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Forecasting the economic costs of desalination technology

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Abstract

Government policy, in the form of grants and contracts for desalination technology, has had a major impact on steadily declining costs of desalination. The process, reverse osmosis (RO), exhibits economies of scale, which increases its feasibility as a water treatment technology for large populations. Ultrafiltration, an RO pre-treatment, also shows economies of scale. The real economic costs of desalination technology can be forecast using an ARIMA model. If these costs fall below those of conventional water treatment processes, RO and ultrafiltration become competitive with conventional water treatment technology. Our ARIMA forecasts are validated by using independent plant level cost data.

Keywords: Federal funding; R&D; Reverse osmosis; ARIMA, Economies of scale

1. Introduction

The objective of this paper is to forecast the real economic costs of desalination technology, to determine whether the costs for this technology are increasing or decreasing, and if there is evidence of economies of scale. If costs are decreasing, then the new technology could be feasible for all water treatment plants, particularly for improving the quality of fresh water for drinking and industrial use, and treating industrial water prior to discharge or reuse. This paper outlines U.S. Government policy towards desalination R&D from the 1950s to the present. This is followed by an ARIMA model to forecast the costs and consider the point at which this new technology is likely to be competitive with conventional water treatment methods. Our forecasts are indeed consistent with information on costs at individual plants.

2. Spread of desalination technology

There are over 11,000 desalination plants in 120 countries around the world, with a combined capacity of 13.25 Mm^3/d [1]. Saudi Arabia has the most capacity with 5,006,194 m^3/d; the U.S. is next with 2,799,000 m^3/d, and Canada has 35,629 m^3/d [1]. According to the May 2003 Newsletter of the European Desalination Society, global desalination capacity at the end of 2001

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was 24 Mm^3/d [2]. Generally, desalination capital and operating costs have been decreasing, but the increase in energy costs during the 1970s also increased production costs for a short period. The decrease in costs is partly attributable to grants for R&D in the US. While desalination costs have been decreasing, the cost of obtaining and treating water from conventional sources has been increasing. This is due to the fact that in many countries water quality standards have become more stringent, requiring increased levels of treatment. Also, conventionally treated water costs more because of an increased demand for water, resulting in the development of more expensive conventional sources, since the less expensive sources have already been used [3].

The feasibility of desalination technology has much to do with government policy, which took the form of grants and contracts for research and development. The US's interest in desalination is long standing. Droughts in the western US began in some areas in the late 1940s and continue in some of the same areas today, although changes in precipitation patterns have also added new areas of drought. In addition, population growth has concentrated in areas where normal water sources are scarce. This includes California and the entire Southwest, south Texas, Florida and the southeast coast of the US.

In the 1950s, the very limited desalination market was dominated by European manufacturers, which held 70–80% of the market. In 1952, the US Federal Government passed the Saline Water Act and began funding desalination research and development. By the mid 1960s, the US had built 45% of the desalination plants in operation. The European market share had fallen to 50%. In 1964 the Water Resources Research Act was introduced in the US, which provided funding for desalination R&D. During the mid- to late 1960s, much research was done on developing membranes and distillation technology. The technology developed during this period was made freely available worldwide through workshops and published reports. This easy access to the technology contributed to the decrease in costs of desalination.

Throughout the 1960s and 1970s the US remained the leader in desalination technology. Federal support peaked in 1967 at over $100 million (1985 dollars), and steadily decreased until 1973 when funding was all but eliminated. The Saline Water Conversion Act of 1971 provided about $70 million/y in the early 1970s for research grants and contracts. In 1973 the oil embargo increased distillation costs and also increased the need for energy efficiency. As a result of the dramatic increases in the price of oil, by 1974 desalination research had been reduced to $7 million. This resulted in large reductions in ongoing R&D. However, by 1974, reverse osmosis (RO) had been commercialized, reducing the need for federal support.

In 1976 and 1977, the western US experienced a drought that increased the interest in desalination technology once again. This led to the Water Research and Conversion Act of 1977, with desalination research once again focusing on RO. The studies authorized by the Act of 1977 for selecting five locations for desalting demonstrations involved some 26 locations across the country. Five were selected, but funding for construction and operation was not authorized by a federal program. However, some were contracted out to private companies or local agency funding.

Between 1952 and 1982, federal funding averaged $30 million/y (1985 dollars). Competition from European and Japanese companies increased causing sales by US companies to suffer. In the late 1970s, federal funding was partly reintroduced, but was eventually phased out by the 1980s. However, the work did not stop completely since the Bureau of Reclamation carried on with money from federal patent rights and with appropriations for their normal research efforts until the new act and funding in 1996.

The Yuma membrane desalter was constructed