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The history of desalination in the Canary Islands

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ABSTRACT

This paper is a review of the history of desalination in the Canary Islands. There are many problems relating to the water supply in the Canary Islands, such as the scarcity of natural resources of drinking water, energy issues, dependency, and overexploitation. Some of these problems are common to many other areas in Europe. Technologies and innovatory systems have been applied over time to improve the situation in the Canary Islands, such as importing water by tanker ships, first and building the first desalination plant in Spain in the year 1964 (the 24th plant in the whole world). The evolution of desalination technologies in the Canary Islands has been dependent on many factors such as volumes, type of plants, recovery rates, the companies involved, among many others, but the authorities, universities and general population have contributed to the success stories through education, research, doctoral theses, papers, and many different innovative projects. Nowadays, the Canary Islands continues to face the challenge of scarce natural resources and is working on new and more sustainable desalination technologies. Special focus has been placed on the use of renewable energies to reduce CO_2 emissions.

1. Introduction

Water and energy interdependently have always been, are, and will be the driving forces for development in the world. Both are intrinsically linked and together form the concept, “nexus”. It is true that water, although it is energy itself (hydroelectric, geothermal, ocean), needs and depends upon energy for the whole of its cycle (extraction, transport, purification, desalination, distribution, and reuse) as does energy need water, especially in the extraction of coal or oil, and their subsequent conversion into electricity.

Nowadays, water and energy are the main problems that affect our planet. According to the World Health Organization [1], 663 million of people do not have access to water (one in ten), and 2.4 billion people (one in three) do not have access to decent sanitation. Similarly, 842,000 people die each year from diarrhoea while, unfortunately, four under-fives die every 40 min from these causes.

According to the World Energy Outlook 2016, 1.2 billion people do not have access to electricity (one in five), and 2700 million of people have no possibility of cooking with clean water [2].

Based on the above the United Nations (UN) has included within the 17 Objectives of Sustainable Development [3], Water, Energy and Climate Change, as objectives 6, 7, and 13 respectively in the Programme, describing a series of actions to be carried out for each of them such as to:

- Ensure water availability and its sustainable management.
- Ensure access to affordable, secure, and sustainable energy.
- Adopt urgent measures to fight Climate Change and its effects.

It is clear from what has been said, then, that energy and water are the problems that have to be solved urgently in the next 50 years. It is foreseen that population will increase from 6083 million in 2000 to 9347 million in 2050 [4–6]. Energy will have to evolve meanwhile from 295 EJ to a forecasted 518.8 EJ in 2050. Similarly, water consumption will increase from 3500 km^3 to 5500 km^3, increasing its consumption in manufacturing, household and electricity production. Figs. 1, 2 and 3 explain the above mentioned [7–9]. (See Figs. 1, 2.)

2. Background

The Canary Islands are no exception to this situation, and have suffered similar problems over the last half of the 20th century into the 21st (see Fig. 4). The specific problems are:

2.1. Water shortage

Scarcity of water, due to low rainfall [10], is a consequence of:

- The Latitude (27° 37′-29° 25′) that situates the Archipelago within

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the influence of the Trade Winds.
- The influence of the African continent (The island of Fuerteventura is only 100 km from Africa).
- The Southern diversion of the Gulf Stream, the Canary current, and the cold water upwelling from the African coast.

2.2. Energy dependence

Fossil fuel dependence is 91.8% at present, as can be seen in Figs. 5 [11] and 6 [12]. (See Fig. 7.) (See Fig. 15.) (See Fig. 19.)

2.3. Over-exploitation of aquifers

Aquifers have been exploited by wells, together with vertical and cylindrical perforations and galleries, even tunnels of $2 * 2$ m with slopes that reach up to 6 km in length or longer [13]. This has produced marked salinity in the aquifers as well as reducing their levels to 490 m [14].

The Canary Islands has been one of the world pioneers in producing drinking water as a perceived need, although the islands are not alone in their scarcity of resources in Europe. For instance, Cyprus had to be supplied by water using ships, due to a persistent drought in 2008 [15,16] (see Fig. 7).

Some areas of Europe have suffered over-exploitation of aquifers such as has occurred in the Archipelago [15]. According to recent reports by the University of Utrecht and Colorado, aquifers may be totally exhausted in the coming decades [17,18]. Southern Europe is one of the regions most under study. A study predicts that 1.8 billion people could live in areas where groundwater levels are fully or almost completely depleted by the year 2015 (see Fig. 8).

3. Transition

While parts of Europe such as Cyprus experienced drought in 2008 making transport of water a necessity, the Canary Islands was working positively on advances in the field. Indeed, as of 1912, the Eastern Islands had always partially covered their water demands with transport of water by ships. The transport was initially via ship, with two main tankers, the “Viera y Clavijo” and the “León y Castillo”. The water was brought in tanks and transported in barrels, which were transported by donkeys and camels (see Fig. 9) [19].

Subsequently, the barrels were replaced by lorries and cisterns of 100 m^3 transported by Spanish Navy tankers called A-2, A-4, and A-6. However, the capacity was insufficient and other greater vessels, such as the “Juan de Cardona” and “Luis de Requesens” were requisitioned to the task. Later, a further vessel was contracted, owned by the Naviera Química de Valencia, which transported some 82,000,000 l of water to the islands between 1961 and 1962 [20].

The installation of the first desalination plants in 1964 on Lanzarote and in 1974 on Fuerteventura put a partial end to water transport although it was to continue through to the Seventies, especially to Fuerteventura on account of malfunctions in the desalination plant. The last year water was transported was 1974, to a total of 1000 Tm of water [21].

The lack of water was a constant concern on the islands of Lanzarote and Fuerteventura. This moved the political agents to look for solutions in Madrid with the State Government. On one of these trips, the mayor of Arrecife, the government delegate, the president of the Cabildo Insular and the Engineer Manuel Díaz Rijo, discussed the problem of water supplies Lanzarote and proposed the installation of the first desalination plant in Spain.

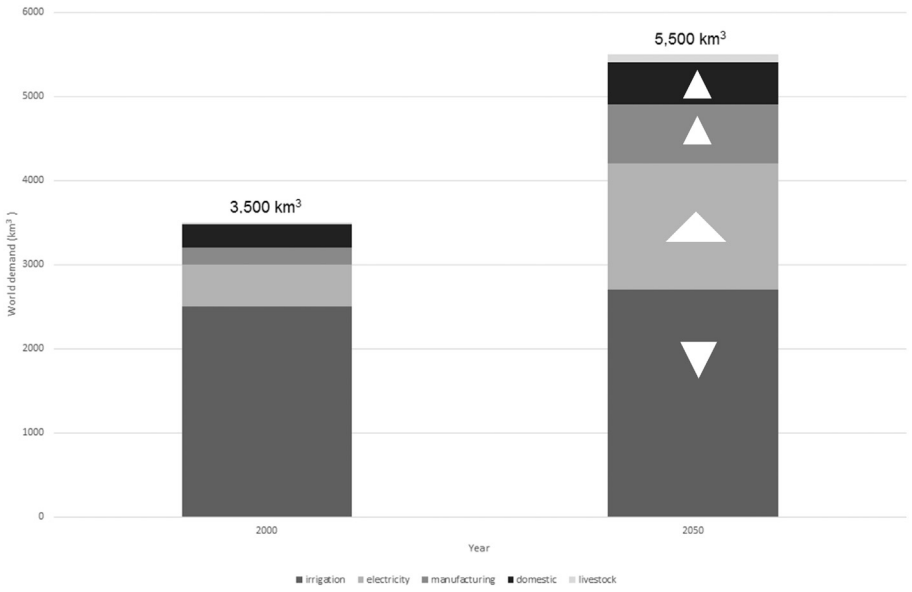
Immediately, forces were deployed to this end including contacts with the Secretary of State in the USA. The future needs of water and energy were calculated at 120 l/person and about 10,400,000 kWh/year. All the administrative procedures for the construction of a multiflash desalination plant (MSF) were initiated, similar to the one already installed in San Diego (California, USA) capable of cogenerating water and electric energy [22].

The plant was owned by Westinghouse Electric CO and it was installed and operated by the engineering firm, Burns and ROE Inc. (see Fig. 10). The plant began to operate at the end of 1964. That year, there were only some twenty desalination plants operating in the world. The technical specifications of the plant are presented in the following table.

4. Evolution of desalination

In the previous section, we described the evolution in the satisfaction of water resources, in the Eastern Islands, from water transport, to the implementation of the first plant in 1964.

This section describes the evolution of desalination in the Canary Islands, detailing this evolution in terms of the following; Volume of desalinated water, desalination plants built, evolution in membranes



Figs. 1, 2. Increase of world water demand. (The Environmental Outlook 2050. OECD 2011).