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Electricity in hospitals: solutions based on economies of scale

Energía eléctrica en hospitales: soluciones basadas en economías de escala

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Due to the characteristics of the operation of a hospital, their demand for supplies and the need for uninterruptibility, hospital becomes an energy-intensive building. Currently, energy policies of building operation are based on strategies of energy saving and efficiency. In order to carry them out, it is necessary to get information about the consumption profile of the target building and make decisions based on it. The aim of this work is to analyse the different options for contracting an electricity supply for large consumers, such as hospitals, in an attempt to achieve the greatest savings in energy costs. The possibilities of managing the purchase of energy from these large consumers were discussed and analysed. It was concluded that there is a wide range of contracting possibilities beyond the traditional ones (fixed or indexed contract). It also highlighted the need for qualified personnel to assume the responsibility of studying the different modalities of purchase since it will provide an enormous benefit to hospital management.

Healthcare Engineering; Electrical energy; Hospital management.

Debido a las características del funcionamiento de un hospital, su demanda de suministros y la necesidad de ininterrumpibilidad del mismo, el hospital se convierte en un edificio energéticamente intensivo. En la actualidad, las políticas energéticas de explotación de edificio se basan en estrategias de ahorro y eficiencia energética. Para poder llevarlas a cabo, es necesario disponer de la información acerca del perfil de consumo del edificio objetivo y tomar decisiones en base a ello. El objetivo de este trabajo es analizar las diferentes opciones de contratación del suministro eléctrico para grandes consumidores, como hospitales, presenten el mayor ahorro de costes energéticos. Se discutieron y analizaron las posibilidades de gestión de la compra de energía a estos grandes consumidores. Se destacó como principal conclusión el amplio abanico de posibilidades de contratación más allá de los tradicionales (contrato fijo o indexado). Asimismo, se destacó la necesidad de disponer de personal capacitado para asumir la responsabilidad de estudiar las diferentes modalidades de compra puesto que aportará un enorme beneficio a la gestión hospitalaria.

Ingeniería Hospitalaria; Energía eléctrica; Gestión Hospitalaria.

1. INTRODUCTION

The current technological level associated with the daily activity of a hospital demands an enormous amount of electrical energy to meet medical and comfort needs. Hospitals are very energy-intensive buildings operating uninterruptedly 24 hours a day, 365 days a year [1].

In addition, they have a continuous need for availability of supplies, medical equipment, special requirements for air conditioning and air quality and disease control, which makes their energy intensity superior to other buildings in the tertiary sector [2]. In 2017, the electricity energy consumption of Spanish hospitals amounted to 419 ktoe, representing 6.71% of the total consumed by the service sector [3].

Quantifying the costs incurred during the life cycle of a building, it is summarized that: 5% correspond to the project phase, 20% to the construction phase, 65% to maintenance and operation and the remaining 10% to rehabilitation or demolition [4]. Hospitals are energy-intensive during operation, so they will have a higher percentage of costs during this phase.

Although it is expected that in the near future this demand will be met with renewable energy sources, the generation of electricity from fossil fuels still prevails. For this reason, the policy strategies of developed countries aim to reduce the environmental impact of energy production [5].

According to the objectives of the Building Energy Efficiency Directive (2012/27/EU), 2020 is established as the deadline for the implementation of the so-called Nearly Zero Energy Buildings (nZEB). Newly constructed buildings in public ownership, including hospitals and health centres, must have almost zero energy consumption after 31 December 2018 [6]. However, energy thresholds have not been defined specifically for hospitals [7]. Hospital management through Healthcare Engineering is focused on energy and environmental efficiency and therefore becomes an effective tool in this regard [8].

In Spain, since energy consumption is recorded as ktoe, electricity consumption correlated with gross domestic product (GDP) until 2014. Since that year, GDP has grown by 13% and electricity consumption by 4.6% [9]. Nowadays, GDP and electricity consumption do not maintain the same proportion of growth. It can therefore be concluded that consumers have opted for energy saving and efficiency measures [10].

Annual electricity demand in Spain has increased by 10 TWh from 2014 to 2018, representing an increase of 4.12%. However, the installed capacity of renewable energy maintains their contribution of around 50% of the net generation structure since 2014 [11]. A building that requires a 1-36 kV supply with a contracted power greater than 450 kW is considered a large consumer in the electric power context. Large Spanish consumers demand 12% (~30 TWh) of the total [12].

Analysing the general energy consumption of a building allows managers to have useful information for making decisions regarding the contracting of supply services, and to study the options of electrical contracting in particular. This is the reason why it is useful to make this audit effort.

García Sanz-Calcedo [13] analysed and quantified the energy performance of 55 health centres in Extremadura (Spain) in order to estimate the possibilities of savings through the use of specific measures to reduce their energy demand. The average annual consumption was 86.01 kWh/m2, with a standard deviation of 16.8 kWh/m2. The results show that a potential annual saving of 4.77 €/m2 can be achieved.

Bakaimis y Papanikolaou [14] estimated a 45% reduction in the electricity consumption of a hospital in Greece resulting from the implementation of energy policies and proposing an investment in photovoltaic panels and the change from current lighting technology to LEDs.

The installation of renewable energy sources in large hospitals should broaden their share of the energy mix by favouring distributed generation. The proximity between generation and consumption is key to reducing transport losses and, consequently, minimising transport taxes. Although this style of decentralized management would greatly benefit large consumers [15], there are a number of technical, economic, regulatory and environmental obstacles that prevent it [16].

Ferreira Silva, Kopp and da Costa Guida [17] evaluated the aspects related to the evolution towards the integration of photovoltaic solar energy in Brazil's centralized generation system, in view of the country's potential in terms of irradiation. They highlighted the role of R&D and the benefits derived from favorable energy policies to ensure their integration.

García Sanz-Calcedo et al. [18] carried out an analysis of the annual electricity consumption of 13 Spanish hospitals between 2008 and 2017 with the aim of determining consumption indicators based on the hospital activity carried out in each hospital. The results showed a high correlation between average annual energy consumption and the annual number of discharges, number of emergency actions and number of hospital stays.

Analyses of historical consumption are a useful tool for optimising energy expenditure in the future; however, tools based on fuzzy logic are being developed to seek the lowest cost of purchasing energy in the electricity market taking into account all the regulatory conditions that govern it [19].

The aim of this work is to analyse the different options for contracting electricity supplies for large consumers, such as hospitals, so that they offer the greatest savings in energy costs. This work will be useful for hospital managers, opening up the possibility of analysing little-known electricity supply options.

2. Methodology

A compilation and study were carried out of the technical-economic conditions required by each of the contracting options offered by distribution companies to large consumers, such as hospitals, in Spain, and their implications for hospital management.

The study of supply contract options took into account the existence of associated risks. The risk can be classified into two types according to its relationship with the consumer himself or with the electricity market.

On the consumer side, the risk is related to energy demand and the accuracy of forecasts. The energy demand of a building defines its consumption profile, but it is influenced by seasonality (monthly, seasonal, etc.), which opens the door to uninterruptibility as a mechanism for active demand management. The accuracy of the forecasts minimizes the penalty that a deviation in forecasts implies, either because they force a consumer to go to the electricity market to purchase the energy or because surpluses are produced after exploitation.

On the electricity market side, the risk is related to the volatility of the daily energy price and the generation profile according to technologies. The price of energy is determined by the result of the daily matching that takes place in the daily and intraday electricity market, which, in turn, is mainly conditioned by weather conditions and the price of the fuels used in generation. The generator profile differs according to the technologies used in generation, being a problem the randomness of those renewable technologies (hydraulic and wind) in comparison with the combined cycle plants (clearly defined).

The established procedure begins with the consumer, in this case the hospital, with the intention of achieving an increase in the energy efficiency of its system. The way to reach this improvement is usually by investing in new, more efficient technology. However, another path that led to such an end was followed in this work. An energy management from the point of view of contracting electricity supply was proposed. In this way, the risk of the investment and the operating cost of the building is reduced. The result is a consequent optimization of energy consumption that allows financing technological improvements.

The monetary savings resulting from the elaboration of energy efficiency and savings strategies, or from the optimization of the electricity contract, were not treated as a benefit but as an economic source to finance investments in renewable technologies or to improve energy efficiency, as results of producing savings in operating costs.

Consequently, energy efficiency was understood not only from the point of view of minimising consumption, but also from the economic point of view, with efficiency being understood as the savings generated by the correct management and contracting of the electricity supply.

3. RESULTS AND DISCUSSION

The first option that is shuffled is through a marketer. The seller is an intermediary agent between the electricity market and the end user. They buy energy as wholesalers and sell it to the consumer by billing each customer individually. This option allows two types of contract: fixed price or indexed price.

On the first place, the fixed price modality transfers a large part of the risk to the marketer since the price is agreed with the client. Traders include a risk premium in the agreed price depending on the volatility of the energy price. This modality implies that the hospital would pay the same price for the electricity supply regardless of its consumption. On the second place, in the indexed price option, the risk is transferred to the client. In this case, the energy price is in line with the market price. This price includes a set part (transport costs, energy and power tolls and applicable taxes, included), which must be paid regardless power delivery, and a variable part (energy price), that will change according to consumption. In this case, the price to be paid for the hospital will be given by the Equation (1):

$$P = F + Q \cdot c \quad (1)$$

Where: P is the price of bill in EUR, F is the fixed part price in EUR, Q is amount of energy consumed in MWh, and c is associated price to the indexed market.

Figure 1 shows the temporal evolution of the cost incurred by the hospital complex throughout the year.

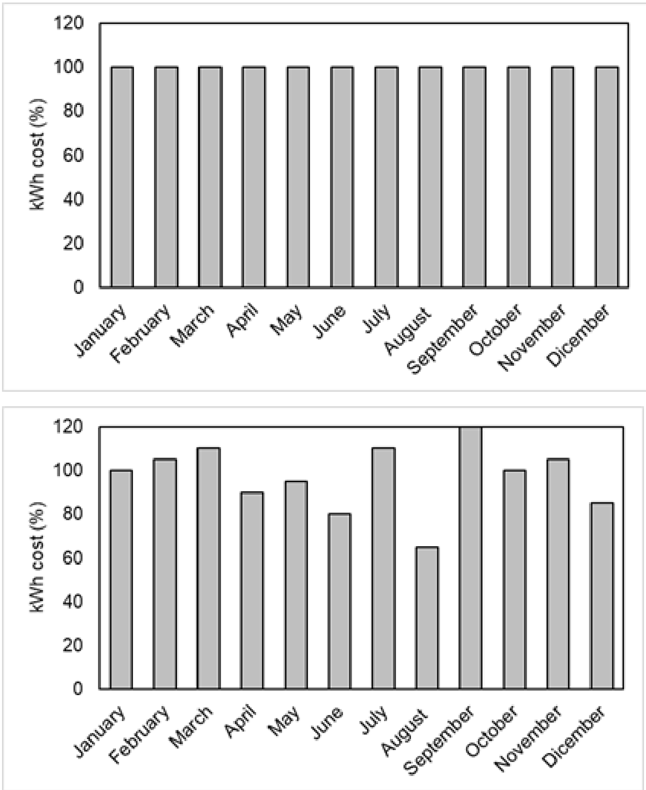

Figure 1. Evolution of the cost of energy throughout the year according to fixed price (left) or indexed price (right).

The second option available to large consumers is coverage. This option is proposed in order to reduce the influence of the daily price volatility. For this purpose, an energy exchange price is proposed for a certain period of time. At the end of this period, the differences between the agreed price and the settlement price are calculated. This is the most complex option and can be carried out through a swap or through a power purchase agreement (PPA).

The energy cost acquired in the market results from the sum of the product of the energy acquired by the hour and its price fixed in the daily market (DMP), which is expressed in the Equation (2):

$$C = \sum_{h=1}^{N} E \cdot DMP \quad (2)$$

Where: C is energy cost expressed in EUR, E is energy adquired expressed in MWh, and DMP is the daily market price of the energy expressed in EUR/MWh.

On the one hand, swap is a funding option as the contracting parties exchange a variable energy price for a fixed one. In this case, a hospital would receive a certain volume of variable-cost energy for a period of time in exchange for a fixed price. The fixed price is determined based on predictions based on current future prices. Therefore, a cost balance showed in Equation (3) is carried out to satisfy the deficit part at the end of the period. Through swap there is a less significant variation in the cost to the consumer in the face of large variations in the daily price. It also implies a risk relative to forecasts, since it implies a penalty if the consumption is overcovered or undercovered.

$$SWAP = e_{SWAP} \cdot \sum_{h=1}^{N} [DMP - c_{SWAP}] \quad (3)$$

Where: SWAP is expressed in EUR, eSWAP is energy expressed in MW, DPM is expressed in EUR/MWh, and cSWAP is expressed in EUR/MWh.

On the other hand, PPA coverage is specific to long-term contracts (> 5 years). This option has an eminent financial nature and is being used as a guarantee for financing energy generating plants from renewable sources.

It provides long-term certainty for both the generator and the consumer. Through this contract, a seller can secure the income of a certain economic amount to, generally, finance its generating plant and a buyer assures the cost of supply during the time of the contract. As in the case of SWAP, defining an expected generation-consumption scenario will be the most beneficial for the hospital manager. This central scenario is defined with a tolerance range. A cost calculation criterion is established for consumption scenarios that are not contemplated.

Becoming a direct consumer offers the possibility of going directly to the daily market to purchase energy according to your consumption forecast. In this way, the consumer pays the energy at the agreed price plus the costs of the system. It is an opportunity to reduce costs if healthcare engineers dispose an adequate consumption forecast, thus avoiding penalties for detours. Not having to participate in other costs of the system (such as efficiency, social bonus, etc.) is the great advantage of this modality. This can translate into a saving of 1 EUR/ MWh compared to contracts made through a sales company. In contrast, there are disadvantages, for example: a direct consumer must present guarantees to the electricity system operator, and their annual consumption must be more than 4 GWh. Within this option, serious modalities are presented, such us not having a representative, have a representative in its own name or in someone else's name.

A consumer association option allows a group of consumers to add their consumption and resources. As advantages, firstly, we can highlight association makes to reach the minimum annual consumption possible. Secondly, the group can negotiate a greater volume of energy in order to obtain prices that are more competitive. The main disadvantage is again the justification of guarantees before the system operator.

On the one hand, integration of the architectural design and the building installations is proposed as an option that can generate an almost zero energy building, however, are strategic decisions taken before the construction of the same [20]. On the other hand, the prediction of energy consumption is a complementary tool for making supply decisions and developing energy efficiency measures, so there are works that apply artificial intelligence to the prediction of energy consumption [21, 22]. In order to reduce carbon footprint derived, efforts should be made to promote in the process of contracting electricity supply that most of them come from renewable sources, such as photovoltaic or wind [23], including environmental clauses in the contracting process [24].

4. CONCLUSIONS

The possibilities of managing the purchase of energy have been presented to large consumers, such as hospitals. To have personnel qualified to assume the responsibility of studying the different modalities of purchase that the traditional fixed contract or indexed with a marketing company will bring an enormous benefit to the hospital management.

The very specific tools, such as coverages, which are very unknown to hospital managers, are really interesting in order to reduce risk by guaranteeing a steady cost of energy. The possibility of becoming a direct consumer is an advantageous option in terms of the reduction of tax burdens that involves.

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