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# The challenge of capacity-building strategies and perspectives for desalination for sustainable water use in MENA

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**ABSTRACT**

The desalination industry is increasingly growing in the Middle East and North Africa (MENA) due to the increase in water demand and reduction in desalination costs resulting from advances in desalination technologies. Within the next 20 years, it is estimated that the MENA region will become so dependent on desalination technology for sustainable water supply that a minimum of 50,000 additional technical experts of various professional levels will be needed to service the desalination industry. Over the last decade, desalination experts, industries and manufacturers have launched awareness programs for building capacity in the MENA where there is a greater need for human resources to cater to the needs of the huge water market. Only a few institutions have implemented some academic programs and provided short courses and workshops in desalination; other institutions developed web-based training to the desalination community. But these actions cannot compensate for the need of real institutional training and education as well as for research and development. Capacity-building is urgently needed at different levels: operators, educators, academics and management. Achieving this target requires more specific training efforts in desalination technologies to encompass the principles, practice, operation and maintenance, design, human resources management as well as research and development. A capacity-building program is necessary not only to operate and improve existing plants but also to develop new sustainable technologies. Wastewater treatment and water reuse technologies should also be included in capacity-building programs to achieve a better integration in water resources management. An overview of a capacity-building strategy and perspectives for desalination in MENA are presented. The Middle East Desalination Research Center's approach to enhance human resources and expertise in the region via training, academic education and research and development is outlined.

*Keywords*: Capacity-building; Training; Desalination; Academic education; Integrated water resources management; Research and development

## 1. Introduction

Most of the countries in the MENA region are in the arid and semi-arid regions with scanty rain fall and the majority of the countries have limited renewable water resources. Renewable water resources in most of the countries of the region are below the water scarcity level of 800 $m^3$ per capita annually; Kuwait has the lowest annual renewable water resource of 103 $m^3$ per capita and the highest is Iraq with 5,340 $m^3$ per capita [1]. Population growth rate per year in these countries is also high with an

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average of about 2.5%. Industrial growth is also high due to the availability of cheap energy resources in oil-rich countries of the Arabian Gulf, amongst other factors. Therefore, in most of these countries, available water resources withdrawal is much above the rechargeable level. The withdrawal rate as a percentage of annual renewable water resources is as high as 510% in Kuwait. Alternative sources like desalination are thus used to meet growing demand for water. Already in several AGCC countries, all potable water needs are met by desalination.

The biggest market for desalination worldwide is in the MENA region and, in particular, in Arabian Gulf countries. Unfortunately the MENA region lacks the proper manpower in desalination among consultants, designers, expert researchers, skilled technicians, operators, etc., to meet the current and future needs. Several estimates indicate that a substantial number of staff at all technical levels is needed to service the existing and future desalination industry in this region. Actually in many existing plants, key personnel are predominantly expatriates. Similarly, most consultants and contractors in this field are not from the region. This is because most desalination activities in the region started in oil-producing countries who could afford expatriate labor, or did not have local skills available; and on the other hand, most of the non-oil-producing countries are new to the desalination field, and thus do not have the needed manpower.

The Middle East Desalination Research Center's (MEDRC) main objective is to foster research and development and capacity-building in the region as stated in its Establishment Agreement: "The Center mission is to conduct, facilitate, promote, co-ordinate and support training programs so as to develop technical and scientific skills and expertise throughout the region and internationally in the field of water desalination and its applications and related technical areas."

At present, regional education programs concerning desalination are limited to private sector initiatives seeking to meet national employment quotas and some regional universities conducting individual research with few specialized courses but not offered on a structured basis. These initiatives alone will not meet the estimated needs of industry growth. A more coordinated education and training approach is necessary, which would include participation from multiple institutes and organizations.

Research and development is an essential component for the development and advancement of any technology. Large amounts are generally spent to develop economically viable technologies. Present-day commercial desalination technologies are based on the well known separation principles. However, a considerable amount of research and development efforts was invested world over to develop these separation principles into economically feasible technologies. Presently, research and development work in desalination is not considerable on a global scale. Research institutes and academia are not concentrating on this field possibly because there does not appear to be much scope for breakthrough inventions. Desalination technology suppliers are also not investing in research and development perhaps due to shortage of funds or other factors. The desalination market is now highly competitive with only a small profit margin for suppliers. Most technology users are also limiting their efforts to improve the performance of their plants. This could be due to non-availability of funds and/or of trained manpower to supervise and conduct research. A considerable amount of research and development efforts are needed to reduce the desalination cost. Even though the costs are still relatively high, a large number of new large-scale plants are under construction in the region to meet the growing needs for water due to increase in population and per capita consumption. These expanding requirements for water call for development of human resources and expertise in the MENA region to manage existing technologies and absorb new ones.

Some countries in MENA (mainly the AGCC and to some extent Libya) already have well established desalination programs. Recently other countries are also adopting this alternative such as Algeria where a dozen of large-scale desalination plants, including the largest SWRO plant worldwide, are under construction. One major issue is the lack of qualified manpower. Most of these countries do not have training facilities or regimented programs for training the needed staff. Plant suppliers are mainly doing the training either on site or for a short period abroad (home country of the supplier). This approach, even though working, does not enhance plant availability and efficiency. MEDRC, since its inception, realized this drawback and has been trying to deal with it. One of the options is to establish a regional Center for Training in Desalination Practice (CDTP). A pre-feasibility study has been conducted for the establishment of such a center and the terms of references (TOR) for a detailed feasibility study are being concluded. In the meantime, MEDRC is following several schemes to assist the region in this endeavor. These include offering short courses conducted in the region by internationally recognized experts in the field, enhancement of research capabilities by including in the research team of each MEDRC-sponsored project a researcher from the region, and by sponsoring students to undertake their postgraduate qualifications in desalination and its related fields in the region or abroad.

There are urgent needs for development and collaboration in desalination in MENA. The Arabian Gulf area continues to be world leaders in desalination technology and could offer their neighbors years of their experience in building human resources base through training.

The urgent need for training and capacity-building in the desalination industry is undisputed amongst industry experts. It is now faster to build a large-scale desalination plant than qualifying the manpower to operate it. This means that there is a continued need for developing the skills and capabilities of people. Several estimates indicate that a substantial number of staff at all technical levels are needed to serve the existing and future desalination industry in MENA. According to a study of Klaus Wangnick for GTZ in Germany, conducted in the year 2000, the total training needs of desalination personnel in the MENA region were estimated to be about 36,500 people by the year 2010. An essential prerequisite for a well established desalination industry is the presence of well qualified and experienced personnel in the field. The most important recommendation in this respect is to establish training and education centers, or train the staff working in the sector at academic institutions. Desirable education programs should include all desalination technologies and their related topics, with particular emphasis on some specific ones that vary with the local needs and characteristics of a country. It should be flexible and dynamic allowing for changes and improvement in the future technologies. The program should be taught in an understandable language and meet the needs of a large population. Like all water issues and programs, awareness should start from primary and high school levels for better acceptability and effectiveness.

## 2.. Capacity-building in desalination

### *2.1. Program objectives*

Capacity-building has a broad meaning. In this paper capacity-building is defined as training, education or material support to organizational needs. Training is a short-term activity to address individual gaps in knowledge and skills that effect-job performance, while education is defined as a long-term effort to prepare individuals for life through specialization [2]. A capacity-building program is developed to enhance local, regional and international desalination education, training and institutional efforts.

The objective of a capacity-building program is to implement a component of practical, hands-on training for instrument handling and laboratory work, chemical and physical analysis, apparatus and plant component testing and understanding. This program component is expected to grow in conjunction with the current trend of privatization in the desalination industry.

MEDRC developed its research and development and communication capacity as a new means of supporting already existing institutions while bringing international expertise together with regional experts. The Center developed new programs that were not previously available to address the capacity-building needs. MEDRC supported the development of local experts and university departments that would have the ability to deliver new courses locally.

The capacity-building program will contribute indirectly to reduce the cost of desalination. It can help technicians, operators, engineers and managers perform more efficiently and greater understand desalination technology, which will certainly save on costs.

### *2.2. Short training courses*

The notable growth in the market has exposed the tremendous need for capacity-building to absorb the somewhat new, yet rapidly evolving, technologies. Though a market for training was created, response has not matched this need. There are individuals conducting training courses such as DH Paul and Masar Technologies, who are fully dedicated to training, while there are others like Schippers, Sommariva, Wilf, Moch and Wade (among others) that have customized courses offered on a somewhat less regular basis. As the need for human resources became more urgent than expected especially at the industry level, recently many other individuals such as Thomas, Winters and some institutions such as DME, Haward Technology Middle East, Bushnak Academy and Apex, started offering specific short training courses. These courses are sometimes conducted in parallel with national or international conferences in the region or outside such as those held by the International Desalination Association (IDA), the European Desalination Society (EDS) and the International Water Association (IWA).

One of the most significant areas of interest from the research needs assessment in the region is the desire to have access to training capabilities. As a contribution towards this need, the Center implemented training courses and seminars related to desalination technology practices in specific topic areas. MEDRC started their short course training program on a regular basis in late 2003 and had since then conducted , in collaboration with local and international institutions, organizations, companies and governments, 32 different shorts courses on desalination technologies in different countries in the region, 16 in the Middle East and 16 in North Africa. For the Maghreb countries the courses were given in French, which has ensured inclusion and the building of capacities of the French-speaking nationals of the region. Some courses included wastewater treatment and water reuse topics with the objective of exposing participants to the broader picture in that the technologies used in desalination can also be used for wastewater treatment and hence the reuse of treated water. It will also keep them aware that

desalination can be a technical solution, among others, contributing to integrated water resources management. The cost of desalination can also be the driving force towards other management aspects such as reducing losses in distribution system. Proper management of water resources in all water sectors is essential for the sustainability of the economic and social development. The key element for such management is developing and applying an integrated management approach which would include a proper assessment of training needs within the water sector in each individual country.

MEDRC courses attracted over 5,000 applications from which 1,225 participants (operators, engineers, consultants, designers, managers, researchers and policy makers) from 25 countries were selected. Thirty internationally recognized instructors taught these courses and 12 local experts participated by giving lectures on the status of desalination projects and presented performance evaluations of existing plants in their respective countries. Some local experts with extensive practical experience became instructors after attending several MEDRC courses and were asked to initiate teaching desalination courses in their own national universities and training centers. Courses were customized to the participants' specific needs and were conducted in the respective countries of the participants, hence avoiding traveling abroad to learn the latest trends in desalination. Indeed, the subjects covered in the courses by specialists, recognized internationally, enhanced the capabilities of the participants in theory as well as in practical aspects. Details of these courses are available on the MEDRC website www.medrc.org.

To acquire and quickly enhance the skills in desalination and its related areas, these short courses are conducted to cater for immediate needs (Table 1). These courses are split into groups based on the targeted individuals (technicians, engineers, researchers, decision makers and managers) and their field of interest. Four groups were defined: those combining thermal desalination, membrane desalination technologies, researchers, decision makers and managers. The last two groups can be in either thermal or membrane desalination or both.

Feedback from participants was encouraging as many noted that they found the courses very useful to enhance the skills of desalination personnel and scientists and provided basic background to newcomers to the desalination field, and appreciated the opportunity to make new contacts especially in venues where participants from different countries were gathered. They also suggested to offer more specialized and long-term training courses, mainly in practical aspects, management, contracting and finance. The courses provided a useful environment for the development of new cooperation between different participants from different sectors and organizations.

Table 1
List of MEDRC short courses split into three categories

| | |
|---|---|
| Thermal processes | • Thermal seawater desalination technologies<br>• Operation and maintenance of thermal desalination plants and lifetime extension<br>• Scaling, corrosion and material selection in thermal desalination plants<br>• Design, construction and commissioning of thermal desalination plants |
| Membrane Processes | • Membrane desalination technologies<br>• Operation and maintenance of RO plants<br>• RO pretreatment (conventional, membrane, innovative) and post-treatment<br>• Fouling/bioflouling and scaling in membrane processes<br>• NF/RO membrane desalination: transport theory, modeling and process simulation |
| General | • Fundamentals and techno-economic evaluation of various desalination processes<br>• Saline water chemistry<br>• Hybrid systems<br>• Costing of desalination systems<br>• Desalination management<br>• Desalination plant procurement, privatization, contracting<br>• Desalination and the environment |

There were major differences among government, private and university participants as to what kind of training they thought the Center should focus on. All agreed, however, that research was the top priority.

### 2.3. Perspectives according to local needs

The approach was to create a training and education program and strategy for each country for academic and non-academic levels according to their own needs. This gives individual countries their uniqueness and brings countries together through their mutual interests. In order to be most effective, training is to be undertaken as a widespread, integrated and continual effort. It would be useful for each country to carry out a broad-based training needs assessment in order to define the types of training that it believes are required over the near, medium, and long term. Once a specific training need is identified, a complete training and education program can be developed to meet the targeted objectives.

Short courses and seminars are organized to satisfy some of the immediate needs whereas long-term needs efforts are directed to implementing institutional and certificated training regimes. To prepare for the increased need for training, local institutions should start to train their own trainers by sending them abroad to learn about

desalination or ask professional institutions like MEDRC to assist them.

Another level of training need is in desalination practice for operators and technicians and site engineers. This is generally lacking in the world and in the MENA region in particular. Where available, it is limited to training on site by the supplier of the equipment when the handover is made. This has proven ineffective in practice, seriously affecting the plant's capabilities, which in reality results in the skyrocketing of production costs.

Even globally, awareness by universities for the growing needs for desalination professionals seems to be at a low level. It is for this purpose that MEDRC established a scholarship program for post-graduate studies. Currently MEDRC is sponsoring 28 PhD and MS students in desalination related studies, which is a very modest number in the face of the actual needs.

MEDRC is also providing technical assistance to universities and specialists dealing with desalination and is prepared to provide assistance to universities who are willing to implement courses and degrees in desalination. In addition, the scholarship program can produce specialists who can work at these universities or industry upon completion of their study abroad.

### 2.4. Courses and degrees in MENA universities

One approach to reduce the cost of desalination is to develop new technologies by conducting basic and applied research. The other approach is to improve the existing processes. The MENA region universities/research centers have limited or no resources, facilities and manpower to develop new technologies. Much of the research work in these universities is on assessment studies, process simulation for performance evaluation of existing plants, small desalination systems and renewable energy applications. There are very few universities providing desalination courses in Chemical, Process or Mechanical Engineering Departments such as King Abdulaziz University in Jeddah, Kuwait University or L'Ecole Nationale d'Ingénieur de Tunis. Recognizing this, the Center offered help in initiating MS and PhD programs and in introducing post-graduate courses in the MENA universities and has developed scholarship programs to provide the opportunity for MENA citizens to study abroad. As a first step in this endeavor, MEDRC sent an awareness letter to MENA universities informing them on the importance of desalination in this region to augment the water supply and the required workforce to meet this challenge. The Center is encouraging MENA universities to establish courses and degrees in desalination.

To tackle the problem at the root level, the Center is conducting a feasibility study for establishing in the MENA region a Center for Training in Desalination Practice (CTDP). It is hoped that MEDRC is emulated by others because the region needs more than one such training center, as the Wangnick and the Gesllschaft für Technische Zusammenarbeit (GTZ) pre-feasibility study on the subject has shown [3].

The need for institutional capacity-building programs in desalination practice and universities cannot be totally compensated for by short courses, hand-over training when plants are commissioned or by education of a small number of individuals abroad. Implementation of institutional programs and facilities in different disciplines is needed to improve the operation and maintenance of existing desalination plants. The author recommends adopting a long-term endogenous capacity-building program in desalination. Universities should also develop special post-graduate programs for desalination. Education and training remain key components of capacity-building.

### 2.5. Scholarship program

The Center launched a scholarship program for MS and PhD students from the MENA region to provide an opportunity to study at foreign universities while participating in a MEDRC research project. It is expected that students will gain skills that will make a long-term contribution to further development of desalination in their respective countries. The program also aims to increase cross-cultural understanding by stimulating international exchange.

The Center also initiated a program that will permit MENA region universities to provide opportunities to obtain a PhD degree. The model would be similar to the government funded "Channel System" scholarship in Egypt where qualified candidates are supervised by a professor at the home university and by a colleague abroad. The candidate conducts part of this research at the university abroad, but much of it is also done at the home university.

Many students who have already obtained their MS or PhD degrees are now working in the region. During their studies abroad they:

- have upgraded their knowledge and skills in desalination and transferred it to the work/academic environment,
- have developed research skills and the ability to transfer knowledge to their compatriots,
- are promoters of the start-up of desalination programs at universities,
- are better qualified and skilled employees in the industry,
- have benefitted personally through promotions and better job offers, and

- have promoted cooperation with MEDRC among their compatriots.

### 2.6. Research and development

Support to the growth in desalination has been through the refinement of research with wider dissemination and improvement of access to information. There are many research centers in the world, with the USBR in the USA most likely to have the greatest impact. In the MENA region, up to now there are only few such centers, namely Salt Water Conversion Corporation (SWCC) in Saudi Arabia, Kuwait Institute of Scientific Research (KISR) in Kuwait, and MEDRC in Oman. SWCC has recently announced that their premises are open to anyone interested in conducting research. KISR has always been a leader in research, though not limited to desalination as SWCC. Other research centers and universities in the region are conducting basic research mostly in renewable energies used for desalination and modeling. MEDRC has been facilitating desalination research for nearly 12 years with a project portfolio of 64 projects valued at over $10 million involving researchers from over 30 countries. In each project at least one partner in the research team is from the MENA region and/or a MENA national MS or PhD scholarship. This is effective in motivating regional academics to enter into desalination as principal investigators or as research partners. As a result, 50 partners and nine principal investigators from the region participated in research and development projects. Research areas cover new technologies development, technical feasibility, performance evaluations, assessment studies, advancement of knowledge and development of design tools. It is the intention of MEDRC to partner with the industry in conducting research at its own new in-house research facilities. In the new premises, the Center is keen to undertake basic and applied research projects to address the problems faced by the desalination industry under real climatic conditions of Oman and to test/evaluate new products and concepts through pilot plants. These facilities could also be used for hands-on training to build capacity in the region. Details of research and development projects including MS and PhD scholarships are available on the MEDRC website, www.medrc.org.

## 3. Conclusions

In most of the MENA countries, education and training programs are available on wastewater and water treatment technologies ranging from undergraduate university to specialized post-graduate studies. Some universities also have incorporated the fundamentals of desalination in their curricula. They have no defined training and education programs in desalination technologies. However, some other universities are assigning topics on desalination and its related fields within various undergraduate courses and to PhD students for their dissertations. Also, numerous short courses, workshops and seminars focusing on desalination and specific aspects of membrane technology were organized to improve the existing individual and group skills. Different local and international organizations and institutions are providing technical programs at different levels but the effort is still too low to meet the actual and future human resources needs in desalination. Considering the huge market of desalination in the region in a short period of time, capacity building is urgently needed at both the undergraduate and postgraduate levels in addition to the implementation of a new water management strategy. Additional support is needed from the end users and the desalination community at large for greater success of this endeavor.

Research and development activities in desalination and its related areas are small in the MENA region even though the region has large desalination production capacity. Only few institutions have specific research and development programs. The research and development activities in most of the institutions focus mainly on performance improvement of their operating plants and on improvements in available technologies. They also concentrate on basic research to understand scaling and fouling and corrosion phenomena in desalination processes.

MEDRC has contributed to capacity-building in the MENA region by conducting 32 short training courses on different topics on desalination and funding 64 research and development projects with participation of research partners and MS/PhD students from the region. Furthermore, MEDRC organized an international conference on desalination costing in 2004 and is planning to organize a second conference on the same topics in 2009.

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