Reconstruction and Analysis of the Energy Demand of a Healthcare Facility in Italy

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Abstract. The energy demand in healthcare and hospital premises has distinctive features. Due to specific constraints in terms of service continuity and indoor air quality, the demand is at a large extent constant during the day and throughout the year. Indeed, a healthcare facility must fulfil several different activities. Medical equipment needs electric energy, while the Heating, Ventilation and Air Conditioning systems require thermal energy. It is extremely difficult to define reference characteristics for the energy demand, since the proportions of the different consumptions are strongly connected with the specific activities/services carried out within each structure. The present work aims at analysing the energy demand of a healthcare facility located near Firenze (Italy). The energy demand has been analysed by means of the available documentation to get a basic knowledge of the expected consumption of each component of the facility. These data have been then correlated with information on the actual healthcare activity parameters (e.g. staff in service, medical services) and on weather conditions. As a result, the study led to the definition of the principal energy drivers that characterize the Healthcare Facility. The analysis procedure is thought of general interest for the community working in the field, representing a benchmark for the calibration of energy digital twins and a reference data set useful to carry out building energy efficiency optimization strategies.

Nomenclature

HDD = Heating Degree Days, [HDD].
Q = Thermal Power, [kW].
r = Pearson correlation coef. [-]
t = Time, [h].
T = Temperature, [°C].
q = Thermal Energy, [kWh].
V = Water consumption, [m^3].
w = Electrical Energy, [kWh].
W = Electric Power, [kW].

Subscripts:
0 = conventional
avg = average
lim = limit
e = external, outdoor

1 Introduction

The energy demand of hospitals and healthcare is characterized by specific features. These activities must be operative 24 hours a day, 365 days a year [1]. Moreover, hospitals need a variety of energy forms, in order to guarantee the continuity of the different medical services.

Compared to other type of buildings, healthcare facilities and hospitals present a very high specific energy consumption. According to Eckelman and Sherman [2], hospitals in the United States are among the commercial buildings with higher energy consumption per square meter, doubling that of a standard office building. Lately, an analysis of electrical and thermal energy demands has been performed in thirteen Spanish Private Hospitals between 2008 and 2017 to evaluate the main hospital building energy drivers [3]. The study analyses the correlation between the energy consumption of the buildings and several parameters. The results show that electrical and thermal energy consumption are closely related to the useful floor area, while weaker correlations between energy consumptions and the number of beds or staff in service were found. Furthermore, the specific constraints in terms of indoor air quality [4] lead complex Heating, Ventilation and Air Conditioning systems (HVAC), which are pivotal to maintain both comfort and security standards [5]. These systems are energetically expansive and require both electrical energy to ensure the air circulation and thermal energy for the air handling, in form of hot water, chilled water and steam. Moreover, refrigeration systems play a fundamental role to increase the energy demand of a healthcare facility [6]. The energy requirements of this application are often related to the air conditioning systems, but also to other typical services like surgery activities. Due to the nature of refrigerators, which often need the presence of cooling towers, the refrigeration system leads to a non-negligible increase of the consumption in terms of electric energy and water. It is worth noticing that, since the heating, ventilation and air conditioning systems do represent the more energy-consuming applications for a hospital building [7-9], external energy drivers (e.g. temperature, relative humidity) could become key for the energy balance. A total of twenty hospitals were analyzed in the period 2005–2014 in order to look for correlations between energy consumption, external climate conditions, and buildings characteristics [10]. The results highlight a strong correlation between the external temperature and the healthcare energy consumptions. Moreover, many studies have been carried out [11-13] in order to evaluate the impact of a climate change on the energy demand, focusing specifically on that related to heating and cooling applications in hospitals.

These studies confirm a strong dependency of the hospital facilities energy consumptions on climate conditions. If on the one hand the air conditioning systems are key for the hospital energy demand, on the other hand also medical equipment, which represents the core activity of a hospital, plays a relevant role. Rohde and Martinez [14] analyzed the energy demand related to the medical equipment used in a Norwegian University hospital. The study highlights that the medical equipment energy consumption during the daytime was 90 kWh/m^2 per year. Christiansen et. al. [15] carried out a study aimed at identifying and evaluate the electricity consumption due to the medical equipment in hospitals laboratories, which imply non-negligible energy demand during healthcare facility operation.

Moving from this background, the present study reports the main findings of an energy demand analysis of a healthcare building located in Sesto Fiorentino, close to Firenze, Italy. The scope of such activity was to provide the scientific community with a detailed data set related to this type of facility in terms of energy drivers. This was thought of particular use for a variety of purposes like stimulating the improvement existing energy management strategies and energy efficiency of similar activities or calibrating digital twin model for Building Energy Modeling. It is worth remarking in fact that this kind of data is very scarce in the relevant technical literature and anyhow not easy to be collected on site, since the simple analysis of documentation and energy bills is not sufficient to the scope.

2 Healthcare facility overview

The majority of the examples found in the relevant literature highlights a strong correlation between climate conditions and energy consumption. Consequently, it is pivotal to first contextualize the building in the corresponding climate conditions. Italy is divided in six climate zones depending on the heating degree days (HDD) of the specific geographical area (UNI EN ISO 15927-6:2008). The HDD parameter is useful to quantify the heating needs of a geographical zone, and it is defined as:

$$HDD = \sum_{e=1}^{n} (T_0 - T_e)|_{T_e<T_0} \tag{1}$$

where n represents the number of days in the conventional heating period, T_0 is a conventional value assigned based on the interested country, while T_e assumes daily mean temperature values. Only the days in which T_e assumes values lower than T_0 are taking into account.

Sesto Fiorentino (where the premises are located – 43°49'24.9"N 11°13'22.4"E) is classified as a climate zone “D”, with a conventional heating degree day value of HDD=1772. Through the climate data provided by “Consorzio LaMMa”, it was possible to recalculate the HDD of the analyzed period, from February 2019 until January 2020. Differently from the conventional value, the calculated one reached a value of 1946.7 HDD, resulting in a colder year in comparison to the conventional one. The healthcare structure has been obtained recently by the enlargement of a historic building, by a modern, larger building, which extends itself into the surrounding lands, reaching a total surface of about 12’000 m^2. Upon examination of the available documentation about the structure and the systems installed inside it, the healthcare facility has been divided in two main areas, corresponding respectively to the historic building and extension area. The first includes the majority of the offices. No healthcare core activities or related services are performed in this part of the building, being all assigned to the extension area. The extension area is composed by four floors and a roof-top terrace. The basement is mainly used for technical systems and ancillaries (electrical cabinet, water station, air handling units, etc.).

The ground floor is composed by a main area near the entrance, which includes the reception, some offices, a bar and a small commercial area. Two hallways also branch out from the main area and they are used as the diagnostic and the ophthalmology department, respectively. The two hallways delimit a central area, which includes the surgery department and the intensive care unit. These areas are characterized by specific constraints in terms of ventilation and air handling and include many medical devices which require electric energy for their operation. The first floor presents two hallways similar to the ones described for the ground floor, but it does not have the central area. This floor hosts offices, day hospital and outpatient activities. The second floor is similar to the first one from a structural point of view, and it hosts the hospitalization departments. The activities performed in first and second floor need careful air handling in order to maintain both comfort and security standards, resulting in electric energy demand for ventilation and hot water, chilled water and steam for air conditioning. Moreover, surgery and the hospitalization departments rooms need the access to compressed air and medical gasses, which lead to an additional electric energy demand for gasses and air circulation.

The building energy requirements (except for electricity) are covered onsite by dedicated systems. The thermal power plant is responsible for providing all the thermal energy needed by the facility. The central water supply is responsible for supplying domestic hot water users, thermal power plant and refrigeration system. HVAC systems use hot and chilled water, steam and electricity to carry out the air handling. The latter is divided into several units, which serve different building areas. The central water supply originates from a water meter placed outside the building. The water, coming from the inlet water system is led to a collector, which subsequently branches out to secondary circuits like domestic water and water handling system. The water cooling is realized by means of three water-cooled refrigeration units. Each unit, characterized by a nominal electric power of 320 kW and a nominal COP of 3.92, is equipped with four centrifugal compressors with digital speed

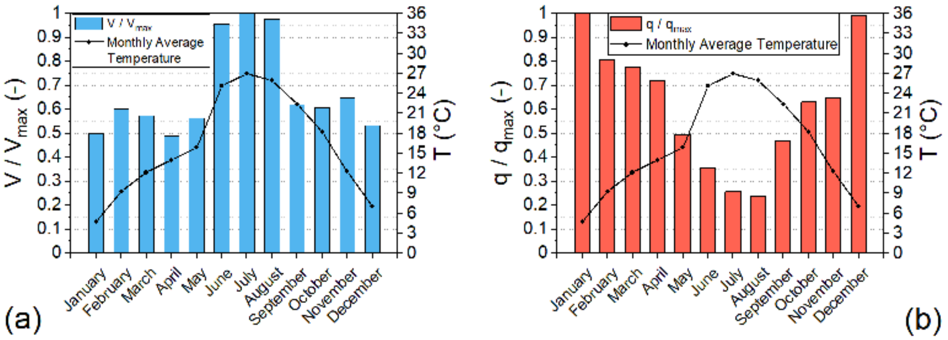

Figure 1. (a) Monthly water consumption in 2019, (b) Monthly thermal energy consumption in 2019

control of the impellers and magnetic levitation bearings. Each refrigeration unit is also connected with two evaporative towers with a total cooling capacity of 4560 kW (6 x 760 kW). The thermal power plant is composed by four natural gas-powered hot water generators for a nominal thermal power of 2800 kW_{th} (4 x 700 kW_{th}). The entire hot water demand is fulfilled by three hot water generators, while a fourth is disabled and running as a backup. The steam generation, needed for the air humidification requirements, is entrusted to three steam generators characterized by a nominal heat output of 606 kW_{th} (3 x 202 kW_{th}). The HVAC system is composed by Twentynine air handling units, necessary to maintain the building indoor air quality. They can be classified based on the building area served by the specific unit. Two air handlers are dedicated to the historic building, while twenty-seven units are dedicated to the building extension. The main areas served by these units are the intensive care unit and the diagnostic, hospitalization, ophthalmology and surgery departments. In particular, the diagnostic department includes several electromedical equipment (e.g. Magnetic Resonance Imaging, TAC), which requires optimal air exchange and indoor climate control in order to avoid any equipment damage.

3 Healthcare energy consumption analysis

The described plants and systems contribute to satisfy the healthcare energy demand, which will be analyzed in the following paragraph. Data gathered from the available documentation will be first presented, in order to give a general idea of both energy and water consumption. Then, the electrical energy consumption will be analyzed in detail through data obtained by the electricity provider. The building water usage is mainly due to domestic water need,

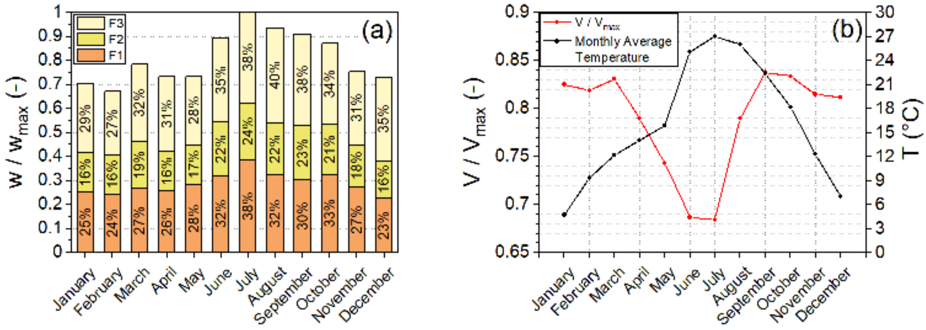

Figure 2. (a) Monthly electrical energy consumption, (b) Behavior of the ratio between the monthly average and maximum power

evaporative towers and HVAC systems. It is important to remind that chilled water is needed during the whole year by the air handling of medical equipment areas, which require particular indoor temperature control. Nonetheless, the significant external temperature rising during the summer period leads to an increase of the cooling plant exploitation and, consequently, to a marked growth of water (Figure 1a) and electrical energy (Figure 2) consumptions. Figure 1a reports the 2019 monthly water consumption. Moreover, the monthly mean temperature trend is shown in order to visually highlight the strong dependency between these two parameters. All the climate data presented in this paper are provided by “Consorzio LaMMa - Laboratory for Meteorology and Environmental Modelling”. It is apparent that the water consumption is mostly independent on the external temperature during the whole year, except for the summer period, in which the monthly consumption increases by 80%. Its behavior during the rest of the year is compatible with physiological variations in domestic water demands.

As regards the electrical and thermal energy demand, the total requirement in 2019 is divided equally. Figure 1b shows the monthly thermal energy demand of the healthcare together with the monthly averaged temperature trend. The majority of the thermal energy requirement of the building is related to heating and domestic hot water. The rest is tightly linked with the external temperature, resulting in high thermal energy demand during winter and minimal needs during summer. In intermediate periods, a gradual variation of the energy consumption can be noticed, which tends to follow the monthly average temperature trend.

The monthly electrical energy demand data was obtained by analyzing the energy provider bills, which divide it in three timeslots, defined as:

- *F1*, which represents the periods between Monday and Friday, from 08:00 until 19:00 (excluding national festivity days);
- *F2,* which goes from Monday until Friday, in 07:00 - 08:00 and 19:00 - 23:00 time slots. Moreover, it includes the Saturday from 07:00 until 23:00;
- *F3* represents the periods between Monday and Saturday, from 00:00 until 07:00 and from 23:00 until 24:00. Every Sunday and all national festivity are considered as part of *F3* timeslot.

The electric energy demand behaviour is depicted in Figure 2a. Like the water and thermal consumptions, the electric energy demand also presents an increase during summer. Indeed, it can be noticed that July is the most intensive month in terms of electric consumption, reaching up to +50% of the February energy demand. It seems reasonable to attribute this marked increase to the massive cooling and ventilation requirements needed during the summer. The division into time slots is useful to preliminary obtain information about the daily electricity demand behavior. Figure 2a shows that the main part of the monthly electrical energy consumption is often related to the F3 timeslot, which corresponds to low energy-consuming period (night and Sunday). This evidence might appear contradictory, and it needs to be additionally contextualized by considering that the three timeslots are not composed by an equal number of hours. F3, which includes the nights, part of Saturday and the whole Sunday, has a number of hours clearly greater than the other two, justifying its higher energy consumption.

The data obtained from the documentation allowed one to carry out an analysis on the average and maximum power of every month throughout the year. They are represented as a ratio between monthly average (W_{avg}) and maximum (W_{max}) power. A lower value can be found in months with marked and brief daily power peaks, typical of the summer period. Instead, higher values mean that the monthly average power is near to the maximum one and they can be found during the winter period, due to the low cooling requirements of the

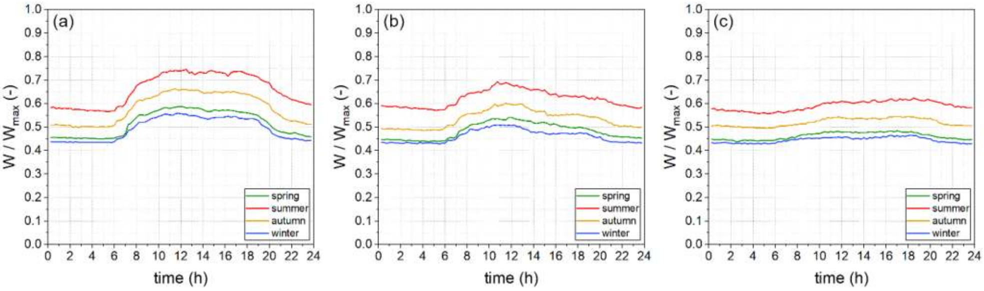

Figure 3. Average power load curve behavior during the four seasons for weekdays (a), Saturday (b) and Sunday (c)

healthcare. Despite the high average temperature and the high total energy consumption (Figure 2a), August is characterized by a value of W_{avg} / W_{max} close to the ones found in the winter period (*0.789*). This can be explained considering that, during this period, the healthcare activities are reduced due to the decrease in terms of staff in service and number of patients, leading to a smoother daily power load behavior in comparison to the other summer months, avoiding high electric power peaks, but maintaining a high total electric energy consumption. The monthly energy consumption analysis highlighted an energy demand dependency on the outdoor climate conditions, in particular on the external temperature. Nevertheless, the monthly consumptions are not detailed enough to draw conclusions about the healthcare energy drivers.

To this end, a more detailed data set about the electric energy demand has been obtained from the energy provider. This made available data from February 2019 to January 2020 about electric energy consumption of the building with a 15-minute time step, which are shown in Figure 3 as average power curves. Marked differences between summer, autumn and winter are apparent. Conversely, spring tends to follow the winter behavior, despite its grater variations around the average power load in comparison to the winter ones (Table 1). The average power curves during weekdays (Figure 3a) present similar characteristics. Starting from midnight, the absorbed power tends to remain constant until 6:00 a.m. Focusing on the summer behavior, an almost linear energy consumption decrease can be noted, which can be related to a lower energy demand by the air conditioning system due to the progressive external temperature drop. From 06:00 a.m. up to 08:30 a.m. there is a gradual increase of the electrical power. All seasons present similar behavior in this time slot due to the intensification of the healthcare activities.

The most energy-intensive period goes from 08:30 a.m. up to 6:00 p.m, in which the structure is characterized by an intense activity. All the healthcare departments and the offices are operative, leading to strong requirements in term of HVAC and lighting, and intensive usage of medical equipment. Morning (from 10:30 a.m. to 1:00 p.m.) and afternoon (from 4:00 to 6:00 p.m.) tend to present higher power values. Then, contrarily to the morning period, a gradual power decrease takes place, until the typical night values are reached.

Sunday, differently from weekdays, is characterized by a smoother average power curve. The absorbed power during the night maintains the same behavior found in weekdays, but the daytime does not present the marked increase of weekdays. Moreover, the transition between day and night is longer than the one in weekdays, given the less intense healthcare activities and the minimum staff in service.

Saturday presents intermediate characteristics between weekdays and Sunday. An energy demand increase during daytime is apparent, but it reaches lower values than in weekdays, and presents a new gradual decrease starting from 3:00 p.m., when the healthcare activities become less intense. Table 1 reports the standard deviation values associated with the power curves shown in Figure 3. It is apparent that their behavior is related to seasons and

Table 1. Power curves standard deviation around the average seasonal behavior showed in Fig. 3

	Spring	**Summer**	**Autumn**	**Winter**
Weekday	0.274	0.361	0.316	0.259
Saturday	0.337	0.337	0.286	0.239
Sunday	0.251	0.321	0.280	0.232

reasonably to climate conditions, reaching maxima during summer weekdays (0.361) and minima in winter Sundays (0.232). Each season presents its minimum standard deviation value on Sunday. This fact led to hypothesize that the variability of the power load is determined also by the healthcare core activities, which are higher on weekdays and lower on weekends. In order to correctly analyze these data, further information about the context was collected and divided in several parameters, which are briefly described below:

- *W* is the electric power described above;
- *T* and *RH* are the external temperature and the relative humidity data, respectively. They refer to the same period of the electric power data, with the same time step (15 minutes);
- *Month* represents the month of the year. It allows one to appreciate the monthly and seasonal power demand variation. In order to avoid discontinuities, it is expressed with a sinusoidal function (Equation 2);

$$f(m) = \sin\left(m \cdot \frac{2\pi}{12}\right) \quad with \quad m = 1, \dots, 12 \tag{2}$$

- *Time* represents the hour of the day (Equation 3). Like the “Month” parameter, it is represented with a sinusoidal function (Equation 3) of the instantaneous hour fraction (e.g. for 00:15 assumes 0.25);

$$f(t) = \sin\left(t \cdot \frac{2\pi}{24}\right) \quad with \quad t = 0.25, \dots, 24 \tag{3}$$

- Day Typology *(Day Typ)* is used to classify the days of the week, assuming different values for weekdays (1), Saturday (2) and Sunday (3).
- *Timeslot* is based on the already discussed time slots division found in energy provider bills. It allows one to classify the power data based on the intensity of healthcare activities, assuming the highest value (3) for F1 and the lowest value for F3 (1), which is the period characterized by lower healthcare activity;
- *Staff in service (Staff Srv)* represents total number of employees during a specific day, clustering medical and non-medical staff;
- *Core activities (Core Act)*: in order to account for the activities carried out within the healthcare facility, it should be remembered that medical exams (e.g. Ultrasound, CAT, Magnetic Resonance) may have a different energy demand. Since no data with this level of accuracy are available yet, it was decided to account for a global parameter including medical activities composed by the number of exams performed during a specific time step.

These parameters were used to carry out Pearson’s product-moment correlation. This analysis allows one to calculate a coefficient (called *r*), which quantifies the correlation between two specific parameters, assuming values between +1 and -1. A coefficient equal to +1 represents a total positive linear correlation, 0 indicates no linear correlation and -1 is a totally negative linear correlation. Table 2 shows the obtained coefficients, allowing to analyze the dependencies between the selected parameters. The table cells have been highlighted with different colors based on how much the correlation between two parameters is significant. A correlation between two parameters is considered high if the absolute value of the resulting Pearson’s coefficient is higher than 0.5. In this case, the related cell of Table 2 will be green. By the same logic, a coefficient lower than 0.1 is colored in red and indicates

Table 2. Correlation between healthcare parameters

	W	Month	Time	Day Typ	Time slot	T	RH	Staff Srv	Core Act
W	1.00								
Month	0.29	1.00							
Time	-0.21	0.00	1.00						
Day Typ	-0.26	-0.05	0.00	1.00					
Timeslot	-0.53	-0.02	0.37	0.41	1.00				
T	0.78	0.21	-0.27	-0.02	-0.25	1.00			
RH	-0.14	-0.12	0.14	0.06	0.14	-0.17	1.00		
Staff Srv	0.32	-0.22	-0.17	-0.71	-0.55	0.12	-0.13	1.00	
Core Act	0.15	0.00	0.00	0.26	0.07	0.28	-0.01	-0.12	1.00

a weak correlation. Finally, a coefficient between 0.1 and 0.5 indicates an intermediate correlation, which is not strong, but neither negligible (yellow cell). Table 2 diagonal collects the correlation coefficients of each parameter with itself, which obviously result in a total positive linear correlation (r = 1.00). Despite the high values, such data are not significant to the current analysis. *Month* shows weak correlation with the other time-related parameters (*Time*, *Day typology* and *Timeslot*). The monthly time scale is closer to seasons than to the daily one, resulting in a more pronounced correlation with climate conditions, particularly with the *external temperature* (r = 0.21). A similar correlation takes place with the *staff in service* (r = -0.22), while the *core activities* are independent on the *month*. *Time* shows an intermediate correlation with *Timeslot* (r = 0.37), due to the time slot definition. Intermediate correlations can be found also with *temperature* (r = -0.27) and *relative humidity* (r = 0.14), due to the daily variation of climate conditions and with the *staff in service* (r = -0.17), which is strongly correlated with other time-related parameters like *day typology* and *timeslot*. It is due to the intensity of daily and weekly activities, which decrease during night and weekends.

As expected, *day typology* and *timeslot* present a relatively strong correlation (r = 0.41) due to the time slot definition, which is based also on the first one. Moreover, they have similar correlation with other parameters, showing high coefficients with *staff in service*. *Day typology* shows a weak correlation with climate parameters (*external temperature* and *relative humidity*), while a high coefficient can be found with *core activities*, due to opening hours of the diagnostic ambulatories. Similarly, *timeslot* shows a high coefficient with *staff in service* (r = -0.55) and results to be strongly related with climate parameters, while a weaker correlation exists with *core activities* (r = 0.07).

Looking at the correlations between climate and activity parameters, it can be seen that they have intermediate correlation coefficients between each other, except for *relative humidity* and *core activities* (r = -0.01). Nonetheless, it is important to notice that climate conditions do not really influence the healthcare operations. In fact, their high coefficients

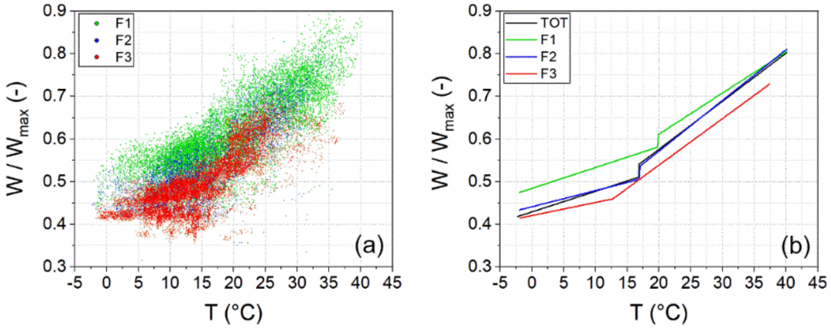

Figure 4. Instantaneous Power consumption vs. Instantaneous Temperature (a), Power-Temperature functions obtained with the linear fit analysis, divided by time slots (b)

Table 3. Linear fit function characteristics

	T_{lim} [°C]	R^2 [-]		ΔW [-]
		$T < T_{lim}$	$T > T_{lim}$	
F1	19.8	0.20	0.37	0.0286
F2	16.9	0.12	0.39	0.0295
F3	12.6	0.09	0.55	0.0011
TOT	16.8	0.12	0.46	0.0295

are due to their correlations with *time*, *day typology* and *timeslot*. The first column in Table 2 resume the correlation coefficients of the discussed parameters with the *electric power* (*W*). Each of them has an influence on the absorbed power. *Month* shows an intermediate correlation with *W* (r = 0.29), due to its dependency on the external temperature (r = 0.21). Consequently, the latter results a better choice to characterize the energy demand, resuming with a single parameter also the *month* influence on absorbed power.

Focusing on *time*, *day typology* and *timeslot*, it can be seen that the latter presents a higher influence on the electrical power demand in comparison with the first two. Moreover, given its strong correlation with *staff in service*, it allows to resume information about *time*, *day typology* and *staff* in service under a single parameter. Nevertheless, it can be noticed that *timeslot* is not useful to take into account the influence of *core activities*. However, the latter shows weak dependency on the absorbed power (r = 0.15) and so it can be ignored. According to these considerations, it can be concluded that *Timeslot* and *External Temperature* are able to resume almost all the analyzed parameters and, coherently, they show very high correlation coefficients with the absorbed power. In Figure 4a, the scatter plot of the instantaneous absorbed power is reported as a function of the external temperature and divided by colors between the three time slots. The instants belonging to *F1* are generally higher than the other two, while those in *F3*, which represent the night period, part of Saturday and Sunday, present the lowest values. Nevertheless, the power consumption trend tends to notably increase with *Temperature*, especially beyond 15°C. In order to extrapolate a relation between power consumption and climate parameters, a regression analysis of available data was carried out.

The aim of this analysis was to find a function able to evaluate the absorbed power. Given the discontinuity in the trend of electric power vs. temperature in correspondence to 15°C, two separate linear fit analyses were carried out for each dataset (*F1*, *F2*, *F3* and *Total*), dividing the data in two temperature ranges. The limit temperature, which separates the two ranges is called T_{lim}. Figure 4b shows the linear fit results. As expected, the linear fit relative to the whole data (black line) presents a trend change at the limit temperature of 16.8°C, like the *F2* function (blue line), which results to be very similar to the first one. *F2* assumes an intermediate behavior between *F1* and *F3*. This is coherent with the discussed timeslots definition. Focusing on the *F3* related curve in (red line), its lower T_{lim} in comparison to the ones related to *F1* and *F2* can be readily noticed. Furthermore, it shows a lower slope along the low temperature range. Considering that *F3* mainly represents night time and Sunday, these differences can be explained with Sunday activities, which are less intense than in other days. The *F1* curve is characterized by higher ΔW and T_{lim} values. Moreover, the relative high slope of these functions highlights a strong power-temperature relation even for $T < T_{lim}$. All the obtained functions show an acceptable R^2 only for temperature values higher than T_{lim}. Indeed, the power-temperature relation becomes more marked with the temperature increase, when the HVAC systems usage is intensive.

4 Conclusions

The energy demand reconstruction provided a good representation of the global energy requirements of the healthcare under investigation. Presented results highlight that the needed power is strongly related to climate conditions. The temperature seems the main energy driver of the healthcare facility, while internal healthcare parameters like staff in service do not have a marked influence on consumptions. The presented methodology is useful to highlight the main energy-consuming systems, which may be subjected to further analyses and management corrections to pursue a higher energy efficiency of the whole building. Moreover, detailed energy consumption analyses of commercial buildings can be pivotal in order to create building digital twins through Building Energy Modelling software, but they are extremely difficult to find in literature. In fact, such models need reliable datasets in order to perform the model calibration and the results validation. The preliminary linear fit analysis carried out on the data obtained from the healthcare energy provider lends itself to further developments. The electric power tendency to follow a systematic trend change over specific external temperatures could be related both to energy systems operations, which are prone to performance decay particularly over a given temperature level, and to healthcare activities, which are mainly concentrated during daytime. Future analyses will be devoted to looking for new healthcare activity parameters in order to better model the electric power load functions. To this end, a great opportunity could be the application of the described analysis to data collected by dedicated monitoring systems for both electrical and thermal energy consumption. These systems are under consideration by the manager of the facility. Indeed, they would allow one obtaining detailed information on the consumption not only from a time-variation point of view, but also in terms of energy repartition between different building areas.

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