



Guía para Desarrollar Proyectos de Ahorro de Energía en Centros Hospitalarios

Guide for Developing Energy
Saving Projects at Hospital
Centers

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Guide for Developing Energy Saving Projects at Hospital Centers

Presentation

This document intends to encourage hospital directors in Colombia to develop projects of Rational Use of Energy RUE at their institutions. These measures contribute to the competitiveness and efficiency of these institutions, producing concrete and tangible economic benefits for the Hospital Center, as well as social benefits in general for the country as it provides a more efficient health-care sector.

The managerial tasks that hospital managers must develop are presented in very general terms in order to start with the culture of the RUE at these institutions. As a complement, a methodological guide was developed for the technical and maintenance personnel of the hospitals. The methodology that is proposed may be applied at all hospitals in the country regardless of their size.

We hope that this document constitutes a valid contribution to create awareness of efficiency at hospital centers and to promote the rational use of energy sources.

If you are interested in more detailed information, you may consult our web page <http://www.upme.gov.co/si3ea/htm/hospitales.htm>. There you will find the final report of the study carried out by the UPME, as well as a software application that will allow you collect statistical data about energy consumption and equipment maintenance at the hospital center in an organized and coherent fashion. Likewise, the CD-ROM which is provided with this guide includes the files to install the application, as well as the worksheet to carry out energy and RUE project audits at hospital centers.



If the hospital centers of your municipality or department are interested, the UPME is willing to provide a presentation of the study that was carried out.

CARLOS ARTURO FLÓREZ PIEDRAHITA
General Director

Introduction



Hospital centers are important entities for the welfare of society. Users of these entities require essential treatment. Therefore, the service must be continuous and uninterrupted, 24 hours a day, seven days a week, and they must provide prompt access to basic attention. The main objective of the managers of these entities is to ensure that they deliver all these requirements to their users.

A critical element for the adequate functioning of the hospital center is that of energy sources, generally electricity and fuels. In the past, the cost of these sources of energy was such that their impact on functioning costs of a center was not significant. Low prices of petroleum and petroleum products, as well as subsidized electricity costs were the norm in the past century. But the situation has changed radically. Now the electric sector operates through private participation and investment and subsidies are applied only to the low income sectors of the population. As far as hydrocarbons are concerned, we have seen an increasingly strong pressure to raise prices, which is motivated by the growing demand generated by giants, such as China and India, as well as for geopolitical reasons.

The passing and implementation of Law 100 of 1993, which modified to the structure and functioning of the Colombian health-care sector, has meant a change in the rules of the game that ruled the operation of Colombian hospital centers. Now factors suggest competitiveness and efficiency have become the standard. An adequate management of energy resources is important in the pursuit of these two objectives, given that the lower energy consumption is, the lower the cost in energy bills will be. The rational and efficient use of energy is ultimately aimed at reducing consumption, while maintaining the energy services¹ of the institution.

¹ Organization, illumination, steam generation, etc..

It was found in a recent study carried out by the UPME at a State Hospital that by investing 35 million pesos to change the illumination systems, 80 million pesos a year could be saved.

It's important to find mechanisms to overcome the barriers that hamper many potential investments in projects of energetic efficiency. Some of these barriers include a lack of technical expertise and financing.

Energy Auditing is the main instrument to identify options to improve energetic efficiency and to generate a culture of Rational Use of Energy –RUE at the institution. By means of this audit, an energetic diagnosis is made, whose purpose is to identify and evaluate the opportunities to generate energetic efficiency projects.

Now, we will give some guiding principles for the activities that a hospital manager must develop in order to promote the saving of energy.

1. Steps for saving energy

- The first thing that hospital manager must do at the entity is to know how much he is spending in the electricity bill. Likewise, he or she must know the consequences that may be caused by the bad and inadequate use of energy resources: an energy balance of the hospital will help him or her identify the critical points, and make the right decisions.
- In case there are no good measurement systems and suitable historical records, key points must be implemented where energy is measured to be able to control it and follow-up on consumptions. In the case of electrical energy, the service provider always places measurement equipment for billing purposes. Depending on the size of the Hospital Center, it may be necessary to install additional measurement equipment in order to detect consumptions and RUE possibilities. In the case of fuel consumption, the purchase data are the initial base, but it is also recommendable to have places where consumption is controlled, especially boilers. The supplier of natural gas also installs a global measurement

PERFORMANCE IMPROVEMENTS BY MEANS OF EQUIPMENT AND PROCEDURE CHANGES

- Redesign of operational processes with energy efficiency considerations.
- Integration of systems and operations.
- Improvement of operations and maintenance procedures.
- Optimization of existing equipment performance
- Update and set up of new equipment.
- Minor maintenance suggest thermal and electrical insulation.
- Major maintenance, rehabilitation and reconstruction of equipment.
- Analysis and renegotiation of energy tariffs and services with the providing company.

point for billing purposes, and it is up to the consumer to have additional measurement spots.

- The hospital manager must be committed and involved in the energy saving plans and programs. This activity will motivate others in the process and this will be the first step to start energy saving programs and to generate or strengthen the RUE culture at his or her institution.
- Managers must seek the support of the employees' practical knowledge to identify and chose the most profitable energy efficiency measures to be implemented. They may provide technical information, carry out technical evaluations, develop specifications, locate equipment suppliers and implement energy saving measures.

Identifying Finance Sources 2

- the options there are in the country to finance performance improvements must be identified. Among the possibilities you may include: financing by the supplier, conventional financing and incentives. The manager must evaluate to advantages and disadvantages of each one of the possibilities and choose the one that best suits the needs.
- An economical analysis of the RUE projects must be made, keeping in mind factors such as the amount of the investment, the internal rate of return, the period of repayment, the net present value, the net benefits, etc. in such way that it allows the management to establish priorities in their execution.
- There may be some measures that require high costs and investments; however, the savings that will be achieved and how long it will take to repay the investment should be analyzed. Therefore, an investment plan must be made, given that it may not be feasible to carry out all the investments at the same time.
- The budget must be followed during the periods that are revised. If this is not the case, the situation must be



analyzed and measures must be taken. It must be verified if the cause is a problem with some equipment or a bad habit or an incidental event. In case it is required. The budget allotted for this purpose, must be readjusted.



3 Do follow-up

- It is important to work on the evaluation method in order to determine and verify the existence and the benefits of the performance improvements by monitoring and verifying. This is done to determine the value and the distribution of the benefits of these improvements.
- Before a project is implemented, a specification of the follow-up must be developed so that it ensures the success of the project, and that the measures that are implemented are sustainable in time.
- Depending on the nature of the project, and the needs of the hospital, the performance follow-up on a project may be extensive or may comprise simple systems or parts of the most critical equipment.
- Performance indicators must be identified. These may include: indexes based on the measurement of a performance factor which has been agreed on, or the measurement of changes in the performance of the whole facility.

4 Carry out audits

- Audits may be carried out directly by qualified personnel from the hospitals, or through a contracting firm with expertise in the field. The methodology is intended to give the Hospital Center personnel a guide and basic tools for its execution, and for the follow-up of energetic behavior of the system or of a particular subsystem. However, it is very important to keep in mind the experience of the personnel and their time availability.
- The recommendations of an audit may be classified in two types: those which require immediate implementation, which generally comprised modifications in processes and operational habits or minor

maintenance of equipment and systems and those that comprise a longer execution time, which generally imply major modifications of equipment and facilities and which imply a higher investment level.

- The state, and the operational practices of energy consuming equipment must be evaluated and the ways to improve their operational efficiency, must be identified.

Methodology

Assumptions

The methodology for energy audits in hospitals is based on the following premises or assumptions:

- All the departments of the hospital are committed to energy saving and will provide all the necessary collaboration.
- The proposed methodology is general and has a field of application for all the hospitals in Colombia. However, the hospital management may choose the type of auditing that they require and its level of thoroughness.
- The basic elements are available. Such elements are plans, modification records and knowledge of how the system operates.
- The person who carries out the study is in charge of the procedures of measurement taking and carrying out the analyses.
- For the database (see step 2) all the months are counted as 30 days.
- All the equipment that is on stand by will work at full load as soon as it is in service again.



FIRST STEP:

SETTING UP AND GETTING TEAMS STARTED

This stage covers the following activities:

Getting the commitment of the top management

The top management's commitment is fundamental for the success of the program. It is important that the program promotion and information regarding its advances and achievements originate at the management of the Hospital Center.

Appointing the leader of the program

The management must appoint someone who will be in charge of the planning and implementation of the methodology. This person will have the necessary resources and authority to obtain the foreseen results and to be the link between the hospital management and the employees. If the hospital is very large, it is recommended that a committee be created, but always under the guidance of a leader who is clearly in charge of the program.

Study and understanding of the methodology that is presented

The program leader must understand the energy saving methodology and install the software application (see step 2) to load the particular data of the hospital, which will be used for the proper development of the methodology.

The leader must also point out the most important consumption centers in order to start out with the biggest ones and identify the activities that have the greatest potential to save energy.

Setting up work teams

It is important to make sure that people with broad experience are included in order to guarantee that there is



knowledge of all the activities that consume energy in the institution.

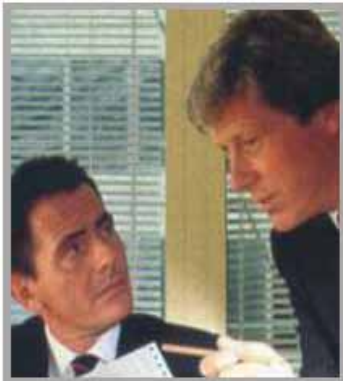
The working teams will be in charge of continuously collecting the data that is required to feed the application, analyzing how procedures work and looking for operational solutions that may be given to minimize consumption, coordinating the staff members and/or users that they are in charge of, and implementing those solutions as well as communicating the results obtained during the period.

Internal Diffusion

The success of an energy saving program in hospitals depends on the cooperation, acceptance, commitment and participation of all those who use the facilities. It is necessary to achieve a change in the organizational culture of hospitals, and in everyone's daily practice. This implies a good information diffusion strategy and the creation of appropriate communication channels.

SECOND STEP:

DATA COLLECTION AND INDEX CALCULATION



The UPME developed a simple application which is destined for the organization and storage of hospital energy consumption data. This software is provided in the attached CD-ROM. Furthermore, it is also available in the web page

<http://www.upme.gov.co/si3ea/htm/hospitales.htm>. It is convenient to appoint someone to collect information and feed the application, which should feed the database with information on the hospital center. This information should be periodically collected by the work teams.



The different indexes for each period must be calculated and compared respectively with the statistical indexes which are presented by the methodology. Likewise, they are to be compared with the historical data – if it is available.

In addition to energy consumption data, it is also required to collect all the available information about the energy systems of the hospital, not only electrical, but also thermal, with petroleum products, coal and/or natural gas. This information consists of construction plans, modification or log books, maintenance records, etc. in case it's not available, it may be necessary to plot the plans in situ.

THIRD STEP:

DECISION MAKING

Analysis of the information

The project leader, along with the work groups, must analyze the information that has been collected, reflect on the critical points of consumption and propose solutions aimed at rationalizing this consumption, which may be of the operational or investment type.

An operational solution is understood as the one that implies changes in the way, order or procedure to do things. Generally, it requires little or no economical investment, but it does imply an organizational change.

An investment solution is understood as the one that implies a change in technology to do things. Generally, it requires a major economical investment and may or may not produce an organizational change.

According to the above, an economical costs versus savings analysis is carried out in both types of solutions.

Establishment of energy saving objectives and action plans

The specific energy saving objectives vary from one hospital to another. Thus, it is necessary to analyze which are the critical points where the major benefits may be obtained and permanently improve each one of them at the different consumption centers.





The team leader and the project leader, along with the top management, will determine realistic, quantifiable and achievable objectives for each consumption center. They must keep in mind, the index comparison which was previously carried out, the operational and investment solutions that have been proposed and their economical analysis. Moreover, they must choose the people who will be in charge of carrying out these changes, the time, and when results must be obtained.

Execution of decisions

The people that are appointed will be in charge of the execution of the action plans. They must take measures monthly, in order to continuously feed the software application.

THEORETICAL RUE POTENTIAL FOR A LEVEL 3 HOSPITAL

The UPME carried out a practical test of the methodology that has been designed in a level 3 hospital in the city of Bogotá. The following energy saving potentials were identified:

By installing energy-saving lightbulbs, and T-8 lamps, more than 400 thousand kWh may be saved a year, with an investment of 35 million pesos. The savings due to a lower electrical consumption will be 78 million a year, which means that in less than six months the investment will be recovered.

By changing standard motors for efficient motors, 100 thousand kWh will be saved a year. The cost of replacing the motors is \$1, 800, 000, and the annual savings will be of more than 18 million pesos.

For the thermal system, only the repair and maintenance of steam lines with hospital center personnel was considered, which does not imply costs. It was calculated that it was feasible to save almost 3 million 400 thousand pounds of steam a year, which with the costs of fuel that is required for the boiler, implies savings of more than 18 million pesos a year.

Energy consumption centers at hospitals



According to the type of energy resource that they use, consumption centers are divided into electrical and thermal, and may be grouped in the following way:

1 Electrical Consumption Centers

General Services

- Illumination: it includes common areas, administration, etc.
- Elevators
- Compressors: compressed air, vacuum, air-conditioning and refrigeration
- Heaters: it includes the heaters in the rooms
- Water transfer pumps
- Ventilation: common areas and hospital areas
- Laundry: washing machines, dryers, irons
- Kitchen
- Cold storage rooms
- Bakery ovens
- Stoves
- Cafeteria
- Stoves
- Burners
- Portable heaters
- Others
- Morgue



Medical Services

This includes motors and medical equipment that use electric power for their normal functioning in the different service areas.

- Imageology: this includes the computed tomography, ultrasonography and Doppler units.
- Cardiology, hemodynamics and electrophysiology: It includes the areas of electrocardiograms, pregnancy tests, echocardiograms, and others.
- Renal unit: hemodialysis, hemofiltration, hemodiafiltration and dialysis.
- Orthopedics and traumatology.
- Intensive care units
- Pain management units
- Intermediate care units
- Surgery: surgery rooms with diagnostic and control support equipment.
- Emergency room
- Pathology and laboratories
- Maternity and neonates
- Recovery room
- Blood bank: refrigeration and transfusion equipment
- Sterilization: electrical autoclaves

Thermal consumption centers 2

They comprise units of equipment which directly consumes thermal energy coming from fuels such as natural gas, propane, diesel fuel, fuel oil, crude oil, coal or those that use heating means such as steam, hot air or water generated by some of the equipment which consumes liquid and/or solid fuels.



Hospitals have the following areas which consume steam and hot air and/or water:

General Services

- Boilers: steam/hot water generators that operate with liquid, solid or gaseous fuels.
- Incinerators: for the elimination of residue. They operate with gaseous, liquid or solid fuels.
- Kitchen:
- ovens: They generally operate with natural gas
- stoves: they generally operate with propane or natural gas for food heating and cooking



- kettles: for steam cooking of food.
- Laundry: Fuels are not consumed directly in this area. They use steam, hot air/or water in the operation of washing machines, dryers, mangles and irons.

Medical Services

- Sterilization: steam is used to achieve the sterilization temperature for instruments and textiles in the different autoclaves.
- Hot water.

Systems to be studied

1 Electrical System

This corresponds to systems, technologies and equipment that exclusively consume electrical power.

Illumination

PASSIVE SOLAR COLLECTORS

By installing this type of collectors it is feasible to eliminate the consumption of fuel which is used for hot water (40°C), which is generally used in kitchens, cafeterias, rooms and general services.

BENEFITS OF USING PASSIVE SOLAR COLLECTORS

- Permanent availability of hot water
- Considerable reduction in the generating capacity of boilers
- Saving of space
- Saving of fuel
- Considerable saving of maintenance

The characteristics of the different types of fluorescent tubes and light bulbs must be identified. The amount of light that each one of them produces is measured in lumens. The lumen/watt ratio indicates the efficiency of the fluorescent tube or light bulb. The greater the ratio, the greater the efficiency.

Motors

The efficiency of electrical motors in operation, their load factor (the ratio of the real load to the peak load of the

design), must be identified. Motors of a higher efficiency must be used.

Pumps and Ventilators

The efficiency of a pump in optimum operating condition varies between 50 and 80%. It must be determined if the size is appropriate and the operating conditions as the flow and velocity are suitable.

Flow versus energy saving	
Flow percentage	Energy saving percentage
100%	0%
90%	19%
80%	36%
60%	64%
50%	75%
40%	84%



Source: Bonneville Power Administration

Compressed Air and Vacuum

The drops and variations that may occur in the compressed air and vacuum lines must be determined, as well as the real need of air and vacuum in each period of time or work shift.

Refrigeration and Air-Conditioning

The real needs of the minimum cooling temperature must be determined. When air-conditioning equipment is going to be used, the type of compression used must be selected (appropriate number of stages).



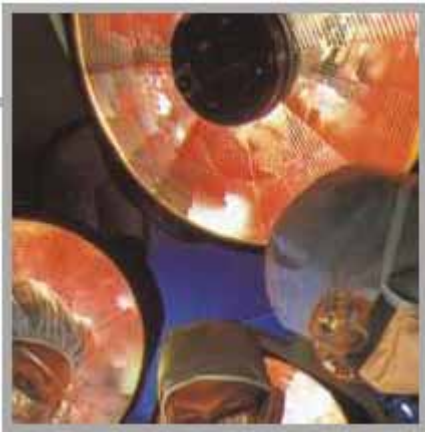
Thermal System

2

It is conformed by those centers, where natural gas, diesel fuel, fuel oil, crude oil, coal, etc. are consumed, as well as the places where steam, air, hot water are used and which are generated from thermal energy.

Boilers

Steam generation constitutes the greatest source of energy consumption, thus the importance of the combustion and operation efficiency of the boilers. Combustion control allows improving the efficiency of the equipment and maintaining control of the temperature and flue gas emissions, which may not exceed the recommended limits. It is critical that the dimensions of the boiler suit the operating conditions²; otherwise, great inefficiencies are generated.



OZONE LAUNDRY EQUIPMENT

- Washing of textiles with cold water
- Use of 50% to 70% less chemicals
- Lower cost of chemicals
- Increase in the duration of textiles
- Reduction of pollution
- Less water required
- Reduced drying time
- Low cost of energy resources
- Increase in productivity
- Lowered maintenance costs

Insulation

The insulation in the steam system pipeline has an influence in the loss of heat, and the quality of the steam due to the greater amount of condensed liquids. The attached table shows the corresponding relation.



Incinerators

Determine the operating conditions of the burner as well as the general condition of the oven regarding the insulation and the door seals. The temperature of the gases indicates the degree of oven efficiency.

Ovens

² It is feasible that physical plant redesigns may change the original conditions for which the thermal system was designed.

The considerations to bear in mind are the same ones as for incinerators. When it comes to ovens that use steam/hot air, the airtightness of the fire doors or lids is essential in order to avoid escapes through sealing gaskets which are in bad condition.

Stoves

Determine exactly the operation cycles to avoid wasting time, while heating or cooking food.

Laundry

Determine whether it is possible to reduce the cycles in each one of the stages. Washing equipment, must work at its (nominal) load capacity. Carry out analyses in order to allow rationalizing the work of each piece of equipment and its use in certain periods of time.

Kitchen

Check the food heating and cooking times in order to reduce the steam consumption cycle in ovens and kettles. Check to see if there are escapes through door and lid seals.

Sterilization

Check the airtightness condition of lids and doors in order to avoid escapes that will not allow adequate temperatures or that a longer time will be necessary than what is specified for each sterilization activity.

General Services

Determine the amount of steam that is necessary for the use of hot water, having the initial and final temperature of the water, and the supply steam volume and pressure as a guide.

Expected results

By following the suggested methodology in this guide, your hospital center should obtain the following results:

- Identification of consumption centers
- Identification of the priority in energy service
- Energy balance
- Identification of the saving potential
- Prioritization of the different RUE projects
- Feasibility for investment projects
- Action plan for the implementation of RUE measures and projects
- To generate an “energy-saving culture” in the actors of the program
- To improve the organizational competitiveness of the hospital center while reducing operational costs and rationalizing energy consumption
- Periodic recollection of energy consumptions in a systematic way



Conclusion

- The methodology, which is developed in this study may be applied to any Colombian hospital, regardless of the level of service that it provides. The success of the application of this methodology greatly depends on the commitment of the administration and the quality and rigorousness of the information that feeds the database that it developed in the study so that it leads to taking the necessary measures in order to achieve considerable energy savings.
- According to the analyses that were carried out, it was possible to deduce that the greatest energy savings are obtained in the illumination of the hospital by means of the use of fluorescent light bulbs, in the steam distribution systems by means of escape control, in the laundry and drying areas, and in the water heating systems.
- The analyses show that it is convenient to use solar energy for water heating. In all hospital centers (level 1, 2 and 3), not only because of the long-term profitability, but also because it is a nonpolluting and renewable source of energy and agree A2's thermal consumptions of a high value that may be used by the country for exportation or giving them a more noble use which could be in the petrochemical industry.
 - The use of photovoltaic solar collectors is not justified due to the high cost of Kw-hr that is generated (approximately 6 times the cost of conventional collectors).
 - It is required to involve recent technology at hospital centers, especially in the laundry, drying, water heating and illumination areas.
 - It is convenient to have energy resource indicators as a way to determine whether or not an optimal use of energy is being made. The proposed methodology in the study offers a simple method so that each hospital where it is applied



collects the relevant information and develops its own indexes.

- Important energy savings are obtained with low capital investments and adequate maintenance and operation programs.
- Adequate internal diffusion mechanisms of the hospital “Energy Saving Program” must be maintained in order to divulge the generalities of the methodology, the parameters to be dealt with by all the people involved in the project and the results obtained from the application of the program.
- The hospitals’ success depends on their ability to operate efficiently, reducing their costs, including their energy bill, and consequently be able to provide quality service.

SOME TECHNICAL RECOMMENDATIONS

- To permanently verify air and steam leaks through traps, valves, joints, etc. into compressed air and vacuum systems, and in the steam system.
- As much as possible, modernize the laundry system to achieve important savings in water chemical and steam consumption, as well as the levels of pollution and a useful service life of the washed garments.
- The statistical record of electric power, fuels, natural gas, water, etc. is indispensable per consumption center, as well as a general inventory of the equipment that uses thermal energy and electric power with a full identification of its characteristics.
- It is required to fully identify the reforms carried out in the electrical distribution lines and the service that they provide from the panels of the substation to the final users’ equipment.
- Record must be kept of the repairs and maintenance that have been carried out.
- Hospital equipment run-times must be optimized, especially in the thermal area.
- Fluorescent tubes with T8 technology and energy-saving lightbulbs must be used.
- It must be verified that the capacity of the motors suits the need of the service.
- As it becomes necessary to change a motor, change it for a similar high-efficiency one, keeping in mind the load factor.
- It is recommendable to employ solar panels for hot water supply at all hospitals.
- An updated record must be kept of all the reforms in the air and steam lines indicating where the filters, valves, traps, gauges, thermometers, etc. are located in each one of them.

