "Nuclear Desalination Technology" and Part II – "Desalination Economic Evaluation") from 24 March to 4 April 2003, at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy.**

- **Training Course on Desalination System Modeling-Technology & Economics is planned for April 2006 at ICTP, Trieste.**

International Symposium on Nuclear Desalination

- An international Symposium on "Desalination of Seawater with Nuclear Energy" was held in May 1997 in Taejon, Republic of Korea. It was hosted by Korea Atomic Energy Research Institute.
- The Agency cooperated in organising the International Conference on Nuclear Desalination- Challenges and Options at Marrakech in October 2002. It was held jointly by World Council of Nuclear workers and Moroccan Association of Nuclear Engineers.
- An International Conference on Non-electrical Application of Nuclear Power was held in April 2007 in Japan. It was hosted by Japan Atomic Energy Agency.

IAEA Web page on Nuclear Desalination

A Web page on Nuclear Desalination has been set up and a Business Collaborator is used for uploading and downloading the relevant reports and information by Member States.

http://www.iaea.org/nucleardesalination

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities:
  - Publications
- Nuclear desalination in Member States
- Conclusion

Publications TECDOCs

- Optimization of the coupling of nuclear reactors and desalination systems, IAEA-TECDOC-1444, Vienna (2005)
- The IAEA power reactor information system-PRIS and its extension to non-electrical application, decommissioning and delayed projects information, IAEA-TRS-428, Vienna (2005)
- Innovative small and medium sized reactors: Design features, safety approaches and R & D trends, IAEA-TECDOC-1451, Vienna (2005)
- Considerations in the development of safety requirements for innovative reactors: Application of HTGCR, IAEA TECDOC-1366, Vienna (2003)
- Status of design concepts of nuclear desalination plants, IAEA TECDOC-1326, Vienna (2002)
- Safety aspects of nuclear plants coupled with seawater desalination units, IAEA TECDOC-1235, Vienna (2001)
- Status of Non-Electric Nuclear Heat Applications: Technology and Safety IAEA TECDOC-1184, Vienna (2000)
- Guidance for Preparing User's Requirements Documents for Small and Medium Reactors and their Applications, IAEA TECDOC-1167, Vienna (2000)
- Examining the Economics of Seawater Desalination using DEEP Code, IAEA TECDOC-1186, Vienna (2000)
- Nuclear Heat Applications: Design aspects and operating experience, IAEA TECDOC-1056, Vienna (1998)
- Options Identification Programme for Demonstration of Nuclear Desalination, IAEA TECDOC-898 (in Arabic), Vienna (1998)

Recent publications

- A Status Report on Nuclear Desalination Activities in the Member States was published as IAEA-TECDOC-1524 (2007)
- The results of the CRP on Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies were published as IAEA-TECDOC-1561 (2007)
- INDAG Newsletter No. 7 – Sept. 2007, 2008
- Proceedings of the **International Conference on Non Electric Applications of Nuclear Energy:** Nuclear Desalination, Hydrogen Production, and other industrial Applications. Oarai, Japan 16-19 April 2007, under printing

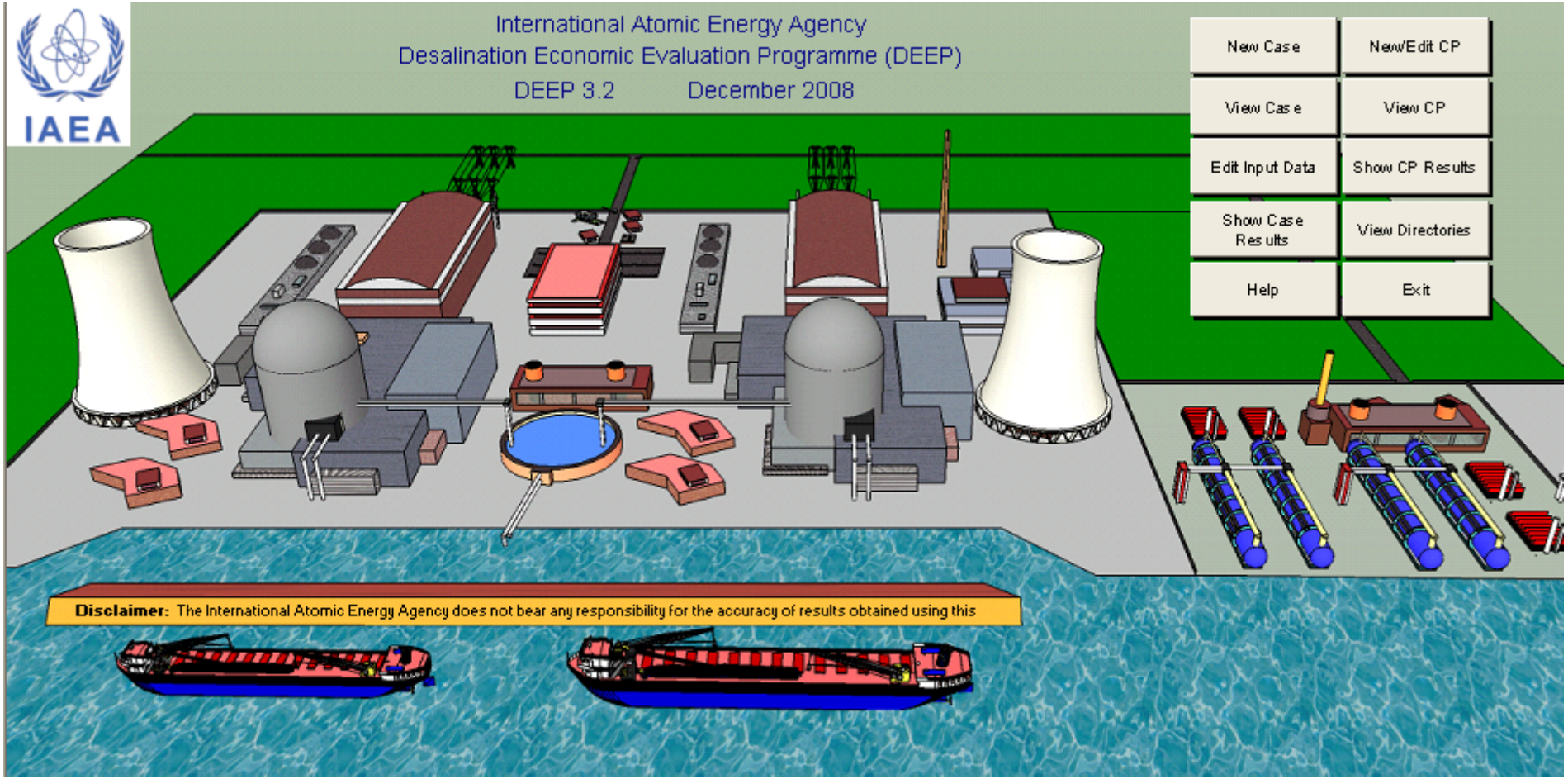
New publication: TECDOC on Environmental aspects

- CHAPTER 1 ***INTRODUCTION***
- 1.1. Worldwide water situation
- 1.2. Worldwide desalination capacity
- 1.3. Importance and potential of nuclear desalination (*including IAEA's role in ND*)
- 1.4. Scope and objectives
- 1.5. Outline of the report
- CHAPTER 1 ***EXPERIENCE AND SPECIFICS OF NUCLEAR DESALINATION***
- 1.1. Experience with nuclear power
- 1.2. Advantages of nuclear power as energy source for desalination
- 1.3. Experience with nuclear desalination (*Cases from Kazakhstan, India, Japan and USA*)
- 1.4. Quality of the product water from nuclear desalination (*Tritium migration – regulations, sources, pathways, impacts, mitigation and experiences so far*)
- CHAPTER 2 ***ENVIRONMENTAL IMPACTS OF NUCLEAR DESALINATION***
- 2.1. Impacts on the marine environment (S*eawater intakes and discharge disposal regulations, designs, pathways, impacts, mitigation*)
- 2.2. Impacts on the coast (*Construction, land use, noise and visual impacts*)
- 2.3 Impacts on the atmosphere (*Nuclear power impact compared with other energy sources*)
- 2.4. Impacts of siting and co-location (*Transport, environmental issues and considerations*)
- 2.5. Conclusions
- CHAPTER 3 ***SOCIO-ECONOMIC IMPACTS OF NUCLEAR DESALINATION***
- 3.1. Social impacts (*water use, development issues and environmental justice*)
- 3.2. Economic impacts (*cost of desalination, effects of water and power availability*)
- 3.3. Public acceptance (*Influencing factors, experience and expectations for future plants*)
- 3.4. Conclusions
- CHAPTER 4 ***CHALLENGES TO NUCLEAR DESALINATION***
- 4.1. Challenges and issues of nuclear power (*introducing NP, small and medium size reactors)*
- 4.2. Preconditions for nuclear desalination
- ANNEX
- A.1. Nuclear desalination technologies (*desalination processes, coupling schemes, cooling schemes)*
- A.2. Methodology for impacts on the marine environment (*entrainment, impingement, discharge*)

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities:
  - Desalination Economic Evaluation Programme (DEEP)
- Nuclear desalination in Member States
- Conclusion

New Version of DEEP



DEEP

- Historical Background of DEEP development and updates:
- 1997: Methodology for the Economic Evaluation of Cogeneration/ Desalination Options: A User's Manual (No.12)
- 2000: DEEP-1 (Computer Manual Series No. 14: DEEP User's Manual)
- 2000: Examining the economics of seawater desalination using the DEEP code (IAEA-TECDOC-1186)
- 2000: DEEP-2 (Click here for DEEP 2 User Manual)
- 2005: DEEP-3 (Computer Manual Series No. 19: DEEP3.0 User's Manual)
- 2006: DEEP-3.1 (Draft Version of the DEEP 3.1 User Manual)
- 2007: Update of DEEP 3.1 with water transport (Expert's report)
- 2008: Update of DEEP 3.1 with Rankin cycle (Expert's report)
- 2009: Update of DEEP 3.2 (Expert's report)
- 2009: Benchmarking of DEEP 1 (Expert's report)

Contents

- Introduction to nuclear desalination
- Summary of IAEA activities:
  - Toolkit on nuclear desalination
- Nuclear desalination in Member States
- Conclusion

Toolkit on Nuclear Desalination

- DEEP
- How to launch a nuclear desalination programme
- IAEA Publications on Nuclear Desalination
- IAEA Activities on Nuclear Desalination
- Activities of the TWG-ND
- Newsletter on nuclear desalination

Nuclear desalination in Member States

Nuclear Desalination Experience

- Experience in nuclear desalination has been gained in Kazakhstan, Japan, India and Pakistan

- Experience with nuclear desalination
  - Number of reactors: 13
  - Number of countries with experience: 4
  - Experience in reactor-years: 247

Demonstration Projects in Member States (1)

- India: the 6,300 m^3/d MSF-RO Hybrid Nuclear Desalination Plant at Kalpakkam, India, consists of 4,500 m^3/d MSF plant (just commissioned) and 1,800 m^3/d SWRO plant (2002).
- Pakistan: construction is underway for MED thermal desalination demonstration plant of capacity up to 4,500 m^3/d at KANUPP.

Demonstration Projects in Member States (2)

- The Republic of Korea: a co-generating integral type reactor SMART combined with a multi-effect distillation (MED) plant producing 40,000 m^3/d of fresh water.
- Russia; Construction of a Floating Power Unit (FPU) pilot plant with KLT-40C reactors started 2007.

The IAEA activities on Nuclear Desalination in 2009

- TM on non electric applications, Taejon Korea, 3-6 March 2009.
- TM for the TWG-ND 8-10 June 2009
- 3ed RCM on CRP" Advances in nuclear power process heat applications", 1-3 July 2009.
- **Consultancy meeting** on ND technologies info Exchange 28-30 July
- Training workshop on " Technology and performance of desalination systems, Trieste Italy, 11-15 May 2009
- 1st RCM on CRP" New Technologies for seawater desalination using nuclear energy", 27-28 Oct 2009, Vienna

Conclusion

You are invited to participate in all IAEA activities on nuclear desalination

…Thank you for your attention

International Atomic Energy Agency