Egypt's Desalination Technology Roadmap 2030

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Purpose

This project was an activity within the framework of Egypt's Vision 2030 project carried out by the Center for Future Studies in the Egyptian Cabinet's Information and Decision Support Center, with the aim of identifying the future needs for desalination technology development, charting a series of research and development activities that will result in cost-effective, efficient revolutionary desalination technologies that can meet the national future needs, and providing short and long term action agenda to guide desalination research and investments in Egypt till the year 2030.

Investment to Meet National Needs

Water shortage is a worldwide problem, where 40% of the world population is suffering from water scarcity. In Egypt, the per capita water share was 771 CM/capita/year in 2005, which is below the international standards of “water poverty line” of 1000 CM/capita/year. Due to the long time horizon required to implement the Upper Nile development projects, directing efforts towards non-conventional water sources - such as; water recycling; reuse of drainage water; treated industrial and sewage effluents; rainfall harvesting; and desalination - provides a short term solution to the water shortage problem. Water desalination should top the agenda of developing non-conventional water resources, since desalination technologies have developed substantially over the last fifty years, especially with the development of "Reverse Osmosis" (RO) technology in the sixties leading to significant reductions in the cost of desalination. Therefore, due to the great advances which occurred in the field of desalination globally, and the noticeable increase in awareness of the importance of such a technology among decision-makers in Egypt, the Center for Future Studies (CFS) at the Cabinet's Information and Decision Support Center (IDSC) has taken the initiative to develop a desalination technology roadmap for Egypt in the year 2030. The desalination roadmap is a program-planning document that identifies the most appropriate desalination technologies and their related R&D projects that Egypt needs to invest in to meet the national needs.

Developing and R&D Agenda

The desalination roadmap is a program-planning document that identifies different desalination technology alternatives and their related R&D projects, and the milestones for meeting future national needs of water resources. Due to its role in investigating the future of Egypt in different areas, the Center for Future Studies (CFS) at the Cabinet's Information and Decision Support Center (IDSC) has taken the initiative to develop a desalination technology roadmap for Egypt. The project objectives are:

1. To identify future needs for desalination technology development.
2. To chart a series of R&D activities that will result in cost-effective, efficient revolutionary desalination technologies that can meet future national needs.
3. To establish development activities that will accelerate the rate of improvement of current-generation desalination technologies, and therefore allowing these technologies to better meet the short-term national needs.

The EFP is financed by the European Commission DG Research. It is part of a series of initiatives intended to provide a ‘Knowledge Sharing Platform’ for policy makers in the European Union. More information on the EFP and on the Knowledge Sharing Platform is provided at www.foresight-platform.eu

4. To develop short-term and long-term action agendas for the required desalination R&D projects in Egypt till 2030.
5. To improve communication within the R&D community and between this community and the end users.

Technology Roadmapping Methodology

The desalination technology roadmap project was divided into **three main phases**: roadmap initiation, technical needs assessment, and technical response development. The first phase was concerned with the **preparation of the actual roadmapping process** and involved agreement on the roadmap's scope, leadership, participants and deliverables. This phase involved constituting the Desalination Steering Committee (DSC), validating the need to roadmap and clearly portraying this need in a clear vision statement.

The second phase was **Technical Needs Assessment**: which involved technical needs definition, by assessing current capabilities and identifying the capability gaps and associated R&D goals. This was carried out by the Steering Committee's core research group who conducted research in the field of desalination, in general, and in Egypt, in particular to determine recent breakthroughs in desalination technologies and how far Egypt has reached in this field. This was followed by identifying and specifying the areas of technical risks/opportunities, and correspondent technical solutions that are either available, or currently under development through a series of brainstorming sessions to identify potential alternate solutions. This phase resulted in a number of critical objectives associated with each need highlighted in the vision statement, and which certain research projects are meant to fulfill. These targets aim at challenging the R&D community to **pursue and achieve major technological breakthroughs** to be used in future projects, and should only be developed if key projects are not scheduled to start for another 10 years or more.

The final phase of the project was the **Technical Response Development**, which involved identifying relevant technological areas and research projects (e.g thermal, membranes, alternative, reuse, and cross-cutting research areas) to meet the metrics of each critical objective, and involved brainstorming to identify all possible technical approaches which represent the mechanisms for achieving the critical objectives. This phase resulted in a Broad Strategic Action Agenda which serves as a guideline for the R&D projects required on the short and mid/long term by providing prioritized suggested R&D projects, their duration and an estimated budget.

Most activities associated with the roadmapping process were conducted through committees or workgroups, and a number of focus group meetings were sequenced and scheduled for all work groups to come together, share results, and reach consensus on the defined targets or critical objectives. In addition, a number of individual follow-up meetings took place.

The Desalination Roadmapping Team was composed of the Desalination Steering Committee (DSC) and the Desalination Working Group (DWG). The main responsibility of the DSC was to oversee the technology roadmapping process, and guide it in the direction of achieving the vision statement or the final goal. The DWG is a committee representing a group of experts in desalination technology, environmental engineering, water resources planning, and energy resources. Their main responsibilities were to brainstorm technology options responsive to the technology strategies provided by the DSC, as well as the costs, benefits and risks of the different options.

Good Water Quality Free of Charge

Upon identifying the steering committee, a meeting was held to highlight the main national needs facing Egypt's water resources in the future till 2030. This meeting was held among a number of prominent experts in the field of water resources and desalination, and accordingly, the following broad vision for desalination was formulated and agreed-upon to cover the main national needs as below:

"Develop desalination technologies that aim to secure cost-effective, drinkable, fits for its uses and sustainable water for Egypt in 2030".

National Needs and Critical Objectives to Meet National Needs

Following the extensive **literature review** carried out by the research team during the second phase of the roadmapping process, the technical needs of Egypt in the field of desalination were identified and were mainly focused on capitalizing on the availability of abundant renewable resources in Egypt, mainly **solar and thermal energy**. As determined by the agreed-upon vision, Egypt's main national needs with respect to water can be categorized as:

- **Cost-effective water**: In Egypt, as in many countries, there is no direct charge for water services provided for agriculture, while water provided for domestic and industrial uses is subsidized. Farmers receive water free of charges and are only responsible for pumping costs from the manual pump to the field. However, the provision of water free of charges to farmers began to pose an increasing burden on the government especially in the face of increasing costs for O&M and irrigation and drainage system rehabilitation, due to the increasing population and construction of mega projects. As with regards to the municipal and industrial sectors, it is estimated that government subsidies amount to 70% of water service in the industrial sector and 88% in the municipal sector. The rate for domestic water supply in Greater Cairo is about LE 0.13/m3, which is much lower than the cost of providing raw water (around 0.56/m3). Charging users for water and water services in Egypt is a sensitive issue, as it involves political, historical, social, and economic factors.

- **Drinkable water**: Access to safe drinking water and sanitation is considered a basic human right, however providing this service and securing the required investments are a real challenge for the government. In Egypt, over 90% of Cairo's drinking water is drawn from the Nile, which has provided high quality water during the 1970's and 1980's. However, the Nile's water quality showed increasing deterioration in the 1990's due to increased industrial and agricultural discharges, and also contamination from human sewage. In addition, water quality provision was increasingly threatened by the inefficient infrastructure and deteriorating distribution systems and water treatment plants.
- **Water fits for its uses**: Given the worsening water situation in Egypt due to the massive and increasing demand by the agricultural sector, supplementary non-conventional sources including desalination of sea and brackish water, and reuse of waste water, represent very important sources to ensure maximum water allocation for its uses. In general, desalinated seawater costs about more than twice the price of freshwater used in irrigation and hence is considered too expensive for all types of agricultural production. However, desalination costs have decreased to nearly one-tenth of what it was 20 years ago, and are likely to continue falling due to continuous advances in the field. This declination in cost is likely to make the use of desalinated sea or brackish water feasible for wide use in both agricultural and industrial fields.
- Sustainable water. Achieving the national need of providing sustainable water resources requires that policy makers widen their scope on the main users of water, to include the environment as well as the traditional industry, agriculture and household users. This measure is crucial in the future in order to overcome the unsustainable "hydrological" debt that Egypt faces today, as its future water flows are more or less fixed while consumption is increasing at an enormous rate leading to water depletion.

Quantifying the Objectives

These are the objectives for each national need that the different proposed desalination technologies are expected to fulfill. These objectives gained consensus by the experts who have participated in this study.

Near Term Critical Objectives (2015):

- Reduce capital cost by 20%
- Increase energy use by 10%
- Decrease operating and maintenance cost by 20%
- In-house manufacture of renewable energy (RE) units
- Increase public awareness, education/training on the importance of desalination.
- Water quality meets drinkable water standards identified by Egyptian Environmental Affairs Agency (EEAA)
- Develop science related concentrate specific regulations
- Microbial removal
- Provide water for supplementary irrigation coupled with greenhouse irrigation
- Water use in industry
- Reduce cost of desalinated water by 20%
- In-house manufacture of RE
- Maintain stability of reclaimed water over time
- Brine reuse for other purposes

Mid/Long Term Critical Objectives (2030):

- Reduce capital cost by 50%
- Increase energy efficiency by 50%
- Reduce operating cost by 50%
- In-house manufacture of multi stage flashing (MSF)/Multi Effect Distillation (MED) desalinating plants
- Develop small desalination units for remote areas
- Address cumulative issues related to concentrate and enhance regulations
- Wider water for supplementary irrigation coupled with greenhouse irrigation
- Wider water use in industry
- Reduce cost of desalinated water between 60-80%
- Development of new systems projects
- Use of nuclear energy for large desalination plants using CANada DUterium Oxide Uranium (CANDU) technology.

Desalination Technologies to Address Critical Objectives: Research Areas with the Greatest Potential

The Roadmapping Team identified three main technology areas where R&D is needed in order to create the next-generation desalination technologies. These technologies and their associated research areas are:

1. Solar/Thermal Technologies:

- Design and manufacture of solar stills
- Application of a reflection reduction solution to the glass of solar desalination units
- continuous improvement in material enhancement for solar desalination unit
- Multistage evacuated solar desalination system
- Multiple effect humidification/ dehumidification at ambient temperature (solar)
- Solar multistage condensation evaporation cycle
- Enhancement of reverse engineering of national made (5000 m3/day) MSF (or MED) units (existing 5000 m3/day of Sidi Krir & Euon Mosa could be used for verification)
- Solar PV-RO system
- Develop solar ponds for energy and concentrate management

2. Membrane Technologies

- Enhancement of in- house manufacture of RO technology
- Enhanced evaporation through Multistage Condensation Evaporation Cycle

3. Other Technologies

- Manufacturing of stand alone small desalination units (1.0 - 20 m3/day)
- Integrated complex for water production (solar stills), electricity (wind, solar, bio mass), food (greenhouses self sufficient of irrigating water, rabbit, sheep and birds breeding), and salts (chemical salts, artemia & fish nutrients).
- Ionization of salty water for irrigation
- Secondary treatment of brine for salt production
- Integrated complex for water production (solar stills), electricity (wind, solar, bio mass), food (greenhouses self sufficient of irrigating water, rabbit, sheep and birds breeding), and salts (chemical salts, artemia & fish nutrients)
- The biology of salty water, including understanding of environmental impacts, using bacteria for beneficial treatment, etc.

Expectations of Impacts

Given that the critical objectives that are to be achieved by the roadmap are divided into short-term and mid/long term, it was seen as most suitable to divide the strategic plan for desalination into a strategic plan to achieve short term critical objectives and another strategic plan to achieve mid/long term critical objective

Mid/Long Term High Priority R&D Projects

- Manufacturing of stand alone small desalination units (1.0 - 20 m3/day). Duration: 10 years, Expected Cost: L.E10 million.
- Integrated complex for water production (solar stills), electricity (wind, solar, bio mass), food (greenhouses self sufficient of irrigating water, rabbit, sheep and birds breeding), and salts (chemical salts, artemia & fish nutrients). Duration: 5 – 10 years, Expected Cost: L.E 2.5 million.
- Storage of brackish water aquifers all over the country. Duration: 10 years, Expected Cost: LE 5 million
- Bio technology using Bacteria, micro, plants…etc, that reduce amount of salt in seawater (e.g. Man-Grove). Duration: 12 years, Expected Cost: 2 million.
- Combined nuclear power & desalination plants. Duration: 20 years, Expected Cost: 50 million.

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