united nations
educational, scientific
and cultural
organization

international atomic
energy agency

the
abdus salam
international centre for theoretical physics

SMR/1314-2

WORKSHOP ON

TECHNOLOGIES FOR DESALINATION

23 - 27 April 2001

Miramare - Trieste, Italy

in co-operation with

The International Atomic Energy Agency (IAEA)

and

the Kuwait Foundation for the Advancement of Sciences (KFAS)

Nuclear Seawter Desalination Activities of the IAEA

Peter J. Gowin

International Atomic Energy Agency
Vienna, Austria

Nuclear Seawater Desalination Activities of the IAEA

P.J. Gowin
International Atomic Energy Agency

International Atomic Energy Agency

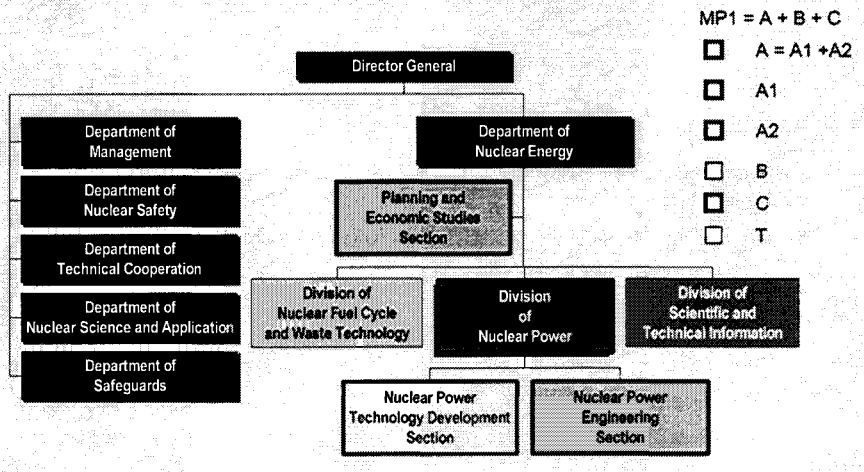
- Independent Organization within the UN system
  - Safety
  - Safeguards
  - Technology
- Division of Nuclear Power
  - Nuclear Seawater Desalination
- Isotope Hydrology

Statute of the IAEA

The Statute of the IAEA includes the following functions:

- *"To encourage and assist research on, and development and practical application of, atomic energy for peaceful uses throughout the world"*(under Article III-A.1), and,
- *"To foster the exchange of scientific and technical information on peaceful uses of atomic energy"* (under Article III-A.3).

Nuclear Power Technology Development Section



Programme A

Specific Objective

- *"To assist Member States, at their request, in planning and implementing programmes for the utilzation of nuclear power, as well as to support Member States in achieving improved safety, reliability and economic cost effectiveness of their nuclear power plants by promoting advanced engineering and technology, training, quality assurance and infrastructure modernization".*

Scope of NPTDS

A.201: Small and Medium Sized Reactor (SMR) Development

A.202: Advanced Technologies for Water Cooled Reactors

A.203: Nuclear Systems for Utilization and Transmutation of Actinides and Long-Lived Fission ProductsA.204: Gas Cooled Reactors

A.204: Nuclear Desalination

A2.05: Support to Technical Cooperation Activities

Member States Needs

- Balanced and objective up to date information on nuclear power technology development programmes and projects in Member States;
- Improved direct contracts between research institutes that are addressing same areas to identify development needs and development trends;
- Umbrella to provide for pooling of resources and expertise;
- Guidance and training in specific aspects of nuclear power.

Target Groups

- Governments
- Industries
- Utilities
- Universities
- National laboratories
- Research institutes

Funding Trends ($1000)

Year		1997	1998	1999	2000	2001*
Project	Renumbered in 2001	Budget $K	Budget $K	Budget $K	Budget $K	Budget $K
A.2.01 and .2.04	A.2.01	492	438	465	457	484**
A.2.02 and .2.05	A.2.02	675	576	612	522	542**
A.2.03 and .2.07	A.2.03	377	377	411	439	464**
A.2.06	A.2.04	481	427	375	384	405**
A.2.08	A.2.05	65	65	70	76	70
Total		1,990	1,883	1,915	1,878	1,965

* Preliminary figures

** Includes $20,000 extra assigned overhead costs

Technical Working Groups

Standing advisory groups **with nominations by Governments:**

- International (Technical) Working Groups (IWGs)
- International Nuclear Desalination Advisory Group (INDAG),

These Groups

- provide for a review of relevant programmes and projects in Member States
- recommend activities to the Agency
- ensure that the proposed activities are supported by the necessary resources in their countries.

- Other international organisations, such as the European Commission and the OECD Nuclear Energy Agency, are also invited to send representatives to the IWG and INDAG meetings.

Target Groups

- ***Symposia;***
- ***Technical Committee Meetings;***
- ***Preparation and distribution of Status Reports;***
- ***Coordinated Research Projects;***
- ***Research Co-ordination Meetings;***
- ***Consultancies and Advisory Group Meetings;***
- ***Workshops***
- ***Publications (IAEA TECDOCs, papers at conferences and in journals).***

Role of Nuclear Energy

- 16% of global electricity
- Fossil versus Nuclear
  - Fossil:
    - Continued use of fossil is not sustainable (GHG).
    - Coal: 200 years, Oil: 40 years.
    - Renewables: 5-8% share (WEC).
  - Nuclear:
    - GHG free, no toxic emissions, supply secured.
    - Financing difficult.
    - Passive safety concepts with IAEA assistance.

Nuclear Desalination

- Production of Potable Water using Nuclear Energy
  - Co-location of the plants
  - Nuclear heat or electricity
  - Sharing of facilities and services

Recent IAEA Studies (1 OF 4)

- Several studies between 1964 and 1968.
- Member States requested renewal of activities in 1989.
- Continued support, especially from

Morocco	Egypt
China	India
Republic of Korea	Canada
France	
Russia	

Recent IAEA Studies

(2 OF 4)

- Overview and technical background:
  - *Use of Nuclear Reactors for Seawater Desalination* (1990).
  - *Technical and Economic Evaluation of Potable Water Production through Desalination of Seawater by Using Nuclear Energy* (1992).
- Technically feasible
- Economically competitive

Recent IAEA Studies

(3 OF 4)

- Concrete Steps
  - Potential for Nuclear Desalination as a Source of Low Cost Potable Water in North Africa, 1996
  - Options Identification Programme for Demonstration of Nuclear Desalination, 1996
- Symposium on "Desalination of Seawater with Nuclear Energy"
  - Jointly with IDA; May 1997, Korea
  - 250 participants from 31 countries

Recent IAEA Studies

(4 OF 4)

- Nuclear Heat Applications: Design Aspects and Operating Experience (1998)
  - Proceedings of four technical Meetings
- User Requirements for SMR in Developing Countries
  - Annex I: Indonesia
  - Annex II: Specific Aspects for Nuclear Desalination
- Status of Non-Electric Nuclear Heat Applications: Technology and Safety
- Examining the Economics of Nuclear Desalination using the DEEP Code (2000)

Reactors and Options

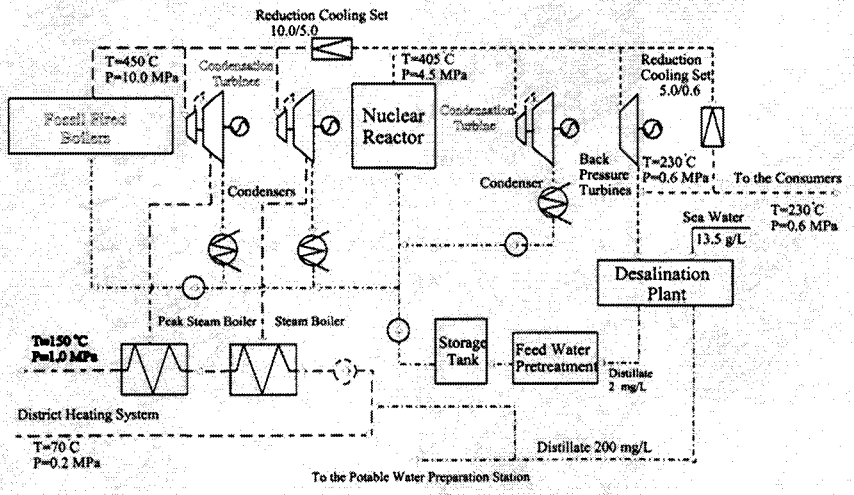
- Use of electricity or heat or both.
- Almost all types suitable.
- Advantages:
  - base load operation for both nuclear and desalination plant
  - low working temperatures
  - Cogeneration: fit to the grid
  - No grid: small units, barge mounted plants

National Experience

(1 OF 3)

- Nuclear Desalination: experience of 80 r.yrs
  District Heating: experience of 500 r.yrs
- Aktau, Kazakstan
  - Continued operation since 1973
  - about 80,000 m^3/d.

Aktau Complex in Kazakhstan



National Experience

(2 OF 3)

- Japan
  - About 10 NPPs
  - for internal plant use: 1,000 to 3,000 m^3/d each.
- Israel
  - Simulation of Nuclear Desalination using fossil steam
  - Operation stopped

National Experience

(3 OF 3)

Country	Plant	Location	Start of Service Reactors (Desal.)	Combination	Power (MWe)	Water (m3/d)
Japan	Ikata-1/2	Ehime	1977-82 (75)	PWR/MSF	566	2,000
Japan	Ikata-3	Ehime	1994 (92)	PWR/RO	566	2x1,000
Japan	Chi-1/2	Fukui	1979 (73-76)	PWR/MSF	2x1175	3x1,300
Japan	Chi-3/4	Fukui	1991-93 (90)	PWR/RO	2x1180	2x1,300
Japan	Genkai-4	Fukuoka	1997 (88)	PWR/RO	1180	1,000
Japan	Genkai-3/4	Fukuoka	1995-97 (92)	PWR/MED	2x1180	1,000
Japan	Takahama	Fukui	1985 (83)	PWR/RO	870	1,000
Japan	Kashiwazaki-1	Niigata	1985 (not served)	BWR/MSF	1100	1,000
Kazakhstan	BN-350	Aktau	1973 (ca.63)	FBR/MED,MSF also district and industrial heat	120	120,000
USA	Diablo Canyon-1/2	San Louis Obispo	1985-86 (85)	PWR/2 stage RO	2x1100	2,200

Activities in Member States (1 OF 3)

- Morocco - China
  - Feasibility study for 8000 m^3/d using a Chinese 10 MW_{th} heating reactor.
  - Assessment of 140,000 m^3/d with 200 MW_{th} heating reactor.
- Egypt
  - Assessment of nuclear desalination together with 1st NPP in El-Dabaa.

Activities in Member States (2)

- Argentina
  - Project to implement a CAREM reactor, 25 MW_{el}, coupled to RO
- Canada
  - Study to couple CANDESAL RO to a Candu 6 in Indonesia
- Russia
  - Design Concept for a Floating Desalination Plant based on KLT-40

Activities in Member States (3)

(3 OF 3)

- India
  - Experimental facility produced 425 m^3/d
  - Project to couple hybrid MSF-RO to an existing PHWR in Kalpakkam with 170 Mwel
- Korea
  - Design of 330 MW_{el} SMART reactor coupled with desalination (MED or RO) for 40000 m^3/d
- USA
  - Since 1985 at NPP Diabolo Canyon: 2200 m^3/d

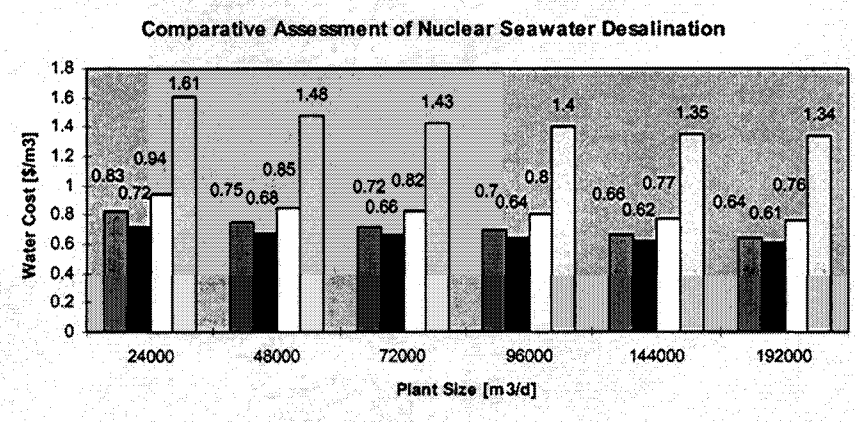
Software Package DEEP

- Desalination Economic Evaluation Programme (DEEP 2.0)
  - used in several independent studies
  - validated by international experts
- MED, MSF and RO.
- Nuclear, Gas, Coal, Diesel, Combined Cycle.
- Focus on plants bigger than 100,000 m^3/d.
- Available from IAEA
- Working Material Series

PWR AP-600 coupled to RO, MED and MSF

■ Discount/Interest Rate	%/a	8
■ Currency Reference Year		1998
■ Initial Year of Operation		2005
■ Plant Economic Life	yrs	30
■ Purchased Electricity Cost	$/kWh(e)	0.06
■ Seawater TDS	ppm	38500
■ Seawater temperature	deg C	21
■ AP 600 Specific Construction Cost	$/kW(e)	1840
■ Base unit cost RO (HF)	$/(m3/d)	800
■ Base unit cost MED	$/(m3/d)	900
■ Base unit cost MSF	$/(m3/d)	1800

Cost Calculation Results



Current IAEA Activities

- IAEA Technical Documents
- Co-ordinated Research Projects
  - Technology
  - Economics
- Nuclear Desalination Simulators
- Guidebook on Nuclear Desalination
- Database for Heat Applications
- Safety of Nuclear Desalination (Dept. of Safety)
- Interregional Demonstration Project

Economic Assessment

- New Document on economics and competitiveness of nuclear and fossil desalination plants
- First Strategy Meeting held in 1998
- Calculations done by INET, China
- Results discussed at AGM in June 1999
- Examining the Economics of Nuclear Desalination using the DEEP Code (2000)

Co-ordinated Research Project 1 (1 OF 2)

- "Optimisation of the Coupling of Nuclear Reactors with Desalination Systems"
  - Nuclear reactor designs
  - Optimization of thermal coupling of NSSS
  - Performance improvement of desalination systems
  - Advance desalination technologies
- Objective
  - Increase the competitiveness by technological optimisation

Co-ordinated Research Project 1 (2 OF 2)

- Participating institutes:
  - INVAP
  - INET
  - NPPA
  - BARC
  - NAEA(Indonesia),
  - KAERI
  - CNSTN(Tunisia)
  - IPPE/OKBM/RDIPE
  - foreseen also from Canada, Israel, Morocco

Co-ordinated Research Project 2

- Focusing on Economic Aspects
- Complementary to CRP 1 on Technology
- Start in 2001 for 5 years
- Participation open
- Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies
  - Economics TecDoc generic
  - CRP case oriented

Guidebook on the Introduction of Nuclear Desalination

- (1) Overview of nuclear desalination,
- (2) Special aspects and considerations relevant to the introduction of nuclear desalination, and
- (3) Steps to introduce nuclear desalination.

Heat Application Information System

- Data collection is in progress
- Integration into PRIS (PRIS-extention):
  - Data integration and maintenance tool modification
  - Data dissemination system modification

Safety of NDS

- TCM in May 1998 was postponed
- Dept. of Safety issued a draft document on safety aspects of nuclear desalination plants in accordance with IAEA safety standards

Congresses

- IDA Congress on Desalination and Water Reuse
- Casablanca, Cairo, Curacao, Dubrovnik, Rome

Co-ordination and Cooperation

- Co-ordination and Cooperation with other International Organizations

UN ACC SWR

- United Nations Administrative Committee on Coordination – Subcommittee for Water Resources
  - Agenda 21, Chapter 18 (Water) Implementation
  - www.un.org/esa/sustdev/csd.htm
  - October 1999: 20th session

. . .

- World Water Development Report
  - All UN organizations concerned involved
  - Announced at the WWF
  - Due 2002, regularly updated
  - Similar: UN Human Development Report

WSSCC

- Water Supply and Sanitation Collaborative Council
  - Cross between professional association, NGO, mandate from UN
  - Transfer to Developing Countries
  - www.wsscc.org
  - Status Report on Desalination
  - Technology
  - Economics and Implementation

WHO

- World Health Organization
- Guidelines for Drinking Water Quality
  - Vol. I: Recommendations
- Update
  - Desalination?
  - Radiological Limits (Chapter 4)?

MEDRC

- Middle East Desalination Research Centre
- Co-operation Agency – MEDRC
- Pre-proposals submitted
  - Integrated Design
  - Nuclear Energy Source
  - Advanced RO
- Status: being evaluated

World Water Forum and Ministerial Conference

- The Hague, 20-21 September 2000
- www.watervision.org
- World Water Council
  - Association of various organizations, not UN

...

- Documents
  - World Water Vision (CD-ROM)
    - *Water for People (→ Agency's papers on Drinking Water)*
  - World Water Vision Commission Report
  - Framework for Action
- Nuclear Desalination
  - Forum Discussions
  - Fair: UN Pavillon
  - Ministerial Conference

IWA

- International Water Association
- Merger of IWSA and IAWQ
  - International Water Services Association
  - International Association on Water Quality
- http://www.IWAhq.org.uk

International Demonstration Project

- Interregional TC Project
- Established 1998 for duration of 4 years
- Objective:
  - Focus the efforts in Member States on one joint project
  - Show feasibility of Nuclear Desalination