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ORIGINAL ARTICLE

Water status in the Canary Islands related to energy requirements

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Abstract A review of the methods of obtaining water in the Canary Islands (Spain) is presented, dividing the islands into two groups: the eastern islands and the western islands. This division is due to the different origins of water resources, with western islands using mainly underground sources, while the eastern ones main source is seawater desalination. Water sources define the way in which water is obtained, as well as the energy expenditure to obtain it. In this review, the energy consumption of different methods of drinking water collection is studied, as well as the resources that make up the energy mix in the Canary Islands. In addition, a projection is made for drinking water consumption and energy consumption related to water use in the archipelago up till the year 2035, in order to observe the expected trends in these sectors.

Keywords Water demands · Projection · Renewable energy · Desalination · Water-energy nexus

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Introduction

Oceanic islands have common patterns with respect to water resources with certain specific features, due among other reasons to (i) geological age, (ii) typology of the volcanic island, (iii) average altitude and orography, (iv) type of vegetation, (v) geographical location, (vi) volcanic constituent materials, and (vii) average rainfall (Santamarta et al., 2014). This common origin means that similar solutions may be found to problems shared by the islands, such as guaranteeing water supply, erosion control and soil conservation, as well as safety from major floods and landslides (Hughes & Malmqvist, 2005).

Thirty years ago, hydrological planning in the Canary Islands was about increasing the water supply without considering the environmental or economic limitations, since this resource was necessary at any cost and was the basis of the islands' economic development. The environment was an irrelevant issue in the decision-making process in the field of hydrology. Currently, and with new regulations such as the Water Framework Directive, which is an EU Directive (Quevauviller, 2009), there is a tendency to conduct water management based on demand, giving priority to guaranteed and efficient water resources. Water planning on the islands is conducted through an Island Hydrological Plan, which is the basic instrument of hydrological planning, aimed at achieving the best possible way to meet all the islands' water demands. This is a document that includes all the specifications of the hydrological cycle of each island, an inventory of all the water facilities on the island; establishes the hydrological balance; and estimates the recharge of the aquifer. In short, it is the official document to know the hydrological status of each island, as well as to know the future trends of the island.

Regarding the water resources in the Canary Islands, there are two operating models: the western model (Tenerife, La Palma, La Gomera and El Hierro) and the eastern one (Gran Canaria, Fuerteventura and Lanzarote). In the western islands, water consumption is mainly supplied by groundwater in some cases; such as in Tenerife and La Palma, the percentages exceed 80% of total supply. Groundwater is complemented to a lesser extent by supply from desalination plants, especially on the island of Tenerife. As an exception, it should be noted that on the island of La Palma, there are no desalination plants providing water from the sea to supply the population. As for surface water resources, their quantity is not especially important in this group, and they only have some relevance in La Palma and La Gomera (Table 1).

In the eastern islands, the water supply comes mainly from seawater desalination plants (reverse osmosis). However there are certain exceptions; for instance, in the case of Gran Canaria, there are significant underground resources, extracted mainly from wells, as well as surface resources, stored by an extensive network of large dams (about 60) (Santamarta, 2014). These water resources are mainly used in agriculture. The urban supply, in Fuerteventura, is provided by seawater desalination plants. In Lanzarote, the supply is practically all from desalination with a percentage that exceeds 80%. Lanzarote is an island where agricultural water consumption is substantial, though the urban and tourism water demand is greater.

There are island systems and areas which due to the low contribution of rainfall (Díaz, et al., 2011), between 100 and 250 mm/year, do not have the necessary aquifer recharge to satisfy water demand. In general, rainfall is irregular, from 100 mm in the south to 900 mm in the north of the islands (Gonzalo et al., 2017). Therefore, it is necessary to resort to industrial water production, by means of desalination plants. This implies an energy dependency for water production and high cost that some islands find difficult to meet. Regarding seawater desalination, according to the Canary Islands Government (CIATF, 2015), the number of desalination plants currently existing in the archipelago is 337, with a total production capacity of drinking water (it should be noted that brine production has not been considered in these data), exceeding 660,000 m^3/day, and an annual production capacity estimated at 242 million m^3/year. Of the total production of desalinated water, approximately 70% (462,000 m^3) is used for drinking water supply, 29% (199,000 m^3) for irrigation and 1% (3,000 m^3) for industrial consumption. In the archipelago, the eastern islands (Gran Canaria, Fuerteventura and Lanzarote) allocate approximately between 13 and 18% of energy produced to desalination (González-Morales & Ramón-Ojeda, 2019), whereas the energy impact is lower on the western islands: El Hierro consumes approximately 10% for this purpose (Frydrychowicz-Jastrzebska, 2018) and Tenerife 5%, according to the Canary Islands Government (Plan Hidrológico de Tenerife, 2006). It should be noted that the reverse hydrowind plant (pumped-storage plant) on the island of El Hierro, *La Gorona del Viento*, has been operating since 2015, and it is possible that

Table 1 Assessment of water resources in the Canary Islands and future prospects

Island	Surface water	Groundwater resources	Desalination and water reuse	Storage method	Future trends
Hierro	Nil	High	Low	Water Gallery	Desalination
La Palma	Scarce	High	Nil	Water Gallery	groundwater
Gomera	Medium	High	Nil	Water Gallery	groundwater
Tenerife	Scarce	High	Medium	Water Gallery	groundwater-Desalination
Gran Canaria	High	Medium	Medium	Wells/Dams	groundwater- Surface water- Desalination
Lanzarote	Nil	Scarce	High	Desalination	Desalination
Fuerteventura	Scarce	Medium	High	Desalination/Wells	Desalination

Source: Santamarta, 2011

this percentage has been modified. In fact, this project has enabled the island of El Hierro to become increasingly self-sufficient in terms of energy, and the model can be exported to similar areas due to the good performance it has shown on the island (Frydrychowicz-Jastrzebska, 2018).

We conclude this section by indicating that seawater desalination should be a complement to conventional systems for obtaining and producing water, and not the basis for an island's water supply, except in cases where there are no other options due to a lack of rainfall (i.e. less than 150 mm/year), as is the case of Fuerteventura or Lanzarote. Moreover, it should be noted that in the case of islands where it is necessary to produce water requiring energy, these energy sources should attempt to be sourced from renewable energies.

Study area

The Canary Islands (Spain) are composed of eight islands and five islets, covering an area of approximately 7,500 km^2. They are located, on average, 1,400 kms from the nearest coasts of the European continent (the Iberian Peninsula) and 100 kms off the western coast of the African continent (Western Sahara) (Fig. 1).

The main economic activity in the Canary Islands is the services sector with a weight of 75% of the total economy (de la Cruz et al., 2020). Tourism is the economic driving force of the Canary Islands since the archipelago is the third most popular tourist destination in Spain. Agriculture and fishing are also relevant (1.7% of GDP) (Minondo, 2010). Fruits and vegetables are important exports with crops being mainly vines, potatoes and bananas (García-Rodríguez et al., 2018). The limiting factor in the production of the latter is the availability of water (García-Rodríguez et al., 2016). Regarding industrial sector, this has little weight on the islands representing only about 7% of GDP (CEOE, 2019).

In the Canary Islands, availability of water resources and energy supply can be considered critical, since the population and the islands' economic development depend on these two factors. Water resources must be managed effectively, considering the unique characteristics of volcanic island systems. The main implication of being an archipelago is that the strategies and methodologies used in continental lands may not be valid for limited spaces, due to its vulnerability and dependence in the exterior (Lazrus, 2012).

Agriculture is the most water-demanding activity on the islands (this is valid for all the islands except for Lanzarote and Fuerteventura, where tourism and urban use have more weight). On the islands of La Palma, La Gomera, Tenerife and El Hierro, percentages for agricultural water demand exceed 80% of the total for this resource (Santamarta, 2013). Tourism also represents a significant water demand. In terms of hydrological planning on the Canary Islands, it is estimated that 300–850 L are consumed per tourist per day (Diaz Perez et al., 2018). Depending on the country, this estimation can range from 84 to 2000 L per tourist per day (Gössling et al., 2012), or be lower, as in the case of Morocco, which is between 300 and 600 L (Hadjikakou et al., 2013).

Fig. 1 Canary Islands belonging to the Kingdom of Spain, where Tenerife, La Palma, El Hierro and La Gomera are the western islands and Gran Canaria, Fuerteventura and Lanzarote are the eastern islands. Source: Google Earth

The following sections will therefore study the methods of obtaining drinking water in the Canary Islands and their relationship with the energy they demand. In addition, predictions have been made of what energy consumption on the islands is expected to be like in the coming years and how this may change our water model.

Desalination vs reuse

In the 1970s, desalinating 1 m^3 of water required energy consumption of 22 kWh (Latorre Carrión, 2004). Nevertheless, the application of new techniques has nowadays managed to reduce energy consumption to 2 kWh/m^3 (Naredo, 2007), and reaching values of 1.06 kWh/m^3 at the present time (Gómez-Gotor et al., 2018). Despite this, some authors consider that instead of using desalination as solution to a lack of water (Aguilera-Klink et al., 2000), it would be less costly, in ecological terms, to undertake better management of water demand since "it is cheaper to save 1 m^3 than to produce it". In fact, Naredo (2003) recognizes that "it is not very promising to support the future of water supply from the desalination of seawater reliant on oil" since it is known that the days of cheap oil reserves are counted. In the Canary Islands, 87% of energy used for desalination comes from oil, followed by residual steam (13%) and wind power (0.02%) (Romero-Ternero et al., 2005). Despite the fact that renewable energy covered 17.6% of the electricity demand in the Canary Islands in 2020 (data from the Government of the Canary Islands), there are still few desalination plants that operate self-sufficiently with renewable energies, less than 1% of the total installed in the Canary Islands (Padrón et al., 2019). In addition to energy consumption, the discharge of brine resulting from desalination is another serious drawback of this water production system (Kress et al., 2020). Studies have been carried out to analyse the tolerance of plants and marine animals to this excess salt, demonstrating its negative effects (Gacía & Ballesteros, 2001). However, it has been found that after 25 m away from the coast, the dilution of the brine is practically total.

Furthermore, the process of wastewater treatment and subsequent reuse (defined by Azqueta and Ferreiro (1994) as a "structural system of hydrological planning" may represent a significant decrease in the water supply.

Introduction to energy production systems in the Canary Islands

As a target for 2050, the European Union has set itself the goal of achieving an 80–95% reduction in greenhouse gas emissions (Connolly et al., 2016), adding a further target that renewable energies should cover 20% of total energy consumption by 2020. In Spain, the percentage covered by renewable energies within the country's energy mix is 33% (Ruiz-Romero et al., 2013), which means that Spain still shows a great dependence on oil. Energy in the Canary Islands is mostly produced by thermoelectric power plants (Schallenberg-Rodríguez et al., 2014) (Fig. 2). The archipelago produces all the electrical energy it consumes (Table 2), and the most demanding sectors are those areas with high tourist concentrations and water desalination plants, whose consumption can be estimated at about 30% of all electricity consumption on the islands (Sadhwani and Veza, 2008).

The first energy resource that supplied electricity in the Canary Islands was hydroelectric power. Between the

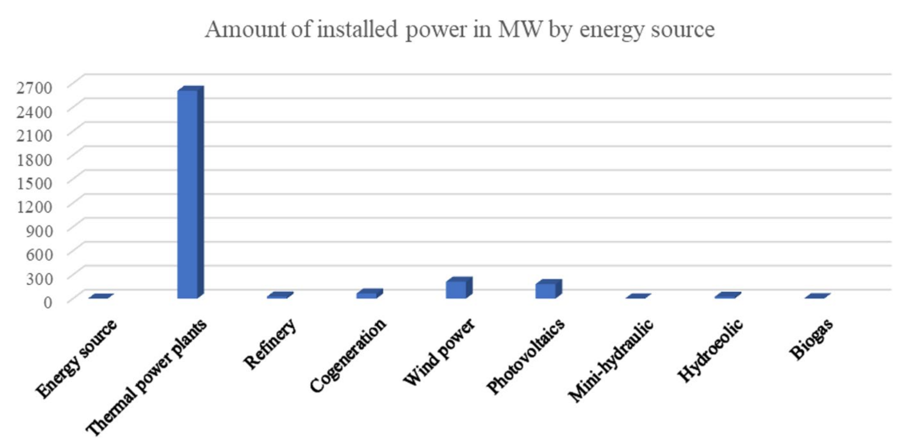

Fig. 2 Installed power in the Canary Islands (MW), year 2013. Source: prepared by authors

Table 2 Produced energy in the Archipelago (2010/2018 period). Source: prepared by authors

Produced energy in the Canary Islands (MWh)							
Year	Tenerife	La Gomera	La Palma	El Hierro	Gan Canaria	Fuerteventura	Lanzarote
2000	2120,5	44,2	186,7	21,8	2470,8	346,6	525,3
2001	2289	44,6	182,7	9,3	2646,8	395,3	573,7
2002	2448,2	49,9	181,7	25,6	2710,6	415,3	609,5
2003	2668,6	55,6	203,8	27,6	2950,7	460,3	669,4
2004	2889,1	57,6	219,6	30,6	3134,9	504	720
2005	3034	58,3	21,818	32,2	3272,4	554,8	755,3
2006	3185,9	60,5	228,4	34,4	3369,7	610	789,4
2007	3327,6	60,9	238,7	36,1	3437,5	620,6	807,8
2008	3402	64	241,6	38	3495,9	629,9	821,1
2009	3277	62,5	242,2	38	3434,4	583	786,2
2010	3235,2	61,1	230,8	35,8	3308,2	584,3	776,6
2011	3194,8	65,2	236,5	38,6	3306	602,5	788,5
2012	3241,7	65,5	240,8	40,6	3287,1	600,4	789,1
2013	3116,6	62,7	225,7	42,2	3186,6	581,1	776,7
2014	3065,6	61,5	225,9	40	3156,6	592	788,9
2015	3109,5	63,5	236	40,4	3176	604,3	799,4
2016	3171,4	65,5	237,5	42	3212,6	630,8	802,2
2017	3252,4	69	234,8	41,5	3246,2	656	817,5
2018	3251,6	67,7	243,7	37,7	3216	647,9	816,5

end of the nineteenth century and the beginning of the twentieth century, electricity arrived in the archipelago through the first hydroelectric plants with mini-Pelton turbines coupled to generators moved by waterfalls on the islands of La Palma and Tenerife, some of which can still be seen in the island's geography. In recent times, the Canary Islands have made a firm commitment to renewable energies, focusing on solar and wind energy. There are several drivers that can lead the energy future of the Canary Islands. Some of the most important correspond to solar and wind energy, reversible plants and the potential of the optimization and use of low-enthalpy geothermal energy (Piña-Varas et al., 2014).

The Canary Islands consist of several distinct electricity systems within an overall isolated archipelago. Consequently, there are certain peculiarities in the electricity supply, which is largely supplied by fossil fuels. This isolated electricity archipelago presents certain problems that can be summarised as follows:

(a) Exponential increase in electricity demand up until 2008 and the subsequent drop introduced uncertainty in energy planning and investments.
(b) Disperse renewable energy production centres (several on each island).
(c) High dependence on fossil fuels.
(d) Pressure for the integration of renewable energies into the electricity system, since in 2019 only 16% of the electricity mix of the Canary Islands was covered by renewable energies (Gobierno de Canarias, 2019).
(e) Administrative and environmental difficulties for the development of new electricity lines and energy projects.
(f) Controversy in the location of new power stations.
(g) Complexity and high bureaucracy for the authorisation of new power generation equipment.
(h) No interconnection between the islands' electricity systems and high construction and operating costs.
(i) Low efficiency in potable water supply services (in some municipalities about 50% of the potable water in the network is lost, with the consequent waste of energy in producing water that is never used) (Custodio et al., 2016).

Water-energy nexus in the Canary Islands

Water can be considered an energy resource when it is stored and turbined, even when small hydroelectric exploitation equipment is installed (mini-hydraulic of less than 10 MW). In other cases, where water is the resource we aim to obtain, it can be achieved by gravity, such as the case of a water gallery, which is a horizontal water mine that perforates the interior of the ground to reach the aquifer and drain the water (Santamartal, 2016).

Another important part of the energy consumption in an integral water cycle is the water treatment process. In a wastewater treatment plant (WWTP), the equipment requires significant energy consumption. Sewage water from WWTPs in urban centres located at high altitudes could also be an energy resource that has not yet been exploited in the Canary Islands, as a potential to install mini hydros in a sewer line falling to a WWTP. Finally, with regard to seawater desalination, although energy consumption has been significantly reduced, it continues to be high and very disparate depending on the type of facility, with economies of scale also having an influence on larger facilities and on costs. In this matter, the new energy recovery techniques in reverse osmosis plants, with specific consumptions in the range of 2.0 to 3.0 kWh/m^3, also stand out (Romero-Ternero et al., 2005).

Projection of hydrological and energy planning in the western islands in the archipelago for the period 2016–2035

Water supply in the future will continue to be devoted to the same sectors, and for the projection period, we are considering the same allocations by use with which consumption has been estimated in the years preceding 2014. It will be assumed, for this first projection, that in the next 15 years, there will be no great variations in water consumption ratios, due to the fact that no significant changes are expected in the population of the Canary Islands, the areas devoted to the primary sector and the number of incoming tourists to the islands.

In the western islands, the forecast for general water expenditure is downwards, mainly due to a decreasing estimation of hectares used for crop cultivation and a decrease in the average allocation per inhabitant resulting from the regional average as a representative consumption of each individual. In this way, consumption is dominated by agriculture and domestic expenditure, as has been the case in the past.

The energy consumption for the projected period will depend not only on the evolution of the population, the number of tourists or the number of workers in the industrial sector, but also on their energy use. Normally, the larger the population, the more services, more public consumption, more likelihood of industries with high consumption, etc., exist. However, we have attempted to develop a forecast that is not only adjusted to the overall evolution of the population. For this reason, we have calculated the consumption ratios according to three groups. These groups are the permanent population, the tourism population (permanent population plus tourism) and industrial workers (Table 3).

Depending on the population segment, their influence will be different on the type of consumption in a more direct and significant way.

A significant part of all hydrocarbons will be consumed as primary energy for electricity generation (Table 4). If the electricity generation mix does not change significantly, this electricity production will

Table 3 Projection of water consumption on the Western Canary Islands

Tenerife (hm^3/year)	**2015**	**2020**	**2025**	**2030**	**2035**
Domestic	72,9	72,4	65,2	65,3	65,1
Agricultural	83	85	82,9	79,7	79,5
Touristic	22	22,3	21,7	20,7	21
Industrial	3,4	3,5	3,4	3,5	3,7
Urban	8,4	8,3	8,5	8,5	8,5
Total	189,8	191,5	181,7	177,8	177,8
La Gomera (hm^3/year)	**2015**	**2 020**	**2025**	**2030**	**2035**
Domestic	1,48	1,43	1,45	1,48	1,49
Agricultural	4,28	4,17	4,16	4,19	4,19
Touristic	0,78	0,85	0,93	0,79	0,8
Industrial	0,026	0,027	0,025	0,025	0,025
Urban	0,2	0,19	0,19	0,2	0,2
Total	6,76	6,67	6,76	6,68	6,7
El Hierro (hm^3/year)	**2015**	**2 020**	**2025**	**2030**	**2035**
Domestic	0,75	0,68	0,64	0,65	0,67
Agricultural	2,02	2,03	1,88	1,82	1,75
Touristic	0,02	0,02	0,01	0,02	0,02
Industrial	0,014	0,014	0,014	0,013	0,013
Urban	0,1	0,09	0,08	0,09	0,09
Total	2,9	2,82	2,63	2,58	2,54
La Palma (hm^3/year)	**2015**	**2020**	**2025**	**2030**	**2035**
Domestic	6,88	6,44	6,36	6,04	5,95
Agricultural	63,98	62,12	59,75	57,76	58,22
Touristic	0,47	0,5	0,53	0,5	0,51
Industrial	0,188	0,189	0,19	0,187	0,183
Urban	0,78	0,75	0,75	0,74	0,73
Total	72,29	70	67.56	65.23	65.59

Table 4 Projection of hydrocarbon consumption on the western Canary Islands

Tenerife							La Palma						
Source		2015	2020	2025	2030	2035	Source		2015	2020	2025	2030	2035
LPG	Butane	22.812	22.649	23.034	23.066	23.002	LPG	Butane	3.126	3.018	2.979	2.955	2.913
	Propane	17,211	17.088	17.379	17.403	17.355		Propane	0	0	0	0	0
	Total	40.023	39.738	40.413	40.469	40.357		Total	3.126	3.018	2.979	2.955	2.913
Gasolines	Gasoline 95	133.997	133.359	134.874	134.483	134.145	Gasolines	Gasoline 95	12.621	12.232	12.093	11.976	11.807
	Gasoline 98	89.690	89.263	90,277	90.015	89.789		Gasoline 98	5.153	4.994	4.938	4.890	4.821
	Total gasolines	223.687	222.622	225.152	224.498	223.934		Total gasolines	17.775	17.226	17.030	16.866	16.627
Gas oil	Gasoil IVP	191.196	190.286	192.448	191.889	191.408	Gas oil	Gasoil IVP	19.383	18.785	18.572	18.392	18.132
	Distributors	75.527	75.168	76.022	75.801	75.611		Distributors	5.115	4.957	4.901	4.853	4.785
	Sector	364.959	363.222	367.349	366,282	365,362		Electric	820	795	786	778	767
	Total Gasoil	631.683	628.677	635.819	633.972	632.381		Total gas oil	25.318	24.537	24.258	24.024	23.684
Diesel oil	Industrial	13.903	14.066	13.851	13.431	13.247	Diesel oil	Industrial	0	0	0	0	0
	Sector	0	0	0	0	0		Electric	0	0	0	0	0
	Total diesel	13.903	14.066	13.851	13.431	13.247		Total diesel	0	0	0	0	0
Fuel oil	Industrial	12.077	12.219	12.032	11.667	11.508	Fuel oil	Industrial	0	0	0	0	0
	Sector	429.591	427.546	432.403	431.148	430.065		Electric	51.159	49.580	49.017	48.543	47.857
	Total fuel oil	441.668	439.765	444.435	442.815	441.573		Total fuel oil	51.159	49.580	49.017	48.543	47.857
La Gomera							El Hierro						
Source		2015	2020	2025	2030	2035	Source		2015	2020	2025	2030	2035
LPG	Butane	727	704	714	725	733	LPG	Butane	321	290	274	279	288
	Propane	0	0	0	0	0		Propane	0	0	0	0	0
	Total	727	704	714	725	733		Total	321	290	274	279	288
Gasolines	Gasoline 95	2.222	2.171	2.206	2236	2.255	Gasolines	Gasoline 95	1.234	1.115	1.056	1.072	1.110
	Gasoline 98	1.127	1.102	1.120	1.134	1.144		Gasoline 98	708	640	606	615	637
	Total gasolines	3.349	3.273	3326	3.370	3.399		Total gasolines	1.942	1.755	1.662	1.687	1.746
Gas oil	Gasoil IVP	3.221	3.734	3.795	3.845	3.878	Gas oil	Gasoil IVP	2.729	2.466	2.335	2.371	2.454
	Distributors	1.280	1.251	1.271	1.288	1.299		Distributors	764	691	654	664	687
	Electric	0	0	0	0	0		Electric	0	0	0	0	0
	Total gas oil	5.101	4.985	5.066	5.133	5.177		Total gas oil	3.494	3.157	2.989	3.036	3.141
Diesel oil	Industrial	270	274	261	257	253	Diesel oil	Industrial	33	33	32	30	30
	Electric	14.960	14.619	14.856	15.053	15.18_’		Electric	9.841	8.891	8.420	8.550	8.848
	Total diesel	15,230	14.893	15.117	15,311	15.435		Total diesel	9.874	8.924	8.452	8.581	8.878

Table 4 (continued)

Fuel oil	Industrial	0	0	0	0	0	Fuel oil	Industrial	0	0	0	0	0
	Electric	0	0	0	0	0		Electric	0	0	0	0	0
	Total fuel oil	0	0	0	0	0		Total fuel oil	0	0	0	0	0

account, as it already does today, for around two thirds of hydrocarbons consumed. This fact has several impacts, such as dependence on the outside world (Rodríguez Portugues, 2010), and the high economic and environmental costs associated with the extraction of this resource (involving its transport, market price, polluting emissions and environmental damage) (Alonso et al., 2016). This is why the estimate was not optimistic about renewable energies and electric vehicles in the coming years and considered that the use of hydrocarbons will continue to grow.

As we mentioned earlier, one of the most energy-consuming activities in the Canary Islands is water desalination. For this reason, we have attempted to make an estimation of the amount of water that will have to be desalinated in the coming years (Table 5). The percentages used are different, as the growth of desalination is not estimated to grow equally in all the islands. These percentages are marked by the importance of other water resources in the islands, which will prevent a greater growth of desalination. The island of La Palma has not been considered, as there are currently no seawater desalination plants on the island.

We must consider that, in this case, there is the possibility that the processes used for desalination decrease their energy consumption, although this possibility is unlikely, since various publications and organizations, such as the Centre for Public Works Studies and Experimentation, attached to the Spanish Center for Public Works Studies and Experimentation (CEDEX), reveal, "the margins available for reducing energy consumption are already quite small, given that the main Spanish plants exceed the optimal consumption calculated in the osmosis phase by a margin that varies between 9 and 14%" (Estevan & García, 2007). According to a study carried out in the desalination plants of the Canary Islands, it is established that energy consumption has been optimised over the years (Arenas Urrea et al., 2019).

Future prospects in the Canary Islands

The Canary Islands are increasingly opting for a future with renewable energies (Gils & Simon, 2017), in fact, this is the objective of the draft law

Table 5 Assumptions on energy consumption and waste generated in desalination in 2025

Desalinated water	Volume	Energy consumption		Tons of hydrocarbons (Tm)			Brine waste
Tenerife (2025)	hm^3	GWh	Ton oil equivalent	Gas oil	Diesel	Fuel oil	hm^3
25% of supply	45,40	227,00	19.525,00	19.134,00	22.724,00	26.214,00	55,50
50% of supply	90,30	454,00	39.050,00	33.267,00	45.443,00	52,428,00	111,00
75% of supply	136,20	631,00	53.576,00	57.401,00	63.172,00	73.642,00	166,50
La Gomera (2025)	hm^3	GWh	Ton oil equivalent	Gas oil	Diesel	Fuel oil	hm^3
20% of supply	1,35	6,30	532,00	570,00	677,00	731,00	1,70
35% of supply	2,37	11,30	1.018,00	997,00	1.134,00	1.366,00	2,90
50% of supply	3,33	16,90	1.454,00	1.425,00	1.692,00	1.952,00	4,10
El Hierro (2025)	hm^3	GWh	Ton oil equivalent	Gas oil	Diesel	Fuel oil	hm^3
50% of supply	1,31	6,60	565,00	553,00	657,00	753,00	1,61
75% of supply	1,97	9,90	347,00	330,00	936,00	1.137,00	2,40
95% of supply	2,50	12,50	1.073,00	1.051,00	1.249,00	1.440,00	3,00

entitled “Law on Climate Change and Energy Transition of the Canary Islands”. There are more and more studies focused on studying the carbon footprint in the archipelago of various sectors: tourism (Diaz Perez et al., 2018; Pérez et al., 2019), transport (Antequera et al., 2021) and desalination (Leon et al., 2021), in order to know the starting point from which to approach the reduction of emissions in the archipelago.

Renewable energy related fields such as geothermal (Perlock et al., 2008), wave and offshore wind (Veigas & Iglesias, 2013) and solar are being explored. The objective is to decarbonize the archipelago, use renewable energies and reduce the dependence on fossil fuels so closely linked today to the production of drinking water in the Canary Islands.

Conclusions

In the Canary Island archipelago, energy and water are totally linked, given that on some islands, the only possibility to cover water demand is through using desalination plants, which, in turn, rely on energy. As tourism and the local population are showing upward trends on the islands, with the islands establishing themselves as a popular tourist destination and a fixed place of residence for many people, it is necessary to establish energy planning that considers renewable energies in order to meet demand. Similarly, water planning that considers water reuse is required. Indeed, it is increasingly necessary to close the water cycle (from supply to reuse) due to decreasing rainfall that directly affects aquifer recharge, which has traditionally been the source of water for the Canary Islands (statements made on the basis of hydrological studies conducted by the Government of the Canary Islands in their Hydrological Plans for each island). From now on, it will be necessary to implement measures to reuse water, either to recharge aquifers artificially or to use this water for purposes that are currently covered by drinking water.

The water and energy nexus in the Canary Islands is key, as anything that affects energy costs will directly affect water supply on the islands, in particular the industrial production of water. According to the results of the projections, the main need, in terms of water consumption, is not to implement policies aimed at increasing water production or production from non-conventional resources, rather the most logical priority is to promote policies to enhance saving and rational consumption.

Wastewater reuse in tourist facilities, for example, should be encouraged as an alternative for irrigation of green areas and for use in closed circuits (cooling of equipment, etc.). In addition, drinking water distribution networks should be improved to avoid losses of drinking water on the way to the end user. Finally, a more rational use of water by agriculture would be necessary to avoid flood irrigation, which requires much larger quantities of water than drip irrigation.

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Declarations

Conflict of interests The authors declare no competing interests.

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