# National Water Research Institute

FINAL PROJECT REPORT

# A Global Perspective of Low Pressure Membranes

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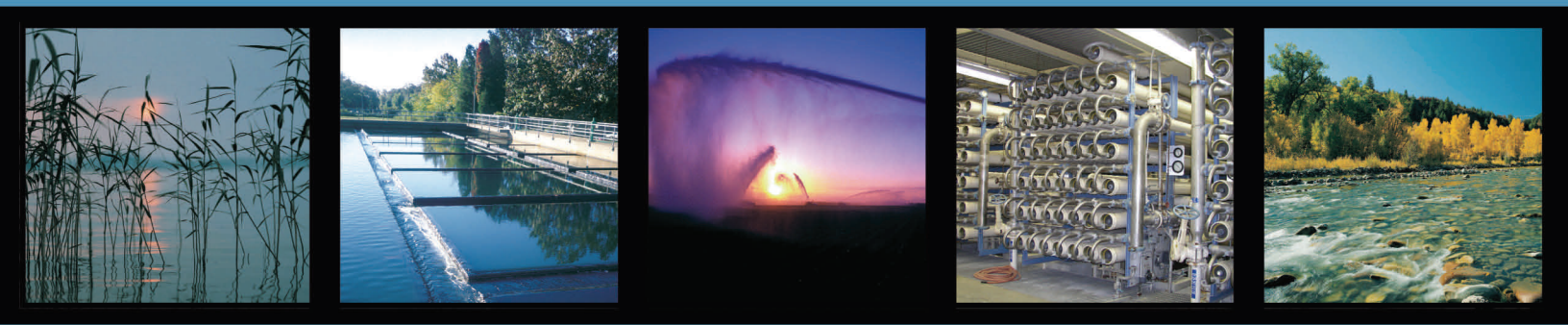

# NWRI Final Project Report

# A Global Perspective of Low Pressure Membranes

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*Published by*:

National Water Research Institute
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March 2008

**About NWRI**

A 501c3 nonprofit organization, the National Water Research Institute (NWRI) was founded in 1991 by a group of California water agencies in partnership with the Joan Irvine Smith and Athalie R. Clarke Foundation to promote the protection, maintenance, and restoration of water supplies and to protect public health and improve the environment. NWRI's member agencies include Inland Empire Utilities Agency, Irvine Ranch Water District, Los Angeles Department of Water and Power, Orange County Sanitation District, Orange County Water District, and West Basin Municipal Water District.

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NWRI-2008-03

This NWRI Final Project Report is a product of NWRI Project Number 07-KM-008.

**Acknowledgements**

The author thanks the National Water Research Institute for providing support for this global survey. The following companies provided data for this study:

- Aquasource (Ondeo Degremont)
- Dow Chemical
- General Electric/Zenon
- Hydranautics (Nitto Denko)
- inge AG
- Koch Membrane Systems
- Kubota
- Kurita Industries
- Memcor (Siemens)
- Mitsubishi Rayon Engineering
- Norit
- Pall Corporation
- Toray Membrane

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# A Global Perspective of Low Pressure Membranes

**Abstract**

Low pressure membrane technology represents a fast-growing industry, and these products will continue to be incorporated into future water and wastewater treatment applications throughout the world. As with reverse osmosis previously, microfiltration, ultrafiltration, and membrane bioreactors underwent a similar development period when they were used for many different niche applications before their broadest applications were recognized. This report is a view of the current status of this industry and includes an account of actual installed capacity through the end of the year 2006.

## *1. Introduction*

This report follows upon the efforts of *Global Status of Microfiltration and Ultrafiltration Membrane Technology*, published in 2002 by the National Water Research Institute (NWRI). The 2002 report was the first effort to publish a global survey of microfiltration (MF) and ultrafiltration (UF) technologies; however, it was compromised by relatively poor record keeping and the reluctance of many companies to share information. As a result, the 2002 report contains incomplete information, compounded by ambitious estimates by manufacturing companies (Furukawa, 2002).

This report was made by contacting nearly 20 companies who were believed to be involved in the manufacturing of low pressure membranes, identified in this report as MF, UF, and membrane bioreactors (MBRs). The data contained herein comprise the results from 13 companies who returned information on their installations. The data are believed to represent more than 90 percent of all installed plants worldwide.

Key colleagues in various regions of the world were consulted to validate estimated capacities. The data presented in this study include municipalities, towns, and communities, as well as industrial uses. The use of low pressure membranes for food and beverage are included in the "other" category. The data were divided into categories of drinking water (DW), wastewater (WW), reverse osmosis (RO) pretreatment, industrial (I), MBR, and other. Laboratory, clinical, pharmaceutical, and biotechnology applications are not a part of this inventory.

## *2. Industry Growth*

The 2002 report discussed the growth of the membrane industry through 2002 and rapid development prompted in the United States by both legislative acts and water-quality related issues. The 1993 cryptosporidiosis outbreak in Milwaukee, Wisconsin, where 403,000 citizens were affected, and the Clark County outbreak were major reasons for rapid growth in this industry when it was determined that MF and UF were capable of removing both *Giardia* cysts and *Cryptosporium* oocysts. Conventional chlorination practiced throughout the United States did not produce a complete kill of these organisms.

Development prior to 1995 was slow and installations were in very specialized niche markets (Furukawa, 2002). The impact of United States regulations and the major *Cryptosporidium* outbreaks in 1993 and 1994 clearly resulted in rapid growth from 1995 forward. The global installed volume for low pressure membranes is shown in Figure 1. It should be noted that this survey is based on installed capacity, not on sales value as reported by others.

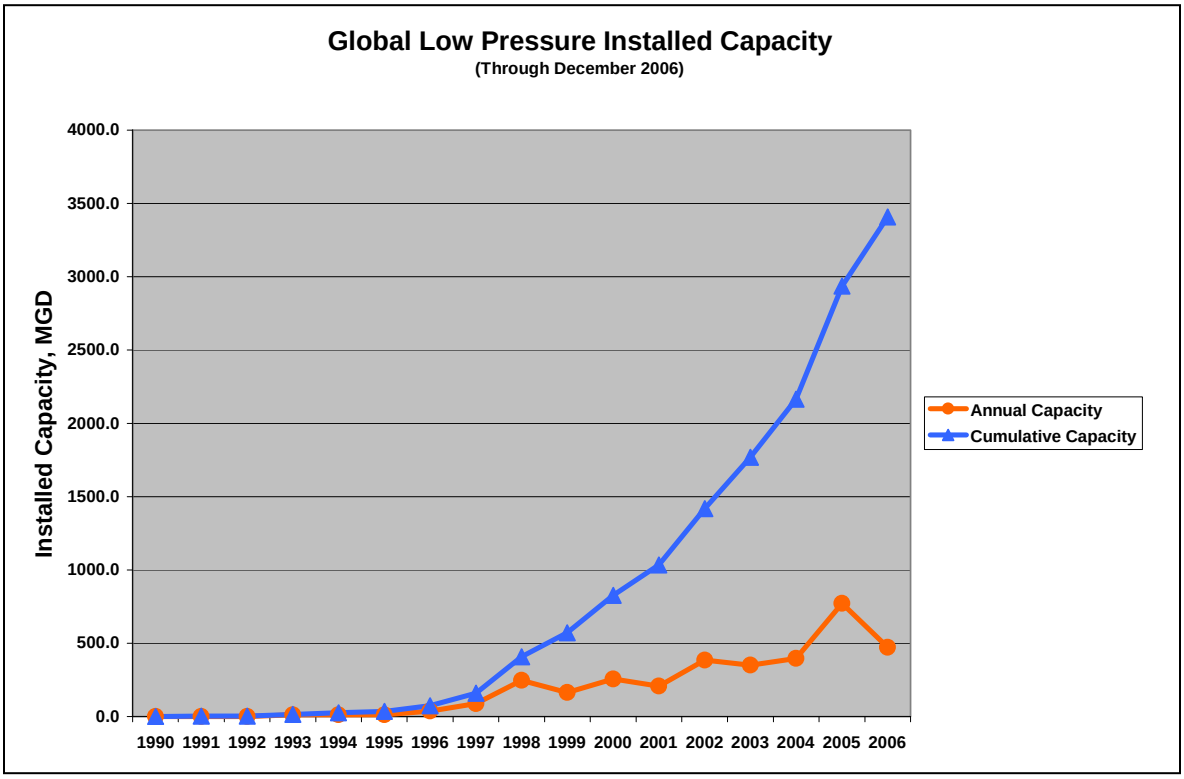


**Figure 1**. Global low pressure membrane installed capacity.

The rapid growth from 1995 is evident and, although the industry has not responded in the nearly exponential growth as predicted earlier, it is growing at an impressive rate. The polymers used for low pressure membranes have progressed from cellulose acetate to variations of polyether sulfones, polyvinylidene fluoride, polyethylene, and polytetrafluoro ethylene. Each has its place in the industry. Some are low priced, others are more robust, and still others are unique for specific niche applications.

The companies responding to this survey are shown in Figure 2. Chinese manufacturers are not represented except from the Dow Chemical acquisition of the Omexell product. The early development of MF in Australia by Memcor was represented by a large number of pilot plant and small systems. As expected in a developing industry, the first company with a viable, economic product has an early and significant effect on market leadership. There has been a trend to gain market share through the acquisition of established companies and businesses. Low pressure membranes have become a significant unit operation in the water and wastewater treatment business. After three acquisitions, the

Memcor business is now owned by Siemens, a global industrial giant with major holdings in electronics, as well as water and wastewater.

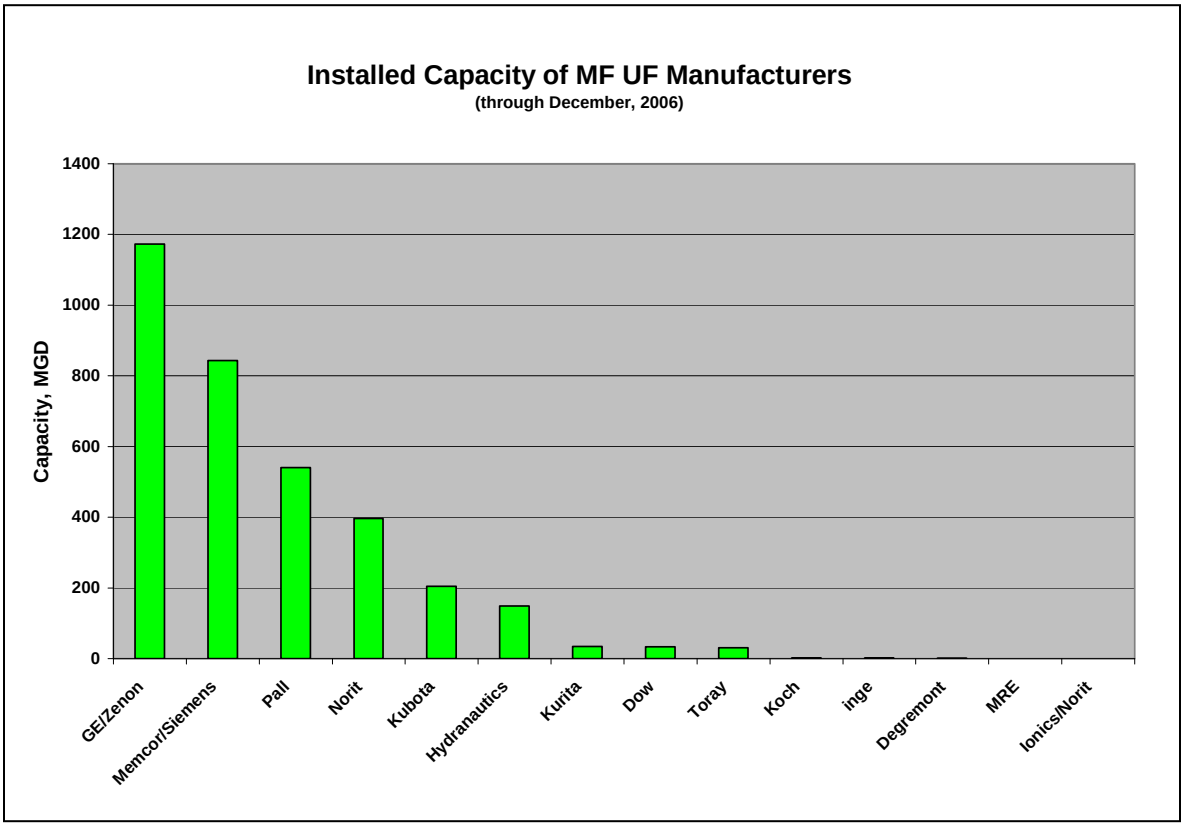


**Figure 2**. Installed capacity of low pressure membrane companies.

Further consolidation was observed with General Electric acquiring Glegg, Ionics, Osmonics, and Zenon companies. The first two were desalination systems companies and the last two were membrane manufacturing companies. Zenon is recognized as an innovator in the low pressure membrane business. Other companies have invested in this business by forming joint ventures or licensing membrane products to remain competitive. Although there will be other consolidations, it seems that the major ones have been made for the present.

At least one company appears to have abandoned low pressure membranes to concentrate on core products, but there are four who have entered the business since 2002. The relatively low installed capacity shown by several companies is typical for products in early commercial development. It is anticipated that their future growth will be substantial, judging from the investments they are making in manufacturing.

### *3. Installed Capacity and Application*

As in the 2002 report, it was found that the greatest installed volume has occurred in the Americas (Figure 3). At the time of this survey, 44 percent of the installed capacity was

in the United States and 19 percent in Europe (including Eastern Europe and a few in neighboring states). The Pacific Rim commands a healthy 23 percent of the capacity, which is growing very quickly. Some of this growth is seen in Australia, where a prolonged drought is causing the country to adapt to other sources for water, including both wastewater reuse and desalination. Although the greatest number of plants are found in Pacific Rim countries, the size of recent installations have been in the million liters per day category. One company is known to have installed significant plants in China, but failed to respond for this report.

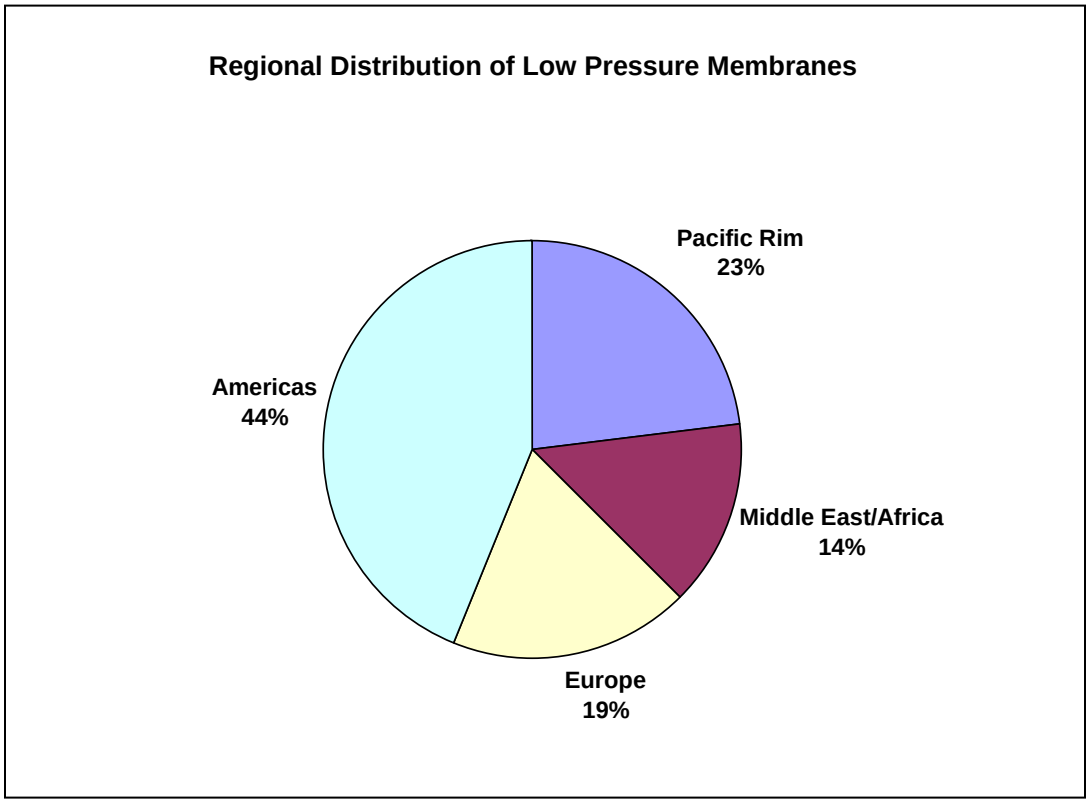


**Figure 3**. Regional distribution of low pressure membranes (by volume).

The Middle East and Africa region has grown rapidly, and this growth was represented by a few very large plants.

MF and UF installations by application are presented in Figure 4. The largest application is for drinking water, followed by wastewater (which is a rapidly growing segment). Although the MBR application is shown as a relatively small 7 percent, most of the wastewater installations for the largest company in the business can also be categorized as used in MBR applications.

Pretreatment for RO is currently shown as a small proportion of installed plants, but it is growing rapidly. In fact, some of the capacity shown for industrial applications is also for RO pretreatment. The same is true for wastewater, where secondary effluent is used

to reclaim high quality water. Such is the case for the Orange County Water District's Groundwater Replenishment (GWR) System scheme. In this single installation, approximately over 80 million gallons per day (MGD) (302,835 cubic meters per day [$m^3$/d]) of secondary effluent will be treated with MF, followed by RO and ultraviolet radiation to produce 70 MGD of highly treated water. This effluent is injected through wells as a seawater intrusion barrier and is transported by pipeline to percolation basins, where the water filters into a groundwater aquifer. In addition, Australia has embarked on a significant water reuse project to supplement drinking water supplies called the Western Corridor Recycled Water Project, as well as is constructing a major desalination plant.

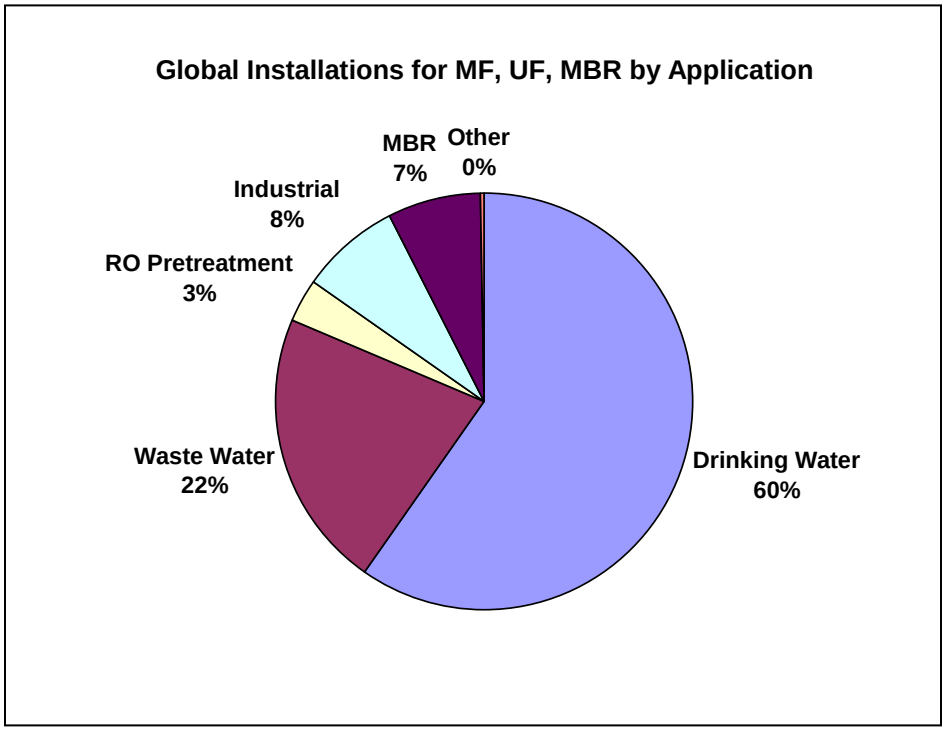


**Figure 4**. Global applications for low pressure membranes.

### *4. Global Market and Costs*

In the 2002 report, it was stated that the cost of MF and UF was nearly equal to the cost of conventional water treatment. Today, the cost for MF and UF is slightly less than for conventional treatment, and they have demonstrated their robustness. The result has been a significant growth in the drinking water sector. Many new water treatment plants are now planning to use low pressure membranes instead of conventional treatment. Plant expansions are also considering a change from conventional treatment to low pressure membranes, which occupy far less land area.

The emergence of submerged hollow fiber and cassette technology has greatly increased the use of these configurations for sewage treatment due to their ability to operate in high suspended solids conditions and their ease in cleaning.

A closer examination of the installations of the top five manufacturers of low pressure membranes reveals different approaches to these markets (Figure 5). Even though Memcor/Siemens was the first to develop and broadly market their hollow fiber technology, their biggest market by far is for drinking water in the Americas. Memcor/Siemens continues to capture a large percentage of drinking water treatment plant installations.

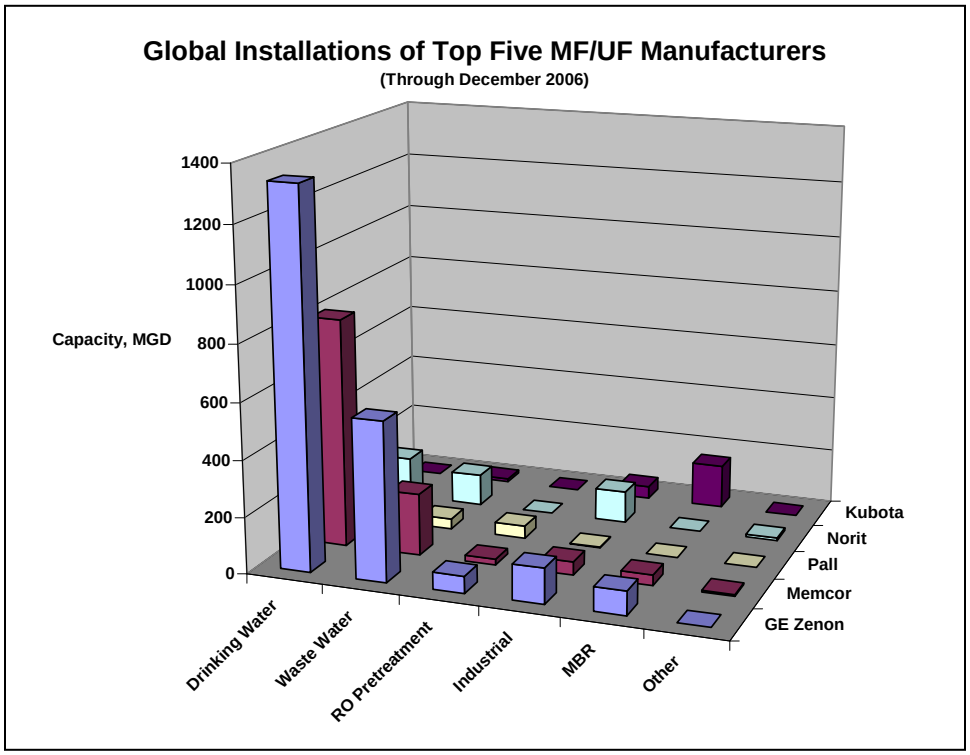


**Figure 5**. Applications of the top five low pressure membrane manufacturers.

Pall Corporation has also been very active in the Americas, followed by GE/Zenon, Norit, and Kubota. Both GE/Zenon and Kubota have been very active in the Pacific Rim, with the latter showing a strong initial presence in Australia and New Zealand. The figure shows the varied interests of the five biggest producers of low pressure membranes, both regionally and in terms of applications.

The global markets for low pressure membranes will continue to grow rapidly, especially in areas that are stricken with prolonged droughts. Both the United States and Australia fall into this category, and both countries are taking major steps to find alternate sources for water. Over 20 seawater desalination plants have been proposed to alleviate water shortages in California, Texas, and Florida. Many of those proposals include the use of MF or UF for pretreatment. Of the proposed California plants, the Carlsbad application

was recently approved conditionally for construction. Others require regulatory and environmental permitting. The proposed plants in Texas are proceeding with pilot plant studies and the preparation of environmental impact reports (EIR). The proposed second plant for Tampa, Florida, has been delayed pending the successful re-start of the Tampa Bay Water plant, where inadequate pretreatment has now been corrected. This plant appeared to be an obvious candidate for low pressure membranes, but a more complex scheme was adopted. Acceptance testing was successful in late 2007.

The broadly-based water improvement plan for Queensland, Australia, demonstrates that a well-planned water development scenario includes many different features. Included in the Queensland development are the Western Corridor Water Recycling Project, seawater desalination, water reuse to replenish surface storage, and major infrastructure improvements (such as an interconnector and distribution pipelines). The desalination plant is a good candidate for MF pretreatment, as is the proposed second seawater plant for Perth, which is proceeding with preliminary design.

Figure 5 indicates that interest has been generated in the Middle East for low pressure membrane equipment, mostly for wastewater treatment. Past experience has shown that once the region becomes comfortable with this technology, the future will be very bright.

There will be a continuing demand for low pressure membranes to replace and augment water treatment plants in the United States. With each year, the plant sizes grow, yet there is a dire need in inland locations for small plants to provide drinking water for small communities. These small communities represent a relatively small volume of the total treated in the country, but comprise a large number of individual installations. Treatment for these communities is made complex by the need for acceptable methods for concentrate discharge and the need for financing.

## *5. Conclusions*

The data presented in this report represent information collected from 13 companies involved in the manufacturing of low pressure membranes, thereby representing more than 90 percent of all installed plants worldwide (through 2006). Major findings include:

- Low pressure membranes have become a significant unit operation in the water and wastewater treatment business.
- The greatest installed volume has occurred in the Americas, with 44 percent of the installed capacity found in the United States, followed by 23 percent in the Pacific Rim, and 19 percent in Europe.
- The largest application is for drinking water, followed by wastewater.
- Some of the capacity shown for industrial applications is for RO pretreatment. The same is true for wastewater, where secondary effluent is used to reclaim high quality water.
- The cost for MF and UF is slightly less than for conventional treatment. The result has been a significant growth in the drinking water sector, with many

new water treatment plants now planning to use low pressure membranes instead of conventional treatment.

Low pressure membrane technology represents a fast-growing industry, and these products will continue to be incorporated into future water and wastewater treatment applications throughout the world.

### *6. Reference*

Furukawa, D. (2002). “Global Status of Microfiltration and Ultrafiltration Membrane Technology.” *National Water Research Institute Briefings*, 11(3): 6-7.