united nations educational, scientific and cultural organization

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WORKSHOP ON

DESALINATION ECONOMIC EVALUATION

30 April - 4 May 2001

Miramare - Trieste, Italy

in cooperation with

The International Atomic Energy Agency (IAEA)

and

the Kuwait Foundation for the Advancement of Sciences (KFAS)

Examining the economics of seawater desalination using the DEEP code

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AGENDA

- Objectives and background
- Contents
- Calculations performed
- Results and their interpretation
- Main conclusions

Objective of the study

Make a comprehensive evaluation of cost comparisons between nuclear and fossil energy sources with selected desalination processes, including regional studies and sensitivity analyses

Preparation at the Agency

- CT 1998: Calculation Scheme and Input Data
- CSA: 500 Calculations
- AGM June 1999: Interpretation of Results
- CSA: Updating of Results and Compilation of Technical Document
- CT 1999: Finalization

Contents

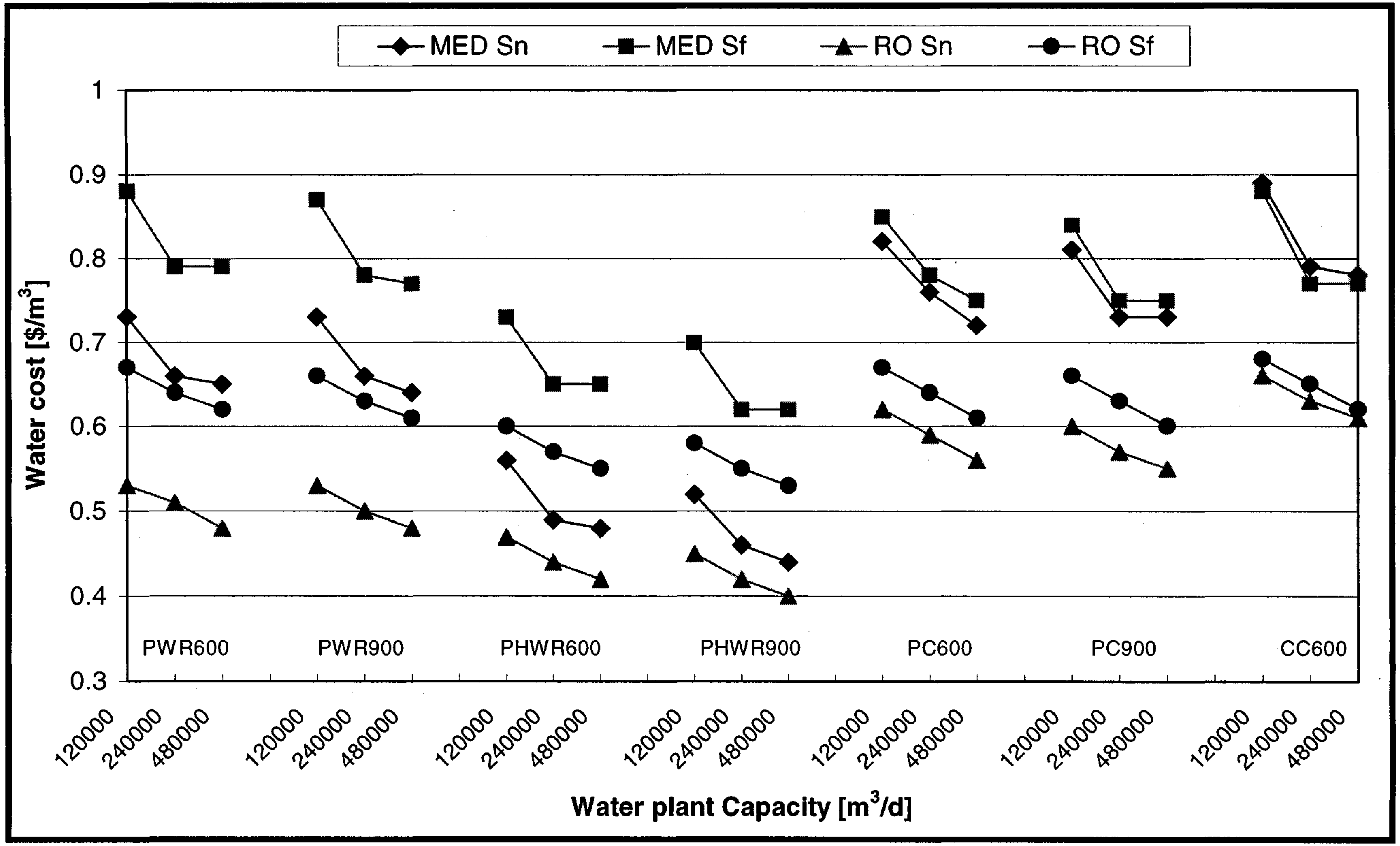
- **Main Document**
  - DEEP Description
  - Input Data and Results
  - Interpretation and Conclusions by the AGM
  - Key results and main conclusions (Executive Summary)
- **Annex**
  - National Studies from Canada , India, Korea, Morocco/China and Russia (AGM)

Calculations performed

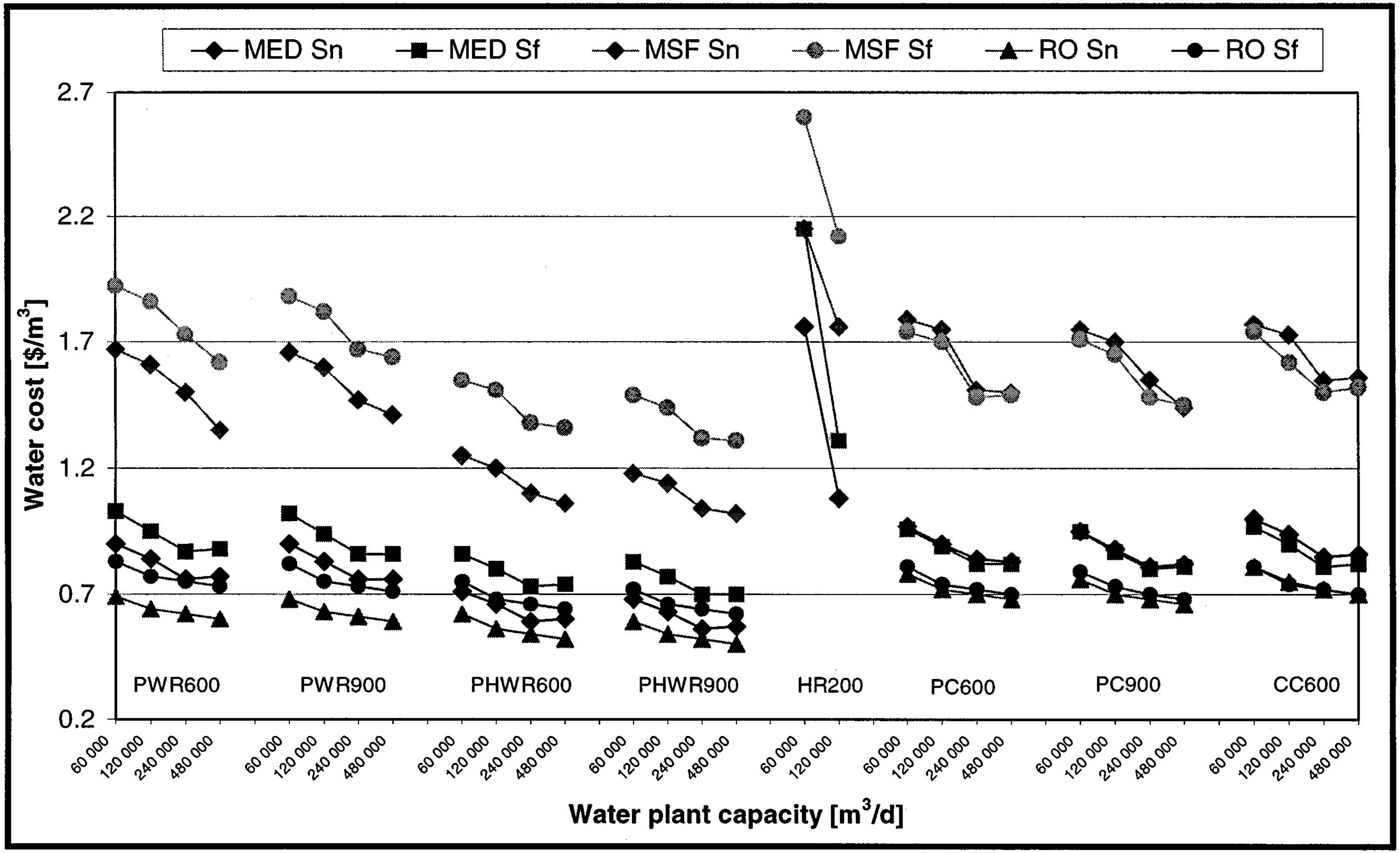
- **Three Regions** (different seawater and economic conditions)
  - Southern Europe (Region 1)
  - SE Asia/Red Sea/North Africa (Region 2)
  - Arabian Sea (Region 3)
- **Two economic scenarios (Sn, Sf)**
  - Sn: lower construction cost and discount/interest rate and higher fossil fuel cycle cost
  - Sf: higher construction cost and discount/interest rate and lower fossil fuel cycle cost

- **Three DS Technologies**
  - MED
  - RO
  - MSF (for Region 2 and 3)
- **Four Water Plant Capacity**
  - 60, 120, 240, 480 x (10^3 m^3/d)
- **Nine Power Options**
  - Nuclear: PWR (600, 900 MWe), PHWR (600, 900 MWe), HTR (100 MWe), HR (200 MWth)
  - Fossil: PC (600, 900 MW), CC (600 MW)
- **Sensitivity Analysis**

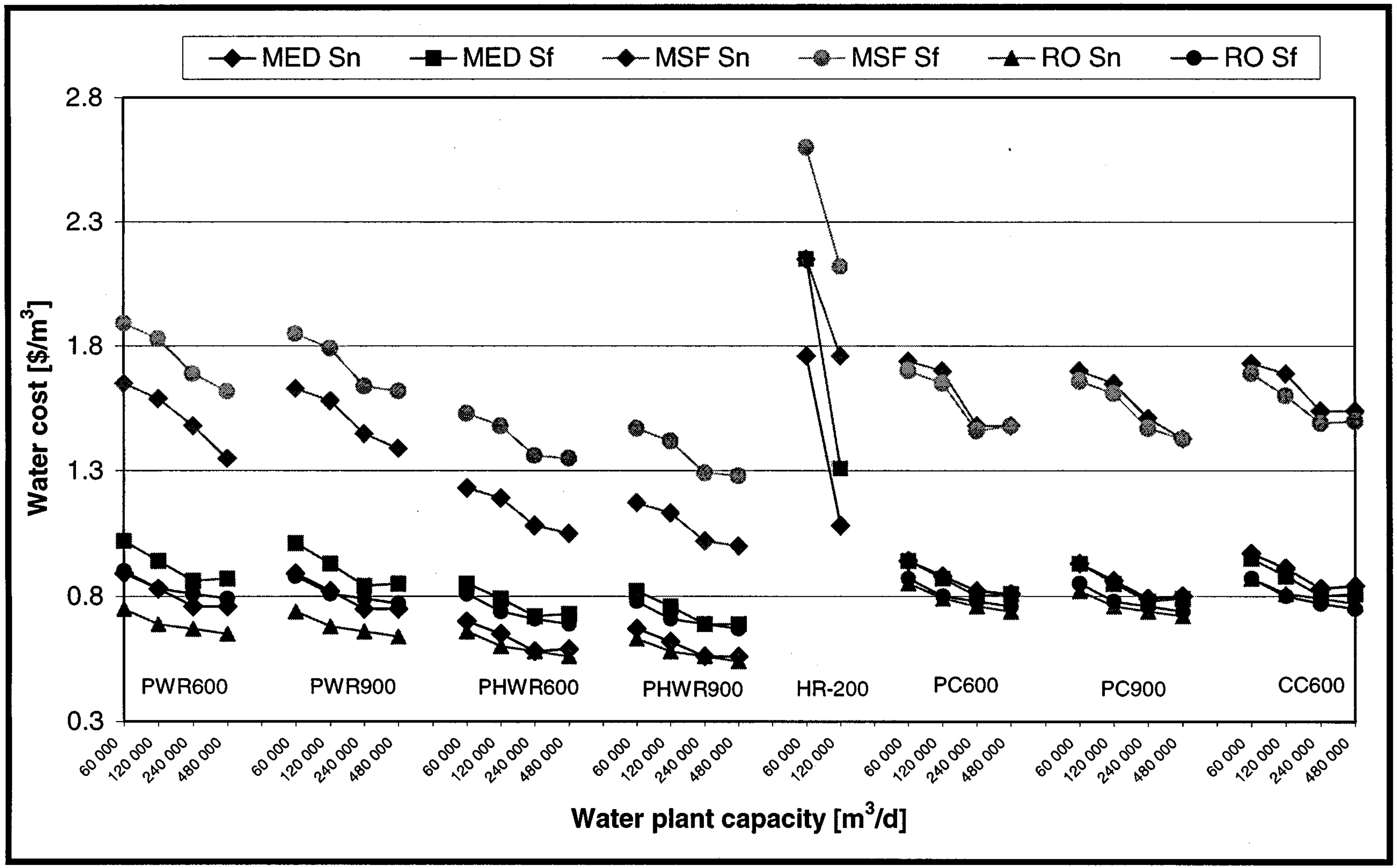
REGION 1: Results



REGION 2: Results



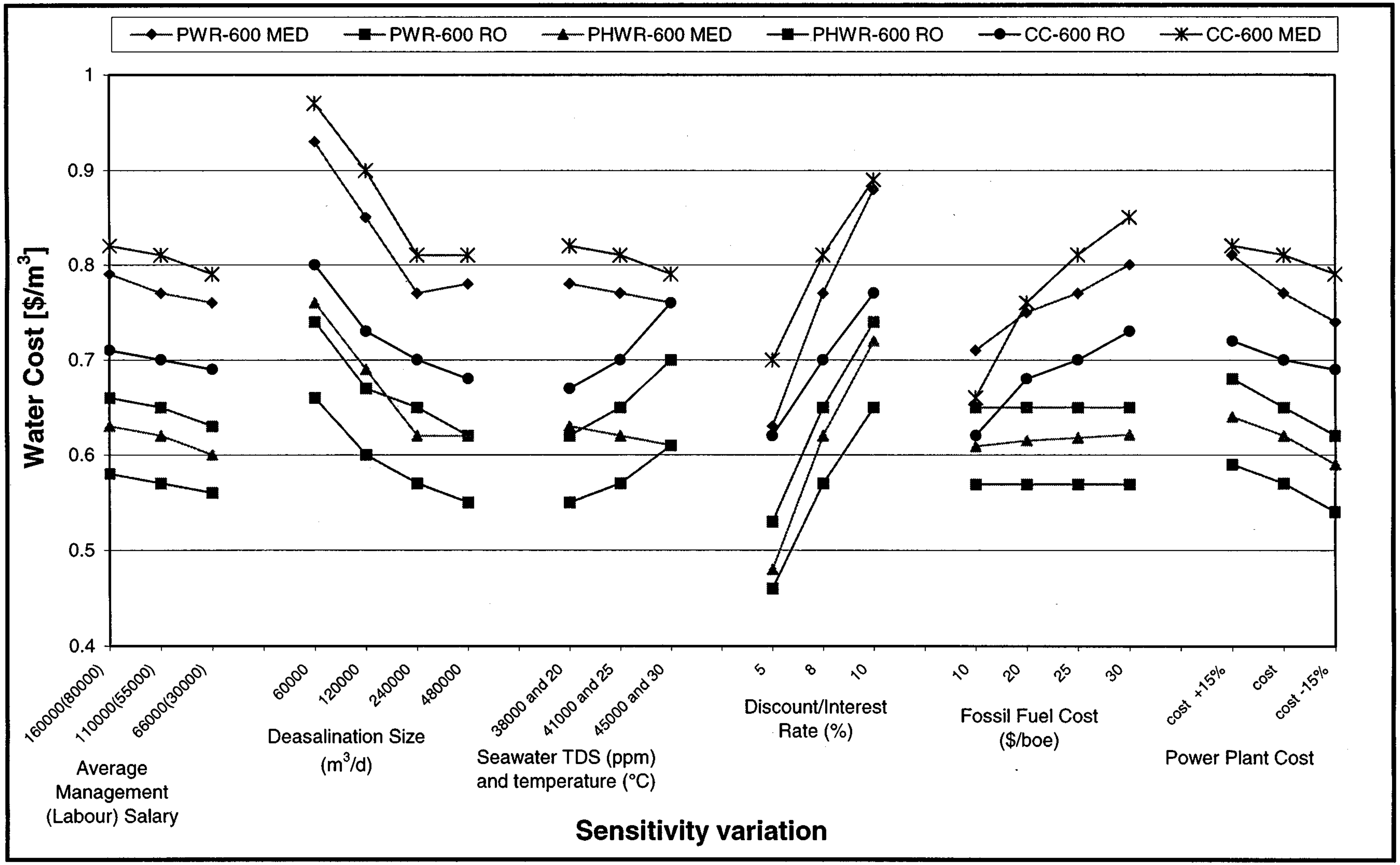
REGION 3: Results



HTR-100: Results

Power Option	Levelized Electricity Cost $/kW·h		Desalination Plant Size m³/d	Levelized Water Cost $/m³	
	S_N	S_F		RO S_N	RO S_F
			120,000	0.47	0.58
HTR-100	0.015	0.024	240,000	0.44	0.55
			480,000	0.42	0.53

Sensitivity Analysis



Conclusions

- Desalination costs range from 0.40 $/m^3$ to about 1.90 $/m^3$ depending upon the water plant type and size, energy source, specific region and economic scenarios.

- Independent of the energy sources and regions considered, in all investigated cases water production costs from MSF appear to be systematically higher than those from RO or MED.

- Water production costs in regions 2 and 3 are higher than in region 1, mainly because of the predominant effect of higher discount rates in regions 2 and 3.

- There appears to be a relatively significant economy of scale as plant capacities increase. This effect is more pronounced for lower sized plants. For higher capacities, the economics of scale are only a few percent of the water production costs.

- Water production costs with small reactors dedicated to heat production only are systematically higher compared to larger dual-purpose nuclear reactors. Thus for example, for the MED process the water production costs from the heat-only reactor are about 30-40% higher than those from the dual-purpose reactor with the highest water costs, mainly because energy costs are higher roughly by a factor of 2.

- For the S_N scenario, favouring nuclear, the nuclear option appears to be particularly advantageous with both RO and MED.
- For the S_F scenario, favouring the fossil option, costs from nuclear and fossil options are comparable.
- The cost of water produced from fossil plants is strongly influenced by the price of fuel.

- Nuclear desalination with PWRs would be less competitive than fossil desalination for fossil fuel prices below 15 $/boe. With innovative nuclear reactor options with significant capital cost reductions (as in the case of PHWR and HTR-100, for example) nuclear desalination would remain competitive even for fossil prices below 10 $/boe.
- The competitiveness of the nuclear option could become questionable if, assuming fossil cost to be 25 $/boe (or lower), the capital costs of nuclear power plants are increased by 15-20 %.

- For RO systems there is a significant variation on water cost with the variation of both temperature and TDS.

- Over a wide range of power sources and regional conditions, the differences between the water production costs by RO and MED tend to be small as compared to the large differences introduced by changes in discount rate.

- The existing nuclear power plants would not be competitive for discount rates above 11 %. There does not appear to be a limiting value for discount rate with innovative nuclear reactors.

- The results of calculations, using DEEP1.1, and analyses made independently by five countries in the context of specific national programmes yields trends which are in line with the above conclusions.

Final Remarks

- DEEP generates Output based on Input
- Cannot derive future water costs in the three Regions
- Graphs reflect input data
  - determined by international experts (consensus)
  - meant to describe future developments appropriately (Regions, scenarios, sensitivity)
- Most general: Nuclear and Fossil yield water costs in the same range

Final Remarks

- DEEP is a simple tool, developed primarily to address the needs of decision makers, project planners and engineers involved in nuclear desalination programmes
- The basic objective of DEEP is not to calculate prices but to provide reasonable cost estimations permitting a choice of technical options or comparative studies of several desalination projects based on different energy sources
- The code is now being increasingly used throughout the world by industrial and R&D organisations