Performance in the operational phase of hotel units: Lisboa Carmo Hotel case study

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Abstract: Over the last decades, with the evolution of civilizations and the impact they have on the environment, the development of an environmental awareness was triggered regarding the need to use of natural resources in a more responsible way without compromising future generations. Worldwide, tourism-related activities are currently amongst the group of activities of high resources consumption at an urban level, particularly in terms of energy and water. Its exponential growth over the past decades has led the operators, in particular hotel units, to seek strategies and methodologies with the aim of preserving resources. Within this context, it is becoming increasingly important to have an efficient asset management system implemented to enable the performance and risk assessment of the assets and allow analyzing alternatives in all their life cycle stages in an attempt to obtain the maximum value. The present research presents an approach to characterize and organize the consumption and costs of the operation stage of hotel units. More specifically, it seeks to establish a structure to detail the use of water and energy for the different purposes that will provide a basis to evaluate alternatives to improve the operational performance. The methodology is applied to the Lisbon Carmo Hotel and the end-use distribution of energy and water consumption is obtained.

Key words: *Tourism, development, sustainability, energy management, water management*

1. Introduction

Man's activities have been interfering with the environment since the beginning of civilizations, which led, especially in early eighties, to the development of an environmental conscience and the definition of concepts such as "Sustainable Development" not only in institutions' lexicon, but also in organizations and even individuals (Brundtland, 1987; SACHS, 2005). The international consent towards sustainability as a generic broad concept is reflected on the seventeen goals for Sustainable Development set by the United Nations (United Nations, 2015) Their implementation is considered the path to end poverty, protect the planet and guarantee prosperity for everyone. Water and energy related issues are amongst the sustainable development goals, either directly or indirectly. Water is vital to human life and to the planet and there are already regions of the globe in water stress situation. Climate change, population growth and consumption habits support the increase of regions of the globe affected by water scarcity. The WORLD RESOURCES INSTITUTE (2015b) estimates an increase in water stress for Portugal of 1.4 times from 2015 to 2040.

Energy is consistently becoming a more essential resource for modern societies. Despite the technological developments and awareness efforts towards energy efficiency, the population growth and lifestyle changes resulted in a continuous increase in energy demand. Noteworthy, the excessive consumption of fossil fuels impact significantly on the ecosystems and are one of the major causes for global warming. The later, in will tend to aggravate energy consumption in the years to come (Dall'O', 2013).

In relative terms, the consumption of water and energy in tourism related activities is high. In Portugal, with 11.423.000 arrivals of international tourists in 2016, it is an import sector of activity that has been growing significantly over the past year – the increase in the number of international arrivals from 2015 and 2016 was 12.7% (UNWTO, 2017). Tourism is surely a positive force with several benefits to worldwide touristic destinations. However, in order to reach it there's a need for a suitable use of resource management (Tang, 2015). The following research effort is a product of this context, since the major concern in the Portuguese hotel sector is competitiveness. This increases the relevance of having an upright resource consumption management in an attempt to reduce costs, turning it into a more cost-effective and more environmentally friendly.

With the intention of assisting the management of some of the physical assets of hotel units, a methodology to obtain the detailed water and energy consumption for different purposes (end uses) is proposed. Its implementation to a case study illustrates how it allows the identification of critical points in terms of resource consumption and performance evaluation of improvement solutions to reduce costs.

2. Literature Revision

2.1. Managing Built Assets

Facility management is described in the ISO 41001 as an "organizational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business". This consists of an optimized combination of efforts aimed at facilitating the activities of all areas of an organization, with the horizon focused on seeking competitive advantage and survival (Rondeau & Brown, 2012; Quinello & Nicoletti, 2006). Within the various areas covered by facility management, there is the need to manage the assets of the organization, including the physical assets.

The ISO 55000 defines asset management as the "coordinated activities of an organization to realize value from assets". This encompasses balancing the performance and risk to an asset throughout its life cycle in order to maximize the benefits from it. These benefits can be (Davis, 2013): i) economic (e.g., cost minimization, profit maximization); ii) environmental (e.g., environmental impacts reduction); and iii) social (e.g., level of service provided).

Within the context of buildings and constructed assets and focusing on the economic benefits, the ISO 15686 sets a

framework for Life Cycle Costing (LCC). It requires a global vision of the economic valuations in all phases of a buildings or constructed asset life cycle, namely acquisition (design and construction), operation/use and end of life. The use phase is the longest of a built asset's life cycle and the most uncertain, in most cases, making it harder to accurately estimate the costs. This phase incorporates operation costs (e.g., consumed energy, water, rents, rates, taxes, insurances) and maintenance costs (e.g., inspections costs, repairs, remodeling).

For this reason, the main concerns are fundamentally trying to reach more effectiveness and cost efficiency, meaning that the more efficient environment management is, the bigger are the impacts in hotel units without reducing its service quality. Impacts can either be direct – when they are related with internal management of the hotel – or indirect – when they are related with increasing hotel performance, as a consequence of the rising competitivity of the destination where it's located. It's also important to remember that tourism is an activity with a strong dependency with the environment (Claver-Cortés et al., 2007; Turismo de Portugal, 2015).

2.2. Water Use

Water is an essential resource to the social and economic development of a country, so it's required to guarantee that it is used in a rational and efficient way. It is essential for life and is an integral part of all economic activities, including the production of food, energy and industrial products. Adequate availability of water is not only a prerequisite for human health and well-being but also essential for freshwater ecosystems and the many services it provides (European Environment Agency, 2012).

Approximately 20% of water abstraction all around Europe provides water public systems, although there are some significant variations amongst countries. There are more than 165 million buildings in the EU, considering that public water not only includes residential buildings' supply, but also non-residential buildings. In these non-residential buildings it can be included commercial, industrial, educational, healthcare, hotel sector buildings, among others (European Commission - DGE, 2012; European Environment Agency, 2012).

In Portugal, around the year 2000, there was the need to initiate a program, regarding environmental politicizes, that could alert the population for the efficient use of water, with the purpose of minimizing hydric shortage risks and improving environmental conditions in hydric means. This resulted in the creation of the PNUEA (National Program for Efficient Use of Water), this program was under study between 2000 and 2008 (Baptista et al., 2012). Between the years 2000 and 2009, the total amount of water demanded was reduced from 7.500 million m^3 to 4.199 million m^3, translated in a reduction of 43% as a result of the application of some of the actions from PNUEA. In 2012, PNUEA was reactivated by the Portuguese Environmental Agency (APA) with a plan from 2012 until 2020 that will integrate each of the sectors that have more consumption in water, such as urban, agricultural and industrial with the intention to reduce water waste (Agência Portuguesa do Ambiente, 2017).

Apart from the measures applied by PNUEA, there's also the National Association for Quality in Building Installations (ANQIP), the only association from the sector intending to make available to the citizens a proper knowledge about hydric efficiency of products in the market (ANQIP, 2018). Apart from the national panorama, there are several countries such as Australia, United Sates of America, Singapore, and Ireland that already possess models that use labels of hydric efficiency with the purpose of guiding citizens to an ideal choice of products, in a way that allows them to make a more efficient usage of water (Afonso, 2009).

The residential use of water represents 72% of the total consumption of water in buildings, where there's a higher percentage of water usage in baths and toilet flushing, representing 35% and 25% of the total water consumption in households, respectively (European Commission - DGE, 2012). In USA 's households, 51% of the total consumption of hot water is used in showers, 23% in bathtubs, 10% to washing machines and 16% in laundry machine (Fuentes, Arce, & Salom, 2018).

In hotels, the consumption of water is influences by year of construction, location, area, classification, number of bedrooms, used equipment efficiency, guest's behavior and employee's behavior (Charara et al., 2011). A key factor to determine water consumption in hotels is the way the laundry room is used, accounting for the fact that the quota for the volume of water used to this end can reach 40% of the total volume of water, while the rest of the consumption is distributed between clients and the kitchen. On the other hand, due to the upward trend from hotels to resort to external laundry services, in most cases, water consumption will mainly be a result of guest's usage and kitchen services (Fuentes et al., 2018).

Nationally, as mentioned before, the PNEUA determined that for normal hydric situations and directed to the industrial sector, considering that it's one of the main sectors in this paper, some measures that may be implemented in order to change procedures and human routines to reduce water consumption, such as: i) awareness to change human habits to reduce water consumption; ii) use of more efficient equipment and devices; iii) replacing showers with others with the aim of reducing water flow; iv) reusing water from industrial cooling in closed systems. It should, however, be noticed that it is not enough to increase water usage efficiency in a building if the total amount of water used doesn't decrease, meaning there's really no purpose in having a more efficient shower cabin if it ends up being used for a longer time (European Commission - DGE, 2012).

Table 1 - Percentage of water usage consumption in different hotels according to its different purposes.

		Europe	Usa	Majorca	Vietnam
Purposes (%)	Laundry	10	16	12	20
	Kitchen	15	14	10	15
	Bath/shower	30	29	27	
	Toilet Flushing	27	-	17	53
	Sink	14	-	3	
	Cooling and heating	-	12	-	-
	Pool	-	1	31	6
	Other	4	12	-	6
	Author	(European Commission - DGE, 2012)	(Environmental Protection Agency, 2014)	(Gössling, 2015)	(Trung & Kumar, 2005)

Table 1 presents a set of studies that calculate consumption distribution according to different purposes in different hotel units and in different areas.

2.3. Energy Use

For the past two decades, we've been watching an increase in energy consumption by buildings and it's likely that the tendency remains this way, with buildings being the main energy consumers, followed by transports with a consumption of 32%, and industry representing an energy consumption of 25% of the total final energy (ENERDATA, 2012; Dall'O', 2013). As such, energy efficiency is the key word to today's industry, portraying a crucial role in sustainable market competitivity and environmental protection. Patterson (1996) indicates "energy efficiency" as a process connected with the lowest use of energy per unit of production (Vera & Langlois, 2007).

In Portugal, the average energy consumption by buildings consists in 25% of the national total. Nonetheless, in urban areas this value can reach 40% of the national total (Correia Guedes et al., 2009). Figure 1 shows an increase in energy efficiency regarding residential buildings between years 2000 and 2012. It's possible to verify that the increase in energy efficiency in Portugal followed other EU members trend. However, this growth was at a higher rate after 2009 as a result of the mandatory application of the energy certification system in all residential buildings (ADENE, 2015).

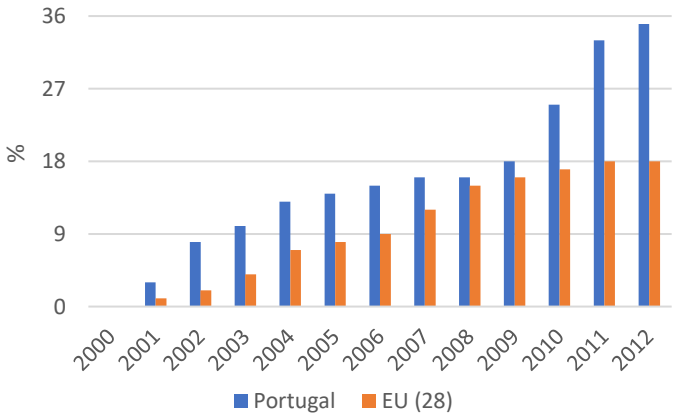

Figure 1 - Increase in energy efficiency in residential buildings, since 2000 (ADENE, 2015)

Every three years there's a National Action Plan for Energy Efficiency (PNAEE), elaborated with the purpose of applying regulation to support the growing efficiency in energy consumption and enhancement of an energy model with economic rational, incorporating six specific areas, namely Transports, Residential and Services, Industry, State, Behaviors and Agriculture (PNAEE, 2006). This third PNAEE mentions which measures to embrace, until 2020, with the purpose of promoting energy efficiency in all Portuguese territory. These measures will impose penalties over inefficient equipment, minimum requirements of energy performance class, energy labelling obligations, among others (PNAEE, 2017).

Energy consumption in residential buildings differs according to the building typology, clime, population awareness, rent, plus other factors. Usually, between more developed countries, there's a higher energy consumption. As we can see by analyzing Figure 2, "space heating" is in every country the principal energy consumer (Ürge-Vorsatz et al., 2014). Hotels are one of the most demanding energy consumers compared to different categories of nonresidential buildings, considering that it operates 24 hours a day (Filimonau et al., 2011).Table 2 illustrates studies conducted in hotels located in different locations, with distinctive characteristics, where it's possible to verify the final energy consumption allocation, by distinguishing the percentage of gas and electricity consumption, as well as electricity consumption allocation by different purposes. It's possible to acknowledge an association between a higher percentage and consumption of this resource with heating, ventilation and air conditioning systems, laundries, hot water, equipment usage and building illumination.

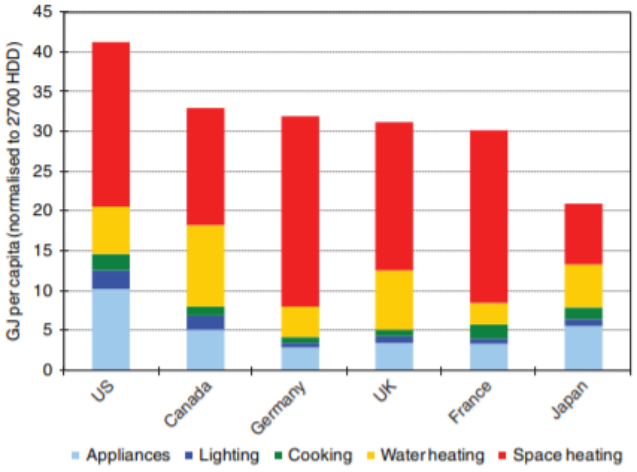

Figure 2 - Energy consumption amongst different purposes in residential buildings (Ürge-Vorsatz et al., 2014)

Table 2 - Allocation of final consumption of energy in different hotels to its purposes

		Hong Kong	England	Vietnam	Europe	Greece	USA
Eşectricity (%)	HVAC	-	30	49	61	24	23
	Refrigeration	-	-	-	-	12	12
	Air conditioning	32	-	-	-	-	-
	Boilers	-	-	-	-	-	-
	Laudry	-	29	-	-	22	-
	Hot Water	-	-	20	15	11	11
	Kitchen	-	-	-	-	12	11
	Ilumination	12	-	20	-	11	12
	Equipment	-	-	-	-	-	16
	Lifts	5	-	9	-	-	-
	Others	23	-	-	25	8	-
	Gas (%)	28	40	-	-	18	
	Author	[1]	[2]	[3]	[4]	[5]	[6]

[1](Deng & Burnett, 2000); [2](Filimonau et al., 2011); [3](Trung & Kumar, 2005); [4](Zografakis et al., 2011); [5](Maleviti et al., 2012); [6](Business Energy Advisor, 2016).

3. Case Study and Research Methodology

The building being studied is classified has a four-star hotel, Lisboa Carmo Hotel, located in the center of Lisbon. The hotel opened in 2012 in a rehabilitated old building in Largo do Carmo (Figure 3). The hotel is a six-floor building above ground, with an accommodation capacity of 98 people, equivalent to a total of 49 bedrooms. On the ground floor there's the kitchen, the restaurant, reception and

administrative office. The first floor is composed by 12 bedrooms, one of them being adapted to guests with special needs. The second, third and fourth floors have 11 bedrooms each, and the fifth floor only has the 4 suites. In the first and second floors there's also the staff locker rooms, female and male, respectively. On each floor, there's a technical area where we can find several equipment, such as communication cabinets that contain all material related to the building's network. Finally, on the sixth floor we can find most technical equipment, such as heating, ventilation and air conditioning, oiler and gas, circulation pumps, among others that will be mentioned further in this paper.

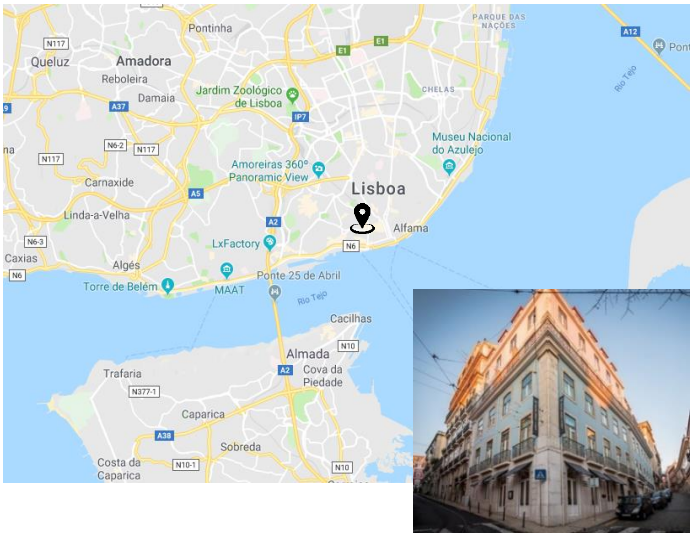

Figure 3 - Location of Lisboa Carmo Hotel (Lisboa Carmo Hotel, 2017)

The hotel has a team of 40 employees distributed by several areas, including administrative, catering, cleaning and reception. It includes a laundry service located on the third floor, that it's used exclusively by the staff, whereas room laundry is provided by an outsourcing company. In the hotel there are a total of 49 rooms of various types, there are some differences between them, for example, the double rooms and the suites give guests the choice between rooms with bath or shower, while the standard and twin rooms have shower only. The hotel has a kitchen for breakfast, lunch and dinner. This is composed of several equipment, the main consumers of energy being the stove, the cooling chests and the freezing chests. There is also a restaurant, open to the public, located on the lower floor where you can find various dishes that show Portuguese gastronomy. Guest breakfasts are served in the restaurant from 7:30 a.m. to 10:00 a.m., lunches usually served from 12:00 a.m. to 15:00 p.m. and dinners starting around 7:00 p.m. 11:30 p.m. On average, 30 meals a day are served, without counting the breakfasts, as these depend on the hotel's occupancy rate. This area has a washbasin and various electrical equipment such as refrigerator cabinets, toaster, handmade beer machine, among others. There is also a small auxiliary laundry which is exclusively used for the washing of uniforms of the staff, is composed of washing machine, dryer and boiler iron. The office has some computers, the printer and lighting. The "Technical Zone" consists of all the spaces where only the employees have access, including the garments. In these spaces there are equipment that will not be quantified in the present work, since they have a residual impact on the hotel's operating costs, such as water deposit, communication cabinets and UPS (uninterruptible power supply).

The research techniques used to answer questions and acknowledge the aim of the present research were divided in three stages, according to the type of data collected. The first stage consists on gathering secondary data based on literature revision. The second stage is based on gathering data by qualitative methods of research, more specifically regular visits to the hotel with the objective of getting acquainted with every room, as well as the integrated equipment, that have an impact in the phase of operating costs of the studied hotel. Initially, it's also presented the status of actual consumption of the hotel, for the year of 2017. This data was collected based on record consulting, which consisted on the analysis of water, energy and gas monthly receipts. Finally, we resorted to literary research and answers given by users of several equipment intended to obtain behavioral data, as a daily use factor of each equipment. Lastly, the goal of the third stage was the quantitative record of performance and characteristics (consumption) of different equipment, collected through local surveys, monitoring and information brochures for each equipment. In electrical equipment, when possible, a digital meter was used, while in equipment such as taps and showers a graduated container was used to calculate the flow rate. When the consumption of the equipment became impossible to calculate, it was used the information leaflets to collect this information.

4. Results and Discussion

4.1. Water Use

For In order to calculate the daily usage factor of all equipment, firstly it's mandatory to determine the daily number of guest per room, which results in approximately 1.5 guest/day/room. The percentage of water consumption can be related to different characteristics, such as the climate, occupancy rate, profile of use by different customers and the use of different kitchen equipment (this with a lower impact on global consumption). For each zone of the hotel, it was made an analysis of the number of existing equipment and respective monthly usage, allowing a distribution of water consumption to march 2018. It is important to note that the number of guests per day, calculated previously, was used to calculate more accurately the daily consumption of the equipment, found mainly in the rooms.

In the rooms the factor of daily use of the showers is of 20 min @ 11 L.min whereas the bath 20 min @ 9 L.min, presenting this one inferior consumption compared with the shower, with these values it was possible to determine the monthly consumption of water for the total of these equipment's.

The kitchen represents 13% of the total water consumption of the hotel and consists of only two equipment's that contribute to this consumption, washbasins and a dishwasher with a daily use factor of 3 uses @ 37 L.use.

The equipment with the greatest impact on the consumption of the restaurant is the ice machine that has a daily consumption of 35 L of water and is connected every day during the month.

The laundry, the time of use of the intervening equipment is greatly reduced due to the purpose of using it. As for iron with boiler its instantaneous consumption was taken from the information leaflet and its use time was measured over a week realizing that it differs from the person who is using it, it is important to note that the pieces are passed to steam, which makes water consumption higher, but at the same time makes the process faster.

In this zone the washing machine has a much higher weight at the end of the month compared to iron with boiler, due to the consumption per use is much higher.

Common bathrooms, an area where consumptions were more difficult to calculate, due to the uncertainty of the time of use of the different equipment that depends on the number of customers that the hotel receives in your restaurant and whether they use the bathrooms. Having said this, it was decided based on the number of meals that are served per day that 75% of people use the bathroom, a total of 23 people. The time of use of the lavatory is based on the minutes that the automatic faucet is programmed, in this case 20 seconds per triggering. The toilets being the main "consumers" of the water in this area, followed by the lavatories and finally the urinals.

Is presented in Figure 4 the compilation of all the information collected during the various analyzes related to each zone of the hotel.

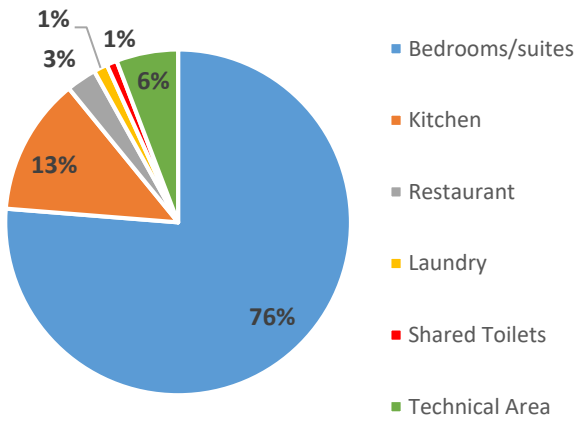

Figure 4 - Percentage of total water consumption in different areas of the hotel

It is understandable that the bedrooms are responsible for the biggest share of water consumption at the hotel. Most of this consumption is a result of using water in bathtubs and showers.

Studies indicate that the percentage of water consumption at a European hotel's laundry room represents 10% of the total water consumption, while the kitchen represents 15%. Compared to the value collected from the hotel subject of this study, laundry rooms represent a significant lower consumption, considering that room laundry is done by an outsourcing company. As for the kitchen, the percentage of consumption obtained is equivalent to the studies already conducted in other hotel units.

4.2. Energy Use

For The consumption of electricity is related to the profile of use of kitchen equipment, laundry, air conditioning and the use of interior lighting. It is important to note that all hotel lighting is made by LED lamps, which are more efficient, durable and sustainable compared to traditional lamps. To calculate the percentage of total consumption of each zone, it is necessary to know the same and all the equipment that contribute to this consumption.

The rooms have three relevant equipment for study, lighting (lamps), television and minibar. For the daily use time of both the illumination and the television the estimation carried out contain associated errors since it is not possible to determine exactly the time of use of both sets of equipment. It was felt the need to resort to studies already performed and the one that best suits the profile of the hotel under study indicates that the time of use of the lighting in hotel rooms is on average 3 hours per day (Puig et al., 2017). For minibars, the values were given by the company that supplied them, since it knows for certain the hourly consumption. In the rooms the equipment responsible for the largest portion of consumption are televisions, followed by lighting and finally the minibar.

The kitchen is the area of the hotel with the largest number of different equipment's, an area that required a lot of monitoring to be able to calculate the average time of daily use of the different equipment and consequently the respective monthly consumption. It is important to note that the refrigerator chests have the same characteristics and dimensions, as does the freezer chests in this space. Since the power of these was not found in any user manual it was necessary to use a digital meter, which is connected between the power plug and the equipment, in order to calculate the consumption of each type of ark. The digital meter was only used in a 24-hour period, in one of the refrigerator chests and one of the freezer chests, since the measurement in the others was impossible to realize with the aid of this apparatus, it was assumed, even though it was not the more correct, that consumption will be the same for all. It is important to be clear that both chests, refrigerators and freezers, need to maintain a certain temperature, the number of times the doors are opened will influence the energy consumption by these, then an advantage to the use of this digital meter is that it records the consumption taking into account the number of door openings during the measurement period. At the end of the 24 hours, for the refrigerator's chests, a consumption of approximately 317 W per hour was registered. For freezing chests, the recorded value was approximately 412 W per hour. In addition to these machines, there is still a dishwasher, a coffee machine, a microwave and lighting throughout the area. The time of all these equipment's were determined by monitoring the daily operation for the month under study.

The restaurant has several electrical equipment, one of them the coffee machine that is dedicated to the coffees that are served with meals, given this, considering that on average the hotel serves 30 meals a day and assuming that for all of them coffees are served, the machine usage factor is 600 seconds (on average 20 seconds per coffee). It is important to emphasize that the powers of the refrigerator chests of this zone were considered equal to the refrigerator chests of the kitchen, where the digital

meter was used, since all the chests have the same dimensions. For the study was also counted the consumption of the toaster, imperial machine and lighting of this whole space.

Common area is composed of all corridors of the rooms and the entrance hall / reception of the hotel, the lighting of these areas runs 24 hours a day. The reception has two computers that are permanently connected during the day, and the consumption of the printer will not be considered since it does not influence the monthly percentages of electric consumption. The estimation of the electric consumption of the elevators contains associated errors since it is not possible to determine exactly how long they are used and there is a standby consumption that could not be considered for the study in question.

Technical area is the one that contains the equipment that have the greatest instantaneous consumption compared to the equipment of other areas, it does not make sense to count the lighting since the consumption of lights is much lower compared to the consumption of other equipment, in percentage levels the consumption of this will be close to 0%. The AVAC keeps the hotel's temperature constant and its consumption was calculated based on the percentage of average consumption in other hotels. There are 3 water pumps in the hotel that interconnect during the day, with a total daily use time of 24 hours.

In a similar way to the procedure adopted to water consumption, the percentage of consumption of each area is calculated accordingly to the electricity total consumption (Figure 5), based on a monthly usage factor of each equipment. This usage factor is computed based on each equipment consumption and the time of use, explained previously.

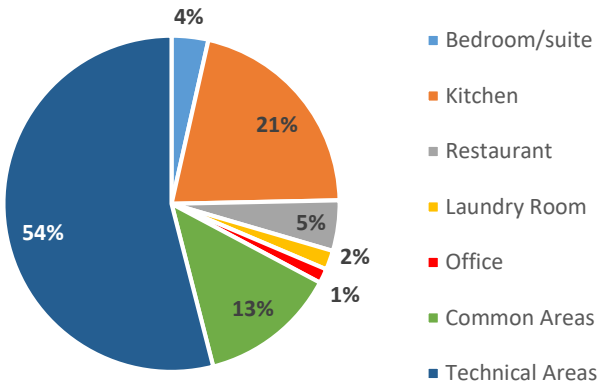

Figure 5 - Percentage of total electricity consumption by the different areas of the hotel

The technical area is responsible for the main share of electricity consumption of the hotel (54%), the kitchen presents a percentage of consumption of 21% (Figure 5).

As for gas, it doesn't really make sense to distribute it by areas, accounting that the quantity of equipment is reduced. There are two stoves in the hotel and both have the same characteristics regarding gas consumption. The stoves consist of three nozzles with different consumptions, since it was not possible to determine, on average, the use of each nozzle and gas consumption charged by each of them, it was decided to agglomerate the values of the consumption of the three (package leaflet).

The consumption of the oven and the fryer, was determined from the maximum consumption charged by them, taken from each of the leaflets. It is important to emphasize again that these consumptions are the maximum consumption, representing the worst case scenario.

Relatively to the number of hours of use of the equipment in the kitchen, these come from a daily analysis over a week, where it was possible to estimate the average hours of use of the equipment.

There are two condensation boilers in the hotel, responsible for all the water heating of the hotel under study. The condensing boilers present in the hotel operate on gas and its main function is to condense the water vapor from the combustion and through that to recover the energy and to use it in the boiler for additional heating, this technology allows to increase the efficiency of the same and save energy. Most of the time boilers are in standby, since there is a thermostat that allows to determine the temperature of the water in the tank, when the water reaches temperatures below 45ºC, one of the boilers is switched on alternately until this temperature returns to reach 60ºC. The consumption of the boiler, contrary to what was done for the others equipment's, results from the difference between the total consumption of the month of March and the consumption of the other gas equipment previously calculated, since it was not possible to calculate through leaflets.

Figure 6 represents different percentages of gas consumption according to different types of equipment. By looking at it, we can observe that the heaviest share of monthly gas consumption is the one deriving from boilers, corresponding to 46%, and ovens, translated in 27%.

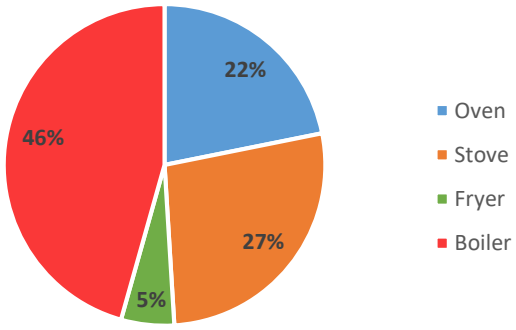

Figure 6 - Percentage of gas consumption from different equipment at the hotel

In accordance with what was done for the previous figure, the consumption of energy (electricity and gas) has now become one figure (Figure 6). The percentage of electricity consumption was distributed among the most consumed

areas / equipment (Figure 7), in order to compare the results with existing studies in different hotel units.

Studies indicate that the percentage of gas consumed by a hotel is on average between 18% and 40% of the total energy used by it. Compared to the values obtained for the hotel under study, this presents a higher percentage of gas consumption, since the boiler used is gas.

Regarding electricity, the percentage consumed by elevators and kitchen in hotels is, on average, between 5% - 9% and 11% - 12% of the total energy consumed, respectively. Comparing with the values obtained in this study, it can be concluded that the values are very close.

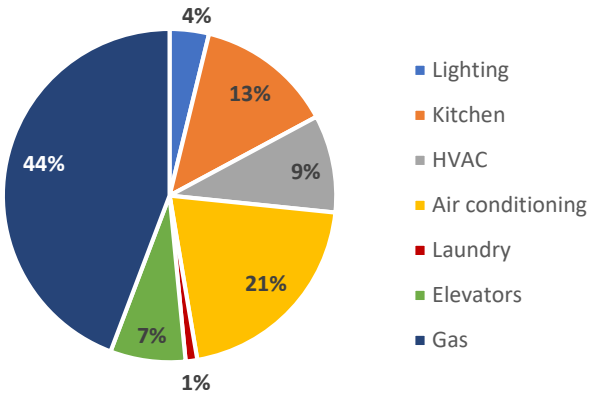

Figure 7 - Percentages of monthly energy consumption for the Lisboa Carmo hotel

5. Conclusions

Considering that tourism is on the factors with a higher impact in the environment, it's important to reach solutions to mitigate it. It's not enough that tourist accommodation contains technologies and proper equipment, but they also need to include maintenance measures, management and awareness to users' behavior.

In that way, the present paper approaches the theme of energy and hydric resource management in a non-residential building (more specifically the hotel unit Lisboa Carmo Hotel) and how consumption is influenced by each purpose.

When it comes to monthly charges, electricity has the major share, also representing the biggest percentage of consumption. Water is highlighted in this image because of its weight in the hotel's monthly charge, and it's also the resource with the smallest percentage of total consumption, as a result of water unit price being higher than energy (gas and electricity).

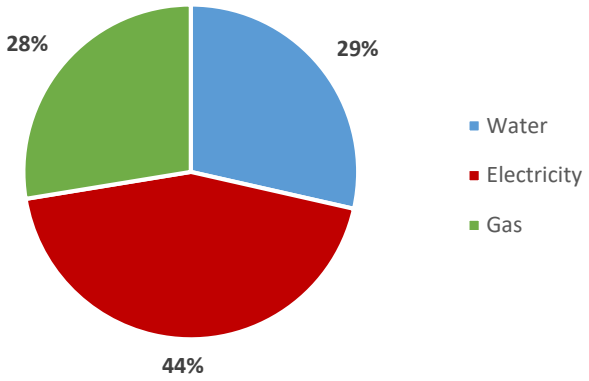

Figure 8 - Percentage of charge associated with each resource for the month of March 2018

Two methods were used to do verification. The first one was to resort to water, gas and electricity bills, related to the studied month with the objective of comparing estimated monthly consumption with real consumptions. The second one was based on the comparison of values obtained with studies conducted in different hotel units. Both methods include estimated valued that comply with the expectations (values between consumption range from studies), apart from laundry and gas consumption that show a deeper variation.

The consumption of the laundry in this case is much lower compared to some studies, as is the case of Trung & Kumar, 2005 and Environmental Protection Agency, 2014, this because the Lisboa Carmo Hotel resorts to an outsourcing company for the purpose of washing clothes of the bedrooms. The percentage of total gas consumption for this hotel is 44% compared to the total energy used by it, while studies say that on average the percentage of gas consumed by a hotel is on average between 18% and 40% of energy total, this discrepancy is due to the existing gas boiler in the hotel.

Throughout this work, some solutions / proposals for improvement were collected with the objective of increasing energy efficiency, since the expenses with electric energy are among the highest expenses of the hotel units.

There are two sets of energy efficiency measures, cross-cutting measures and specific measures. Cross-cutting measures have a greater impact on increasing energy efficiency and can be applied to most Portuguese industries. Specific measures are tailored to the needs of each sector, as the processes used are different and may require different energy efficiency measures.

The following proposals fall under cross-cutting measures such as:

- for refrigeration chests it is possible to minimize energy consumption with the correct choice of cooling system fluid (it can be optimized to consume 15-26%) and avoid constant opening of the doors;
- correct sizing of the lighting system, this should take into account several factors such as the hotel plan, the preference for natural lighting, in this

case, there would be no need for the restaurant lights to be all connected from the opening to the closing of the same, taking advantage of hours of natural light;
- installation of photovoltaic panels, producing electric energy for the most varied uses.

The work developed serves as a starting point for minimizing the hotel's operating costs. It presents the consumption divided by purposes, allowing the knowledge of those that contain the largest portions of consumption, which are the ones where we firstly need to intervene. The proposed methodology can also be applied to other hotels to carry out equivalent studies. Expanding the sample and increasing the level of resolution of the data collection of the consumption, will allow an understanding of the underlying determinants of water and energy consumption in hotel unit. This information is fundamental to define more general policies and measures for the sector, in order to define minimum criteria and standards of excellence in these aspects of sustainability.

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