Energy Policy 132 (2019) 839–853

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Calculation of tourist sector electricity consumption and its cost in subsidised insular electrical systems: The case of the Canary Islands, Spain

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ARTICLE INFO

Keywords:
Electricity
Archipelago
Tourism
Costs
Prices
Subsidies

ABSTRACT

The Canary Islands is a European archipelago whose principal economic activity is international tourism. Due to its geographic isolation, it does not have any connection with continental electricity grids. The Spanish state subsidises the extra cost of electrical energy generation in isolated systems. The purpose of this study is to quantify the proportion of the electricity bill that corresponds to tourist activity that is being subsidised. With this aim, three complementary methodologies have been developed. These tools could also be used in similar environments. The results reveal an average tourist sector consumption in the study years (2014–2017) between 12.8% and 16.5% of the total amount of electricity generated in the archipelago, with a monetary value of Spanish state subsidy estimated in €143.5 M in the year 2014. Additionally, a calculation was made of the values of CO_2 emissions due to tourist electricity consumption for the years of the study period, with an estimated peak of 1.1 $MtCO_2$ in 2017. From the point of view of energy policy, these results could be used to justify the adoption of various types of compensatory measures, including ecotaxes to be paid by the tourist visitor.

1. Introduction

Insular electrical systems are an interesting field of study. Not only do they display the characteristics of isolation and the conditioning socioeconomic factors of islands, they are also complete electrical systems which contain all the complexities associated with such systems, albeit on a relatively small scale (Cross et al., 2017). A significant proportion of the world's population lives on island territories of varying size. By way of example, there are some 2,400 inhabited islands in the European Union (EU). The 15 million people who live on these islands make up about 3% of the total population of the EU (European Commission, 2017). For various reason, insular electrical systems are also a challenge in terms of energy management. These reasons include: (i) electricity generations costs tend to be higher in island as opposed to continental territories because most islands depend on the importation of conventional primary energy sources to satisfy demand, which implies additional transport costs (Colmenar-Santos et al., 2013); (ii) the economies of scale associated with major generation units are generally not applicable as the shut-down of such a unit could destabilise the entire generation system of an island (Perez and Ramos-Real, 2007); (iii) most electricity generation systems are based on the use of petroleum derivatives with high emission rates of polluting and greenhouse gases (Cross et al., 2017; Michalena et al., 2018); (iv) problems related to voltage and frequency control are normally more complicated because of the limited possibilities of interconnection with the electrical systems of other islands or continental territory (Perez and Ramos-Real, 2007).

In consequence, when no interconnection with continental systems is possible, an infrastructure is generally employed on islands which has the capacity to generate more electricity than is strictly required to ensure the availability of a reserve margin. Such a reserve margin is not limited to the generation systems, but also includes fuel storage - especially when the systems are based on petroleum derivatives. Any breakdown in the electricity generation infrastructures or delays in the arrival of components or fuels can thus be dealt with. However, the need for such contingency measures means that both investment and maintenance costs tend to be higher than for continental systems. These extra costs compared to continental electrical systems can result in higher electricity prices for consumers on islands than on the mainland, even when they form part of the same country. This is the situation in Hawaii, in the USA, where the price of electricity is three times higher than the country-wide average (Hawaii State Energy Office, 2018). In

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https://doi.org/10.1016/j.enpol.2019.06.032
Received 18 October 2018; Received in revised form 15 May 2019; Accepted 17 June 2019
Available online 27 June 2019
0301-4215/

other countries, like Spain, the extra costs incurred as the result of insular electrical systems are proportionally divided throughout the country so that the price of electricity is identical for all consumers, whether they live in one of the Spanish archipelagos or on the mainland (Perez and Ramos-Real, 2007).

International tourism is today regarded as one of the most important economic activities in the world. It accounts for 10% of world Gross Domestic Product (GDP), with 1,184 million international tourist arrivals in 2015 and approximately 1 in every 10 workers employed in tourism-related activities (UNWTO, 2017). The global economic activity associated with tourism has resulted, in general terms, in socioeconomic improvements in many of the cities, territories and countries where it is prevalent. Nonetheless, as with any other industrial activity, it is also associated with environmentally harmful effects. Some of these effects are related to the, mainly electrical, energy consumption of the tourists during their stay and to the transportation from and back to their places of origin. According to Rutty et al. (2015), there is clear evidence that the negative impact on the environment due to energy consumption in the tourist sector has progressively increased since the 1990s. These authors estimate at 5% the contribution of the tourist sector to global anthropogenic CO_2 emissions in 2005. High values like this have led various authors to specifically study the relationship between energy consumption and the tourist sector, both from the perspective of the type of tourist activity (Becken et al., 2003; Matthew et al., 2017) and in terms of geographical location (Katircioglu, 2014; Katircioglu et al., 2014, Pablo-Romero and Molina, 2013). In this respect, 195 countries signed the 2015 Paris Agreement (United Nations, 2015), the aim of which is to strengthen the global response to the threat of climate change by keeping the increase in global average temperature to below 2 °C compared to pre-industrial levels. This agreement requires countries to submit intended nationally determined contributions (INDCs), which in practice imply limitations to the emission of greenhouse gases.

Although not directly linked to the scope of the present paper -tourist sector electricity consumption and its cost in subsidised insular electrical systems-, the literature shows several research contributions addressing the problematics of isolated electrical systems consumption. The work by Bakhat and Rosselló (2011) assessed the electricity demand pattern and investigates the aggregated contribution of tourism to electricity consumption using the case study of the Balearic Islands. Their findings suggest an electricity demand with an increasing sensitivity depending on the population stock. Cross et al. (2017) developed a comprehensive benchmarking survey of power systems in 28 different islands to identify unique challenges faced by this kind of territories. The focus of their study was on environmental, economic and social sustainability. They attempted to identify solutions to particular technical issues encountered in islanded systems. Katircioglu et al. (2014) investigated the long-run equilibrium relationship among international tourism, energy consumption, and carbon dioxide emissions, and found a positive and statistically significant direction of causality among these variables in the case of Cyprus. The study of Tsai et al. (2014), on the other hand, focused on the microanalysis of hotels and homestay facilities in Taiwan. They evaluated the average CO_2 emissions of international tourist hotels, standard tourist hotels, general hotels, and homestay facilities, to endorse the formulation of government policy for CO_2 reduction programmes in Taiwan.

Many island territories base part of their economy on tourism and, as they are surrounded by sea, this is often what is known as 'sun and beach' tourism. In such cases, tourism demand is commonly seasonal in nature, incorporating an additional complexity to the difficulties of electricity generation in islands. This added complexity as the result of the extra seasonal demand will depend on the weight of the tourist sector in the island's economy. Given the above, the importance is clear of an in-depth knowledge and understanding of the dynamics of electrical energy production and consumption in island territories.

These factors, namely the existence of isolated electricity generation systems with additional costs compared to continental systems, an important tourism-based economic activity, and the consequent negative environmental impact due to the generation of polluting and greenhouse gases, can all be found in the Canary Islands (Spain). In addition, the fact that the price of electricity in Spain is the same for all consumers, regardless of where they happen to live, makes it important to know the additional economic cost that the inhabitants of mainland Spain have to bear to defray the costs of electricity generation in the insular systems. This is of particular interest when part of this additional cost is due to visitors from abroad who take their holidays in the archipelago. Likewise, it is useful to know what proportion of the quota of CO_2 emissions corresponding to Spain is due to an extrinsic factor as is the tourist activity in the Canary Archipelago.

In this study, using different methods, a calculation is firstly made of electrical energy consumption as the result of tourist visits to the Canary Islands in the period 2014–2017. The value of the subsidy attributable to this sector is then quantified along with the equivalent tonnes of greenhouse gases emitted as the result of energy consumption associated with the tourist activity. This study will focus exclusively on analysing the electrical energy consumed in the tourist sector, without considering other energy sources such as the thermal energy (butane or propane gas) consumed in the kitchens of the hotel sector or the energy (petrol, diesel or kerosene) consumed in the transportation of the tourists to and from their holiday destination. For the purposes of this work and using as a reference the definition of the UNWTO, the tourist sector is considered simply as integrating all the activities carried out by people during their stay in places other than their usual environment.

This study addresses an issue of potential interest for many territories that converge similar characteristics to those of the Canary Islands: the presence of an isolated electrical system based mainly on fossil energies with an important contribution from the State in form of subsidies to afford extra costs, and where the touristic activity constitutes an important part of the local economy. The study shows that the touristic activity can give way to significant electrical consumption and CO_2 emissions, whilst being benefited by subsidies paid for by citizens. This could be a matter of concern for public bodies that, eventually, would find justification to adopt compensatory measures. To our knowledge, this is a new line of research. The work can contribute to similar territories to apply and improve the evaluation tools explained on this paper, as well as to compare the results, thus generating a new body of knowledge of potential interest for the academic community and policymakers. The structure of the study is as follows: firstly, a description is given of the territory which is the object of the study, namely the Canary Islands, and of the main characteristics of its systems of electrical energy generation; different methodologies are then proposed to quantify the electrical energy consumption that is attributable to tourist activity; to ensure the reliability of the methodologies a table is provided which shows the corresponding margins of error in the study as well as the convergence of the different methodologies used; finally, the conclusions of the study are given.

2. The Canary Islands: physical and socioeconomic characteristics, and characteristics of its electrical energy generation system

The Canary Islands are situated in the Atlantic Ocean, facing the northwest coast of Africa at between 30° and 32° north latitude. There are seven main islands with a permanent population of around 2 million in 2017 (ISTAC, 2018). The two most populated islands (Gran Canaria and Tenerife) correspond to 78% of the total population. The location of the archipelago, in an area with temperatures considerably higher than those of the northern territories of Europe in winter, has made the islands an attractive destination for the inhabitants of these countries. In addition, the relative closeness of the archipelago to the main airports of central Europe and the United Kingdom (flights of between 4 and 5 h) has encouraged the influx of large numbers of tourists, especially between the months of October and May, when temperatures are considerably lower in the countries of origin.

In terms of grid interconnection, the islands are completely separated from each other (except in the case of Lanzarote and Fuerteventura, which are interconnected by a 50 MW capacity underwater cable). The installed electrical energy production capacity of the islands amounts to 2,790 MW in 2017 (REE, 2018a). Most of this installed capacity (80% of the total) is concentrated on the two most populated islands (Gran Canaria and Tenerife). With respect to electricity generation outside the continental market, the specific costs incurred by the insular systems have to be taken into account in order to compensate the generating companies for their higher production costs. These additional costs are proportionally spread out in the electricity bills throughout the country with the result that electricity consumers on the islands pay the same price per kWh as those who live on mainland Spain.[1] This in turn means that the electricity bill for mainland consumers is higher than it would otherwise be.

3. Methodology

Assessments of the impact of the tourist sector on energy consumption have been performed for numerous territories (Becken et al., 2003; Katircioglu, 2014; Zaman et al., 2016). Modelling, using different techniques, is required to evaluate the impact of tourism in energy terms. Transferring these techniques to the analysis of insular systems requires significant amounts of data and its subsequent modelling to obtain the desired results (Bakhat and Rosselló, 2011). One of the main measures of interest to enable scheduling of the precise energy supply required is the estimation of the energy and/or electricity consumption that is demanded by tourism.

Estimation of the electrical energy consumed in the tourist sector is complicated by the fact that tourism is not recognised as an economic sector in a strictly conventional sense. Likewise, some subsectors of tourism are of a mixed nature given that their activity can be considered partly a service for tourists and partly a service for the local population, as for example with restaurants and shopping centres (Bakhat and Roselló, 2011). Three methods are explained in the present section to calculate the electrical energy consumed by the tourist sector in the Canary Islands. The aim of the calculation is to separate the annual electrical energy consumption of the two sectors of the population, resident and tourist. The data used include both global (covering all the archipelago) and local (each island) data and extend from 2014 to 2017. These data series correspond to a period of stability and sustained growth, as had indeed been the trend in the sector before the emergence of the economic crisis which shook Spain and other European countries between 2009 and 2013. All the data were obtained from official sources, including the regional Canary Government, the National Institute of Statistics, the electricity system operator (REE), etc. As the two smallest islands of the archipelago (La Gomera and El Hierro) have no official tourist data, this study will concentrate on the five islands which do and their four insular electrical systems: Gran Canaria, Tenerife, Fuerteventura-Lanzarote and La Palma.

[1] ITC/913/2006. Order of 30 March regarding the method for calculating the cost of each used fuel, and the procedure for the dispatching and payment of energy in the islands and off-mainland electrical systems. www.boe.es/boe/dias/2006/03/31/pdfs/A12484-12556.pdf. [accessed June 2018].ITC/914/2006. Order of March 30, which establishes the method for calculating the remuneration of guaranteed power, for generation installations in the ordinary regime, in the islands and off-mainland electrical systems. www.boe.es/boe/dias/2006/03/31/pdfs/A12557-12585.pdf. [accessed June 2018].

3.1. Method of linear fit between energy and population

The proposed model estimates the unit electrical energy consumption of the resident population and the unit electrical energy consumption of the tourist population. The expression proposed is as follows:

$$Energy_{year} = Residents_{year} * consumption_{res.\ year} + Tourists_{year} * consumption_{tou.year} \quad (1)$$

The electrical energy consumed in a year is a function of the electricity consumed by the resident population and the electricity consumed by the tourist population. The only thing that needs to be calculated for the first equation is the unit consumptions defined as $consumption_{res.year}$ *and* $consumption_{tou.year}$, as the other data are available. Applying in Eq. (1) the years for which data are available, we have:

$$\begin{pmatrix} E_{year\ 1} \\ \cdots \\ E_{year\ n} \end{pmatrix} = \begin{pmatrix} R_{year\ 1} & T_{year\ 1} \\ \cdots & \cdots \\ R_{year\ n} & T_{year\ n} \end{pmatrix} \begin{pmatrix} c_{res.year} \\ c_{tou.year} \end{pmatrix}; \ \hat{E} = \hat{RT} \cdot \hat{Crt} \quad (2)$$

The two unknowns, electrical energy consumption of the resident population in the year and electrical energy consumption by visitors to the territory (island or archipelago), can be calculated by applying a least-mean-squares (LMS) fit (Treichler et al., 1987).

$$\hat{Crt}_{optimal} = (\hat{RT}' \cdot \hat{RT})^{-1} \cdot \hat{RT}' \cdot \hat{E} \quad (3)$$

An additional restriction also has to be considered, namely that the two variables obtained must always be positive. In this way, the consumption of the resident and of the tourist population in the Canary Islands can be calculated.

3.1.1. Annual consumption of electrical energy in the Canary Islands

The data available in most of the databases at national and regional level correspond to the archipelago as a whole. An initial calculation can thus be made to study the impact of tourism on electrical energy consumption based on these data for all the islands together. As information is available for various consecutive years on the number of tourists who have visited the islands and the energy generated on the islands, a calculation can be made of the electrical energy consumption per resident and the electrical energy consumption of each tourist who has visited the islands. In this case, the very low resident population and number of tourist visitors to the islands of La Gomera and El Hierro will not distort the overall values for the archipelago. The Canary Islands data for electrical energy consumption, resident population and number of visiting tourists are shown in Table 1.

After performing the fit proposed in Eq. (1) and for the different years of data shown in Table 1, the following values were obtained (Table 2).

Table 2 shows the values of the coefficients and the percentage applied in Eq. (1). Applying these data to the years 2014–2017, the total values of energy consumed by tourists during the study years can be obtained as well as percentage of consumption. The results are shown in Table 3.

3.1.2. Annual electrical energy consumption in the different Canary Island insular systems

The four of the six insular systems for which information related to the tourist section is available were studied. As previously mentioned, the two subsystems of the islands of La Gomera and El Hierro were excluded from the study because of their relatively low resident population, number of tourist visitors and levels of electricity consumption compared to other insular electrical energy subsystems. The annual resident population and the number of tourist visitors in each of the 4 insular subsystems studied are shown in Table 4.

The annual electrical energy consumption in each of the four insular

Table 1
Global data of electricity consumption, resident and tourist population for the Canary Islands.
Source: (1) Gobierno de Canarias (Canary Islands Government), REE - Red Eléctrica Española (Spanish System Operator); (2) ISTAC - Instituto Canario de Estadística - Canary Institute of Statistics; (3) INE - Instituto Nacional de Estadística (National Institute of Statistics).

Year	Electrical energy: Canary Islands (GWh) (1)	Resident population: Canary Islands (2)	Tourist population: Canary Islands (3)
2014	8580	2104815	11475211
2015	8669	2100306	14011490
2016	8777	2101924	15538019
2017	8955	2108121	16713975

Table 2
Results of specific consumptions of the resident and tourist population in the Canary Islands.
Source: Own elaboration.

Annual resident consumption (MWh/year/resident)	3.5897
Annual tourist consumption (MWh/year/tourist)	0.0804

Table 3
Electrical energy consumed by the tourist sector and its percentage with respect to total electrical energy consumption in the Canary Islands.
Source: Own elaboration.

Year	Electrical energy: Canary Islands (GWh)	Energy consumed by tourists (MWh/year)	Tourism electrical energy consumption percentage: Canary Islands
2014	8580	922607	10.9%
2015	8669	1126524	13.0%
2016	8777	1249257	14.2%
2017	8955	1343804	15.1%

systems must be equal to the annual electrical energy consumed by the corresponding island resident population and by the tourists who have visited it, according to Eq. (1). Table 5 shows the amount of electrical energy generated in each of the four systems.

As with the procedure in the previous section, since information is available for four consecutive years (corresponding to the period 2014–2017) on the resident population, tourist population and electrical energy generated, it is possible to calculate the consumption per inhabitant and per tourist for each of the four insular electrical energy systems. Using Eq. (1) and the LMS procedure, the unit consumptions of the resident and tourist population can be calculated for the four electrical energy insular systems. The results are shown in Table 6.

Table 7 shows an estimation, following the previously explained methodology, of the total amount of electrical energy consumed by the tourist sector in the Canary Islands over the study period. As can be seen, in 2017 the percentage corresponding to the tourist sector in the two biggest insular systems was 10% in Gran Canaria and 14% in

Table 5
Electrical energy generated in each of the four electrical energy insular systems.
Source: REE - Red Eléctrica Española (Spanish System Operator).

Year	Gran Canaria (MWh)	Tenerife (MWh)	Fuerteventura-Lanzarote (MWh)	La Palma (MWh)
2014	3367809.90	3362189.65	1461798.37	244620.26
2015	3384191.78	3395210.88	1486679.52	255180.92
2016	3410548.70	3445462.13	1518662.25	255240.42
2017	3465865.48	3521100.27	1565831.35	259838.82

Tenerife. The corresponding value for the Fuerteventura-Lanzarote system was 34.1%, showing the high dependence on the tourist sector in these two islands. The island of La Palma also had a significant percentage consumption by the tourist sector, with the highest value of 23.5% of total electrical energy consumption taking place in 2017.

3.2. Method using percentage data of the sectors of highest demand

An alternative to the calculation performed in the previous section can be developed by using the distributions of electrical energy demand by sectors. Each year the regional Canary Government publishes an energy report for the Canary Islands which includes distribution tables of electrical energy consumption by sector. Of the 34 sectors included in the report, the four highest in terms of electrical energy percentage demand are: (1) Hospitality; (2) Commerce and Services; (3) Administration and Public Services; (4) Domestic. For the purposes of this study, the average value has been taken of the four study years. The corresponding percentage values of total electrical energy consumption for the four biggest sectors are shown in Table 8.

The differences between the four insular systems can be seen in Table 8. Gran Canaria and Tenerife have a similar distribution, although the Hospitality sector in Tenerife has a higher consumption that of Gran Canaria which, in turn, has higher consumption in the Commerce and Services, and Administration and Public Services sectors. The Hospitality sector has considerable weight in the Fuerteventura-Lanzarote system. Contrastingly, the Hospitality sector in La Palma is very small and practically half the electrical consumption is in the Domestic sector.

The four sectors of highest consumption have a direct relationship with the resident and tourist population. An approximation can thus be made between the dependency of the sector on the resident and tourist population. It is considered that the electricity demand of each sector is influenced by the two population groups and, at the same time, that there may be an additional relationship of fixed or variable consumption depending on the group. Table 9 shows the relationship between the sector and type of consumption (fixed or variable), depending on whether the population is resident or tourist. This relationship defines the dependency between the sector and the type of consumer.

The relationship between the sector and the two population categories represented in Table 9 does not have to be an exact one, but rather represents an initial approximation. A fit can thus be made to calculate the energy consumed by each of the sectors, supposing that

Table 4
Resident and tourist population in each of the four insular electrical subsystems.
Source: ISTAC - Instituto Canario de Estadística (Canary Institute of Statistics).

Year	Gran Canaria		Tenerife		Fuerteventura-Lanzarote		La Palma	
	Resident population	Tourist population	Resident population	Tourist population	Resident population	Tourist population	Resident population	Tourist population
2014	853144	3591257	898486	5201884	247570	4508949	83874	330712
2015	854747	3717626	904713	5195209	251490	4742064	83376	356591
2016	855458	4223679	909298	5769992	255427	5203377	82943	340971
2017	857702	4587576	920253	6181592	261467	5537099	83159	407708

Table 6
Annual electrical energy consumption of the resident and tourist population for each of the electrical energy insular systems.
Source: REE - Red Eléctrica Española (Spanish System Operator).

Specific consumptions	Gran Canaria	Tenerife	Fuerteventura-Lanzarote	La Palma
Annual resident consumption (MWh/year/resident)	3.6230	3.2830	4.0245	2.3995
Annual tourist consumption (MWh/year/tourist)	0.076373	0.080442	0.096340	0.149711

Table 7
Electrical energy consumed by the tourist sector and percentage values with respect to total consumption in each of the four insular systems.
Source: Own elaboration.

Year	Gran Canaria		Tenerife		Fuerteventura-Lanzarote		La Palma	
	Tourist consumption (MWh/year)	Percentage of tourist consumption (%)	Tourist consumption (MWh/year)	Percentage of tourist consumption (%)	Tourist consumption (MWh/year)	Percentage of tourist consumption (%)	Tourist consumption (MWh/year)	Percentage of tourist consumption (%)
2014	274277	8.2%	418450	12.4%	434416	29.7%	49511	20.2%
2015	283928	8.4%	417913	12.3%	456876	30.7%	53386	20.9%
2016	322578	9.4%	464150	13.5%	501321	33.0%	51047	20.0%
2017	350370	10.1%	497260	14.1%	533474	34.1%	61039	23.5%

Table 8
Average percentage values of the distribution of electrical energy consumption by sector in the electricity insular systems.
Source: Gobierno de Canarias (Canary Islands Government).

Code	Sector	Gran Canaria (%)	Tenerife (%)	Fuerteventura-Lanzarote (%)	La Palma (%)
S1	**Hospitality**	12.14	17.44	28.75	8.70
S2	**Commerce and Services**	18.75	15.10	13.80	16.05
S3	**Administration and Public Services**	19.27	16.62	18.10	16.02
S4	**Domestic**	35.39	37.74	32.96	47.82
S0	**Other**	14.46	13.10	6.39	11.41

Table 9
Relationship between the sector and the type of consumption of the resident and tourist population.
Source: Own elaboration.

Code	Sector	Fixed demand (yes/no)	Resident population consumption (fixed/variable)	Tourist population consumption (fixed/variable)
S1	**Hospitality**	Yes	Variable	Fixed
S2	**Commerce and Services**	Yes	Fixed	Fixed
S3	**Administration and Public Services**	Yes	Fixed	Variable
S4	**Domestic**	Yes	Fixed	Variable
S0	**Other**	No	Variable	Variable

the relationship is a linear one. Tourism is evidently related to the sectors of Hospitality and Commerce and Services. So, to know the energy consumption by tourists in the different islands we will concentrate on these two sectors. The information available about the resident population shows that its consumption is constant over the course of the year. For this reason, the fit that it is intended to make is that indicated as fixed consumption plus tourist consumption. Monthly data are available for the number of tourist arrivals, enabling a more precise fit. The specific data can be consulted in the Appendix. So, for each of the four insular systems data is available on electrical energy consumption and the number of tourist arrivals. The results of the fit are also shown in the tables of the Appendix.

The first set of results contains the monthly fit of resident and tourist consumption to each electrical energy system (Tables A3, A8, A13 and A18). Shadowed rows correspond to possible data errors. These data were excluded from the subsequent calculations. These errors may be due to a number of factors, including the impossibility of an exact tourist population count in the month being studied (given that only tourist arrivals are recorded, and it will be common for a tourist to arrive in one month and leave the following). So, for example, tourists who arrive at the end of a particular month are recorded as tourist population of that month, but it is possible that their electricity consumption is of the following month. There may be significant differences in electricity consumption depending on whether it is high, medium or low season.

Following these tables are the corresponding tables with the average annual value of the four study years for each system (Tables A4, A9, A14, and A19) and, finally, the energy consumed by each sector and the percentage value with respect to total consumption of the insular system (Tables A5, A10, A15 and A20). These percentages will be within the values indicated in Table 8, as can be seen in the results obtained in each of the four insular systems. In this way, the resident consumption and the tourist consumption can be calculated.

By way of summary, Table 10 shows the estimated results of annual consumption per tourist for the four electrical insular systems.

3.3. Method using the equivalent population

A third method has been developed to calculate the electrical energy consumed by the tourist population in the Canary Islands. The calculations are first made using the global data for the archipelago as a whole, and then for each of the four main insular systems. This third method involves assimilating tourists as though they were resident population as a function of the average number of days spent in the islands.

Table 10
Annual consumption per tourist in each of the four electrical insular systems.
Source: Own elaboration.

Annual tourist consumption (MWh/year/tourist)				
Sector	Gran Canaria	Tenerife	Fuerteventura-Lanzarote	La Palma
S1 + S2 (Hospitality + Commerce and Services)	0.10683	0.11224	0.09605	0.60069

3.3.1. Equivalent population of the Canary Islands

In this method, the equivalent population in the Canary territory will be calculated. For this purpose, the equivalent tourist population will be added to the resident population. This new variable, equivalent tourist population, can be calculated through the number of overnight stays by tourists in the islands. According to the data of the Canary Institute of Statistics (ISTAC), the average number of overnight stays per tourist ranges between 9 and 10 during the study years. A value of 9.5 overnight stays is therefore assumed in the present study for calculation purposes. The equivalent tourist population is calculated as follows:

$$Number\ of\ equivalent\ tourists = \frac{number\ of\ visitors\ x\ number\ of\ average\ overnight\ stays}{number\ of\ days\ in\ the\ year} \tag{4}$$

The sum of the resident population and the equivalent tourist population provides the total equivalent population in the Canary Islands. The percentage represented by the equivalent tourist population with respect to the global population can then be calculated. Multiplying this percentage by the energy consumed in the Canary Islands will give us the energy consumed by the tourist sector in the years under study.

Table 11 shows the results obtained. It can be seen that the resident and equivalent tourist population have grown over the course of the four years of the study period. The increase in the percentage of the equivalent tourist population roughly coincides with the increase in electrical energy consumption attributable to tourism.

3.3.2. Equivalent population of each of the four electrical energy insular systems

An evaluation of the electrical energy consumed by the tourist sector in each of the four insular systems can similarly be made. The methodology is the same as that described in the previous section. Only the most relevant results are shown for this calculation. Table 12 shows the results for the two islands of highest consumption (Gran Canaria and Tenerife). The highest percentage represented by the tourist sector with respect to the total is 12.2% for the Gran Canaria electrical energy system and 14.9% for that of Tenerife.

Table 13 shows the results for the two systems of lowest consumption (Fuerteventura-Lanzarote and La Palma). The highest percentage represented by the tourist sector with respect to the total is 35.5% for the Fuerteventura-Lanzarote electrical energy system, and 11.3% for that of La Palma.

4. Results

After obtaining the values of electrical energy consumption by the tourist sector in the Canary Islands using the three methods described in section 3, the aim is to obtain a representative value based on the results obtained. The average of the three values obtained will be the result considered in the present study. Table 14 shows the results of the percentages obtained by the three methods of the previous section and the calculation of the average value. A column has been included which shows the range of variation between the maximum and minimum values.

Similarly, Table 15 shows, for each insular system and year of the study period, the estimated electrical energy consumption by the tourist sector as a proportion of total electrical energy consumption. The results are shown for the three methods employed, with the final column showing the average value of the three methods. A column has also been included which shows the range of variation between the maximum and minimum values.

Fig. 1 offers a graphic representation of the values of the final column of Table 15 to make it easier to visually compare the average percentage values of electrical energy consumption by the tourist sector in the different insular electrical systems during the 2014–2017 period. It can be seen that the electrical energy consumption attributable to the tourist sector attains its maximum relative importance in the Lanzarote-Fuerteventura system. It can also be seen that the weight of electrical energy consumption attributable to the tourist sector increased between the first and last year of the study period in all four insular systems.

An evaluation is made below of the subsidy which in effect the tourist sector in the Canary Islands receives as part of Spain's extra-peninsular (non-mainland) electrical energy generation system. There is a specific procedure to calculate the contributions made by the Spanish Government to the energy generator sector in the non-mainland systems. The system operator knows the cost of electrical energy generation in each of the insular systems. The cost of electricity generation in each of the four insular systems of the present study is shown in Table 16.

The cost is higher than in mainland European countries in all years (Eurostat, 2018). As the size of the electrical system also affects the final generation cost, it can be seen that the larger systems (Gran Canaria and Tenerife) have the lowest costs of the four, while the smallest system (La Palma) has the highest cost.

By considering the rate of electrical energy consumed in the tourist sector (Table 15) and its cost in each of the insular systems (Table 16), it is possible to calculate the amount, in Euros, that the tourist sector has consumed in terms of electrical energy. For each year and insular system, the corresponding coefficient value shown in the final column of Table 15 was applied to the corresponding electrical energy generation value shown in Table 5. The resulting value was then multiplied by the corresponding value for each year and insular system in Table 16 to obtain the average cost of electrical energy consumed by the tourist sector in each of the four electrical energy insular systems (Table 17).

In Spain, the tourist sector is assimilated as an industrial activity. Therefore, the electrical energy price for the tourist sector is the same as the price of electrical energy for any manufacturing facility. The price

Table 11
Equivalent tourist population and energy consumed by the tourist sector in the Canary Islands (2014–2017).
Source: Own elaboration.

Year	Equivalent tourist population	Increase (%)	Resident population	Increase (%)	Percentage of tourist population with respect to total population (%)	Increase (%)	Consumed electrical energy attributable to tourism (MWh/year)	Increase (%)
2014	298670	–	2403485	–	12.4	–	1066196.7	–
2015	364683	22.1	2464989	2.5	14.8	2.4	1282534.8	20.2
2016	404414	10.9	2506338	1.7	16.1	1.3	1416226.8	10.4
2017	435021	7.6	2543142	1.5	17.1	1	1531811.8	8.2

Table 12
Equivalent tourist population and electrical energy consumed by the tourist sector: electrical systems of Gran Canaria and Tenerife.
Source: Own elaboration.

Year	Gran Canaria			Tenerife		
	Equivalent tourist population	Percentage of tourist population with respect to total population (%)	Consumed electrical energy attributable to tourism (MWh/year)	Equivalent tourist population	Percentage of tourist population with respect to total population (%)	Consumed electrical energy attributable to tourism (MWh/year)
2014	93471	9.9	332545.7	135392	13.1	440295.8
2015	96760	10.2	344143.3	135218	13.0	441464.8
2016	109931	11.4	388368.0	150178	14.2	488385.0
2017	119403	12.2	423530.4	160891	14.9	523993.7

Table 13
Equivalent tourist population and electrical energy consumed by the tourist sector: electrical systems of Fuerteventura-Lanzarote and La Palma.
Source: Own elaboration.

Year	Fuerteventura-Lanzarote			La Palma		
	Equivalent tourist population	Percentage of tourist population with respect to total population (%)	Consumed electrical energy attributable to tourism (MWh/year)	Equivalent tourist population	Percentage of tourist population with respect to total population (%)	Consumed electrical energy attributable to tourism (MWh/year)
2014	117356	32.2	470098.1	8608	9.3	22767.6
2015	123424	32.9	489423.0	9281	10.0	25560.6
2016	135430	34.6	526209.8	8875	9.7	24670.1
2017	144116	35.5	556388.3	10612	11.3	29404.7

of electrical energy for the industrial sector is approved by Royal Decree by the Spanish Government and is modified on a six-monthly basis. As commented above, the price is the same for the whole country, regardless of the generation costs in the different electrical subsystems. The electrical energy consumed by the tourist sector, considered energy for industrial use, has a price lower than that for domestic use. Table 18 shows the price of electrical energy for the industrial sector in Spain in each six-month period of 2014–2017 and the average price for each year.

As electrical energy in the Canary insular systems is heavily subsidised in terms of the difference between the generation cost and the end-consumer energy price, the total subsidy of the tourist sector electrical energy consumption in the four insular systems can be calculated. Table 19 shows the estimated amounts of subsidy in the period under study for each insular system.

The values shown in the final column of Table 19 are based on official data for electricity production in the Canary Islands. However, in addition to absorbing the extra cost of electrical energy generation in non-mainland territories, the Spanish state additionally assumes costs which, though not directly due to the generation of electricity, are nonetheless associated with this activity. These costs increase the total amount that the Spanish state has to cover and have to be retroactively calculated because of the complexity of the calculation and the fact that many of the data required can only be compiled after the electricity generation event. The extra costs recognised by the Spanish state, other than the actual costs of electrical energy generation itself, are as follows:

a) Fixed costs of generators pending inscription and/or recognition of parameters.
b) Measurement costs of a temporary and extraordinary nature.
c) Costs due to blending of fuels.
d) Costs due to grid access tolls.
e) Costs due to system operator financing.
f) Costs of taxes derived from Act 15/2012.[2]

For this reason, in 2017, the Spanish state published[3] the definitive generation costs and the compensation to be paid to the (only) electrical energy generation company in the Canary Islands for the extra costs of production activity corresponding to 2014. Acknowledgement and settlement of the generation extra costs of 2015, 2016 and 2017 have not yet been made.

In 2014, the total acknowledged extra costs of electrical energy generation in the Canary islands amounted to 1,121,115,816 €. Given that 8,580 GWh were generated in the Canary Islands in 2014 (see Table 1), this means that the real subsidy per MWh amounted to 130.67 €/MWh in 2014. This value allows a more precise calculation of the subsidised amount attributable to the tourist sector. Taking as reference the average value of 12.8% of total electrical energy consumption attributable to the tourist sector (see Table 14) in 2014, it is found that the actual subsidy on the part of the Spanish state of electrical energy consumption attributable to the tourist sector was €143.503 M. This value is approximately 44% higher than the estimated value of €99.71 M (see Table 19), which was calculated on the sole basis of electrical energy generation without considering extra costs.

Finally, a calculation was made of the values of CO_2 emissions due to tourist activity for the years of the study period. For this calculation, the average (of the three methods) global proportion of total electrical energy consumption attributable to the tourist sector was used as the starting point (see Table 14). These percentages were applied to values published by the Spanish System Operator (REE, 2018b) corresponding to emissions by thermal power plants of public use in the Canary Islands. As can be seen in Table 20, an increase in CO_2 emissions attributable to the tourist sector is noted for the study years.

5. Conclusion and policy implications

In terms of generalising the results and conclusions of the present study, the Canary Islands were chosen for this study for a number of reasons. Firstly, the relative importance of the tourist activity which, in

[2] Spanish State Gazette N. 312, dated December 28, 2012 Act 15/2012, December 27, on fiscal actions for energy sustainability [https://www.boe.es/buscar/doc.php?id=BOE-A-2012-15649].

[3] Resolution of June 30, 2017, of the General Directorate of Energy Policy and Mines; Spanish State Gazette N. 166, dated July 13, 2017 [https://www.boe.es/boe/dias/2017/07/13/pdfs/BOE-A-2017-8209.pdf].

Table 14
Global percentages of total electrical energy consumption attributable to the tourist sector in the Canary Islands.
Source: Own elaboration.

Year	Method 1 (%)	Method 2 (%)	Method 3 (%)	Variation range between maximum and minimum values	Average (%)
2014	10.9	15.0	12.4	4.1	12.8
2015	13.0	15.3	14.8	2.3	14.4
2016	14.2	16.5	16.1	2.3	15.6
2017	15.1	17.4	17.1	2.3	16.5

Table 15
Proportion of total electrical energy consumption consumed by the tourist sector in the four insular systems under study.
Source: Own elaboration.

Insular electrical system	Year	Method 1 (%)	Method 2 (%)	Method 3 (%)	Variation range between maximum and minimum values	Average (%)
Gran Canaria	**2014**	8.2	11.4	9.9	1.5	9.8
	2015	8.4	11.7	10.2	3.3	10.1
	2016	9.4	13.2	11.4	3.8	11.3
	2017	10.1	14.1	12.2	4	12.1
Tenerife	**2014**	12.4	17.4	13.1	5	14.3
	2015	12.3	17.2	13.0	4.9	14.2
	2016	13.5	18.8	14.2	5.3	15.5
	2017	14.1	19.7	14.9	5.6	16.2
Fuerteventura-Lanzarote	**2014**	29.7	29.6	32.2	2.6	30.5
	2015	30.7	30.6	32.9	2.3	31.4
	2016	33.0	32.9	34.6	1.7	33.5
	2017	34.1	34.0	35.5	1.5	34.5
La Palma	**2014**	20.2	13.6	9.3	10.9	14.4
	2015	20.9	14.4	10.0	10.9	15.1
	2016	20.0	13.5	9.7	10.3	14.4
	2017	23.5	15.6	11.3	12.2	16.8

2016, amounted to 34.4% of GDP (Exceltur, 2017), and secondly the isolated nature of the archipelago which requires all the electrical energy consumed to be generated in the islands themselves without any external contributions that would allow alternative sources or serve to stabilise the grid. In addition, the depths of the sea between the islands (except between two of them) is a major obstacle to any interisland electrical connection. It should also be noted that the primary energy with which the electrical energy is generated comes overwhelmingly from fossil fuels which have to be imported from production centres outside the archipelago. Similar conditions to those set out in the present study can be found in numerous archipelagos, which implies that the methodologies proposed here can be applied elsewhere and the results can be considered generalizable.

Table 16
Average cost of the electrical energy generated in each of the four electrical energy insular systems.
Source: REE - Red Eléctrica Española (Spanish System Operator).

Year	Gran Canaria (€/MWh)	Tenerife (€/MWh)	Fuerteventura-Lanzarote (€/MWh)	La Palma (€/MWh)
2014	171.08	171.78	177.43	231.63
2015	134.15	134.92	132.60	183.28
2016	120.30	123.50	124.82	175.17
2017	123.92	127.02	132.68	184.45

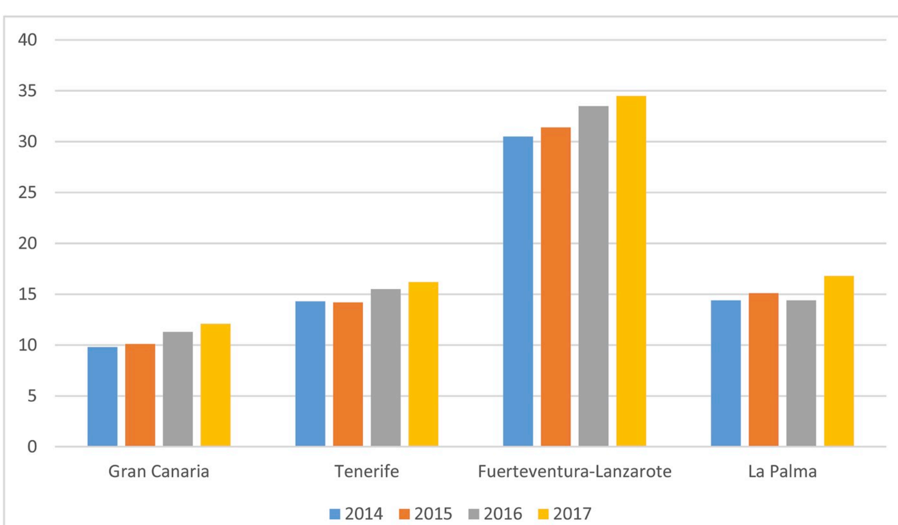

Fig. 1. Average percentages of electrical energy consumption attributable to the tourist sector in the four different insular electrical systems during the 2014–2017 period. Source: Own elaboration.

Table 17
Average cost of electrical energy consumed by the tourist sector in each of the insular systems.
Source: Own elaboration.

Year	Gran Canaria (M€)	Tenerife (M €)	Fuerteventura-Lanzarote (M€)	La Palma (M €)
2014	46.923	71.881	22.065	12.778
2015	38.089	56.384	17.343	10.902
2016	38.806	57.322	17.913	9.9637
2017	43.417	63.161	20.263	12.545

Table 18
Price of electrical energy for industrial use in Spain during the study period 2014–2017.
Source: Own elaboration based on official data published in the BOE - Boletín Oficial del Estado (Spanish State Gazette).

Year	First six-month period (€/kWh)	Second six-month period (€/kWh)	Average (€/kWh)
2014	0.099	0.098	0.098
2015	0.092	0.091	0.092
2016	0.086	0.082	0.084
2017	0.084	0.084	0.084

Table 19
Estimated amount of subsidy of electrical energy consumption by the tourist sector in the four insular systems.
Source: Own elaboration.

Year	Gran Canaria (M €)	Tenerife (M€)	Fuerteventura-Lanzarote (M€)	La Palma (M€)	Total subsidy (M €)
2014	24.12	35.47	35.41	4.71	99.71
2015	14.41	20.69	18.95	3.52	57.57
2016	13.99	21.09	20.77	3.35	59.20
2017	16.74	24.54	26.30	4.38	71.96

The methodologies proposed here offer a novel and easy-to-apply solution to the problem of estimating the proportion of total electrical energy consumption that can be attributed to the tourist sector. In addition, the similarity between the ranges of values of the three methodologies suggests that the results can be considered reliable. Consequently, the methodologies developed in the present study can, eventually, constitute a potentially highly useful tool with respect to the planning and decision-making processes of the corresponding public bodies and institutions.

In the specific case of the Canary Islands, the results can be interpreted in various ways and, consequently, could be used by the public institutions to adopt certain decisions. An initial reading of the results could lead to the conclusion that tourist activity is responsible for a high proportion of the total electrical energy consumed and, hence, a high proportion of both generation costs and CO_2 emissions. To this must be added the fact that the cost of the generation of electrical energy on the islands is subsidised and, therefore, the price paid for it is lower than the actual cost. In other words, Spanish citizens as a whole are subsidising the extra costs of electrical energy generation on the islands, with the added complication that a high percentage of the electricity generated is consumed by a tourist sector which is overwhelmingly comprised of visitors from other countries.

In such circumstances, the argument for applying some sort of special tax or ecotax for tourist stays could be justified as a way of compensating the Spanish system for the extra cost of electrical energy generation in the Canary Archipelago. The income from this tax could be used to reduce the extra costs borne by Spanish consumers in their electricity bills. Likewise, if considered an ecotax, the income could be used to implement ways of treating and/or reducing CO_2 emissions due to electrical energy consumption by the tourist sector. Nonetheless, the creation of a tax of this nature, though it may have the support of a significant number of groups (consumers, ecologists, councils, etc.), could well be opposed by the tourist sector itself, which would most likely argue against its imposition because of the possible deterrent effect on the number of tourist arrivals as the result of the extra cost they would have to pay for their holidays.

However, taking as a reference point other industrial sectors in countries in Europe, a comparison could be made between the tourist sector, understood as an industrial activity, and any other sector. So, for example, in all European countries the price of electricity is the same regardless of the region in which it is consumed. Following a logic similar to that of the present study, it can be argued that some industrial sectors situated in areas in which the generation of electricity is more expensive are benefitting from the supportive contributions being made by all the inhabitants of the country. For this reason, it would be difficult to argue that the consumers of the products or services of these industrial sectors should be subjected to a tax for consuming those products or services. A similar line of reasoning could be applied to CO_2 emissions, given that quota allocations are established by country and not by regions, regardless of whether certain activities in some regions are more polluting than in others. This argument could be used to dissuade against the appropriateness of imposing a tax on tourist visitors for the extra costs incurred in the consumption of electricity during their stay.

As well as the above interpretations, others are possible and, hence, institutional decisions which follow another path are also equally possible. In any case, what is important is to have reliable ways of obtaining the desired information. Although, as has already been commented, the methodologies proposed in this study show a high degree of reliability, it should be mentioned that there are also some limitations in terms of generalization of the results. Firstly, while there are many archipelagos around the world whose economy is heavily dependent on tourism and which also depend on external energy sources, their physical and socioeconomic characteristics may differ

Table 20
CO_2 emissions in the Canary Islands attributable to the tourist sector.
Source: Own elaboration based on data published by REE - Red Eléctrica Española (Spanish System Operator).

Year	CO_2 emissions of thermal power plants of public use (tCO_2)	Average electrical energy consumption attributable to the tourist sector (%)	CO_2 emissions attributable to the tourist sector (tCO_2)
2014	6592938	12.8	843896.1
2015	6697174	14.4	964393.1
2016	6784626	15.6	1058401.6
2017	6965396	16.5	1149290.3

considerably. Secondly, the utility of the methodologies proposed in the present study depends on the reliability of the secondary sources. In this case, data from several bodies are brought together and, although it is hoped that verified statistical methods would have been used to compile them, they may be subject to sampling errors of the different techniques used to obtain them. At the same time, not all insular territories have secondary sources which would allow the methodologies to be applied in the same manner as in the present work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations of interest

None.

Appendix

Tourist population and electrical energy generation data in each of the four insular electrical systems.

Table A1
Electrical energy generation: electrical system of Gran Canaria. Source: REE - Red Eléctrica Española (Spanish System Operator)

(MWh)	2014	2015	2016	2017
January	285054.93	285722.00	284640.87	290726.38
February	257442.36	259291.26	267405.15	260074.94
March	278700.09	280125.50	279798.06	287854.96
April	267284.95	265357.05	270380.55	275184.85
May	274242.65	276582.52	273504.90	284364.10
June	268185.07	267444.75	274652.01	282282.00
July	286362.11	297325.47	295020.83	295606.50
August	288937.84	295348.09	303593.33	308684.33
September	293256.23	290067.43	289027.42	292124.95
October	302627.10	297058.17	298173.29	306863.92
November	281858.42	281338.38	283292.04	290793.60
December	283858.16	288531.15	291060.26	291304.97
TOTAL	3367809.90	3384191.78	3410548.70	3465865.48

Table A2
Tourist arrivals in Gran Canaria. Source: INE -Instituto Nacional de Estadistica (National Institute of Statistics)

	2014	2015	2016	2017
January	351253	366609	396418	401569
February	318262	321684	354409	384173
March	374791	332523	382164	432327
April	271195	275241	311729	395982
May	216481	229207	267345	285339
June	215293	221454	276614	302001
July	279056	291040	357816	377085
August	293215	295999	352039	383268
September	235781	257651	304653	351313
October	312854	343650	407125	422058
November	355290	384941	399076	425014
December	367786	397627	414291	427447
TOTAL	3591257	3717626	4223679	4587576

Table A3
Fixed and tourist consumption: electrical system of Gran Canaria (average monthly value for the four study years).

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
January	286.53	7.3226E-06
February	241.90	0.055580
March	250.72	0.081208
April	247.12	0.071527
May	253.01	0.096793
June	232.97	0.158265
July	277.11	0.050486
August	236.02	0.190607
September	291.12	5.5684E-09
October	301.18	6.671E-10
November	235.28	0.125394
December	235.79	0.131668

The average annual values of fixed and tourist consumption are calculated after eliminating the data marked in the shadowed rows of Table A3.

Table A4
Average fixed and tourist consumption: electrical system of Gran Canaria

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
Annual average	245.54784	0.10683684

Table A5
Electrical energy consumption and percentage attributable to the tourist sector: electrical system of Gran Canaria

	2014	2015	2016	2017
Annual (MWh)	383678.548	397179.412	451244.515	490122.121
Percentage of the total (%)	11.4%	11.7%	13.2%	14.1%

Table A6
Electrical energy generation: electrical system of Tenerife. Source: REE - Red Eléctrica Española (Spanish System Operator).

	(MWh)			
	2014	2015	2016	2017
January	286141.16	288403.04	286219.03	294977.13
February	263740.81	261555.12	269109.79	263719.88
March	277855.09	281987.26	285109.54	291672.44
April	264163.78	264117.21	272818.40	277326.89
May	274300.70	275007.60	275268.33	286865.36
June	272865.53	268979.28	279149.98	288218.24
July	286091.78	299408.32	299281.09	303449.94
August	289917.29	296534.23	308779.67	315495.07
September	290494.02	293151.53	294028.78	299337.19
October	295115.57	296807.68	297226.03	309858.15
November	276434.51	280006.90	284002.86	293178.69
December	285069.40	289252.72	294468.63	297001.31
TOTAL	3362189.65	3395210.88	3445462.13	3521100.27

Table A7
Tourist arrivals in Tenerife. Source: INE -Instituto Nacional de Estadistica (National Institute of Statistics)

	2014	2015	2016	2017
January	469898	474671	470980	537310
February	447267	427003	461482	505532
March	513884	510984	522213	545201
April	435972	407165	477573	554842
May	350658	364860	414506	453622
June	347123	359067	424357	468535
July	406138	413184	520278	521396
August	448006	444894	505127	537569
September	379656	389585	451926	482332
October	466315	464801	509210	535775
November	457341	466786	484987	515619
December	479626	472209	527353	523859
TOTAL	5201884	5195209	5769992	6181592

Table A8
Fixed and tourist consumption: electrical system of Tenerife (average monthly value for the four study years).

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
January	228.1180369	0.124570137
February	253.7224043	0.023480638
March	102.9999613	0.346331996
April	223.7126162	0.097878564
May	235.1710070	0.107825905
June	221.2646977	0.140176882
July	259.2238967	0.081319756
August	183.2894444	0.246729329
September	265.4578352	0.067613957
October	217.5824229	0.166326366
November	148.5064989	0.280348927
December	210.1894332	0.162269946

The average annual values of fixed and tourist consumption are calculated after eliminating the data marked in the shadowed rows of Table A8.

Table A9
Average fixed and tourist consumption: electrical system of Tenerife

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
Annual average	218.422799	0.11224451

Table A10
Electrical energy consumption and percentage attributable to the tourist sector: electrical system of Tenerife

	2014	2015	2016	2017
Annual (MWh)	583882.91	583133.68	647649.92	693849.76
Percentage of the total (%)	17.4%	17.2%	18.8%	19.7%

Table A11
Electrical energy generation: electrical system of Fuerteventura-Lanzarote. Source: REE - Red Eléctrica Española (Spanish System Operator)

	(MWh)			
	2014	2015	2016	2017
January	120634.44	123088.16	123100.89	127946.26
February	108495.42	110149.90	114383.02	113696.90
March	119006.65	119796.61	122599.67	126090.53
April	114690.96	113320.06	116873.27	123154.55
May	117255.82	119509.35	119987.43	127298.27
June	116860.38	116924.53	122485.18	128764.79
July	127264.67	134502.16	135193.75	137809.35
August	134396.18	139037.44	144276.93	147650.18
September	130868.78	131729.56	133235.02	135111.92
October	131443.44	132623.53	134188.65	140080.30
November	119819.86	122616.23	125016.88	128915.65
December	121061.79	123382.02	127321.57	129230.78
TOTAL	1461798.37	1486679.52	1518662.25	1565749.47

Table A12
Tourist arrivals in Fuerteventura-Lanzarote. Source: INE -Instituto Nacional de Estadistica (National Institute of Statistics)

	2014	2015	2016	2017
January	363855	390823	392320	453607
February	358117	361591	410626	415369
March	402254	440523	468743	493788
April	374279	376326	421734	521025
May	315913	337652	379558	403128
June	339441	350959	386046	409073
July	404924	419758	477125	498801
August	417469	458274	474159	492678

(*continued on next page*)

Table A12 (*continued*)

	2014	2015	2016	2017
September	356495	383466	418118	435161
October	398809	442172	497056	505390
November	372678	394831	441206	457607
December	404715	385689	436686	451472
TOTAL	4508949	4742064	5203377	5537099

Table A13
Fixed and tourist consumption: electrical system of Fuerteventura-Lanzarote (average monthly value for the four study years)

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
January	91.4206364	0.08064904
February	77.4105887	0.08868639
March	87.2955447	0.07661362
April	90.4731035	0.06268369
May	86.4983604	0.09612354
June	57.2380784	0.17238605
July	96.0578381	0.08360399
August	59.4883974	0.17768946
September	112.341028	0.05120459
October	106.166402	0.06166228
November	84.987183	0.09387138
December	80.1574606	0.10745321

Table A14
Average fixed and tourist consumption: electrical system of Fuerteventura-Lanzarote

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
Annual average	85.7945518	0.09605227

Table A15
Electrical energy consumption and percentage attributable to the tourist sector: electrical system of Fuerteventura-Lanzarote

	2014	2015	2016	2017
Annual (MWh)	433094.785	455486.009	499796.17	531850.925
Percentage of the total (%)	29.6%	30.6%	32.9%	34.0%

Table A16
Electrical energy generation: electrical system of La Palma. Source: REE - Red Eléctrica Española (Spanish System Operator)

	(MWh)			
	2014	2015	2016	2017
January	120634.44	123088.16	123100.89	127946.26
February	108495.42	110149.90	114383.02	113696.90
March	119006.65	119796.61	122599.67	126090.53
April	114690.96	113320.06	116873.27	123154.55
May	117255.82	119509.35	119987.43	127298.27
June	116860.38	116924.53	122485.18	128764.79
July	127264.67	134502.16	135193.75	137809.35
August	134396.18	139037.44	144276.93	147650.18
September	130868.78	131729.56	133235.02	135111.92
October	131443.44	132623.53	134188.65	140080.30
November	119819.86	122616.23	125016.88	128915.65
December	121061.79	123382.02	127321.57	129230.78
TOTAL	1461798.37	1486679.52	1518662.25	1565749.47

Table A17
Tourist arrivals in La Palma. Source: INE -Instituto Nacional de Estadistica (National Institute of Statistics)

	2014	2015	2016	2017
January	55033	37756	34254	43550
February	36336	42787	47819	49491
March	20315	30270	25571	32735
April	13305	28718	27276	23794
May	18957	19228	25126	29758
June	14293	19214	19470	23284
July	11201	12785	17459	18944
August	12606	14768	19739	20627
September	21719	29142	25613	32130
October	52302	53444	41951	34992
November	39213	24107	27053	41469
December	35432	44372	29640	56934
TOTAL	330712	356591	340971	407708

Table A18
Fixed and tourist consumption: electrical system of La Palma (average monthly value for the four study years).

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
January	123.691735	3.572E-08
February	91.6308873	0.45456943
March	111.141809	0.39421491
April	116.109073	0.03869504
May	103.343172	0.75943171
June	96.6815589	1.28909502
July	117.98497	1.04041951
August	116.245714	1.48181645
September	124.129992	0.31696851
October	134.584117	4.4053E-07
November	120.878028	0.09752356
December	119.666246	0.13421864

The average annual values of fixed and tourist consumption are calculated after eliminating the data marked in the shadowed rows of Table A18.

Table A19
Average fixed and tourist consumption: electrical system of La Palma

	Fixed demand (GWh/year)	Tourist consumption (MWh/year/tourist)
Annual average	111.781145	0.60069528

Table A20
Electrical energy consumption and percentage attributable to the tourist sector: electrical system of La Palma

	2014	2015	2016	2017
Annual (MWh)	198657.137	214202.53	204819.67	244908.271
Percentage of the total (%)	13.6%	14.4%	13.5%	15.6%

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