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GUIDELINES for ENERGY EFFICIENCY in HOSPITALS

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Guidelines for Energy Efficiency Measures in Hospitals

The need for energy saving in hospitals

Energy saving measures can play a significant role for lowering energy consumption and energy costs, as well as for environmental protection. Energy consumption is responsible for CO_2 emissions to the atmosphere, that contribute to the "greenhouse effect".

- An important parameter for energy saving in the buildings sector is the high efficiency of the energy infrastructures, which requires excellent quality of the relevant equipment installed, as well as the compliance with all the requirements set by the legislation.

In order to maximize the energy efficiency of a building -based on the capabilities of the existing shell and infrastructure, and minimise the need of any reconstruction or energy saving measures the development of an Energy Management Programme for the building is proposed. This programme will require the energy book keeping, in order that all the energy data and bills of the building are registered in a database. These data will be very helpful for any future energy inspection or audit, in order that energy saving measures are proposed. An energy management programme for a building or group of buildings usually include:

- Thorough energy inspections and energy book keeping aiming at recording the evolution through time of the energy consumption and identifying the energy saving potential of the building
- Identification of the adequate targets for energy consumption
- Feasibility studies for concrete energy saving measures, including the implementation of new energy technologies (eg. cogeneration, central automated management systems, RES technologies etc)
- Energy book-keeping for registering the energy consumption of the building
- Development of energy reports, periodically, targeting the manager of the building
- Implementation and monitoring of an Energy Management Programme for the rational operation and use of the building's infrastructures (heating, cooling, lighting, hot water) and the electric and electronic equipment

- Informing the users of the building on the targets set in the framework of the Energy Management Programme and on their participation in it
- Training of the personnel of the technical department that are involved in the operation and maintenance of the building and of its infrastructures
- Identifying the adequate funding mechanisms for energy projects
- Monitoring of the construction of energy applications and monitoring of the efficiency during their operation

Energy saving potential in hospitals

One of the main building types with a great potential to apply measures of energy saving is the hospitals. Below, some of the most important reasons why hospitals consume lot of energy and some simple ways to reduce their energy consumption are mentioned.

1) 24hour operation (lighting, heating, air condition, electricity consumption)

The non-stop function of the hospitals is an important factor why there is such a big energy consumption. Below, some sectors in which energy can be saved, consumption can be restricted and energy efficiency can be increased, are mentioned.

Ligthing

Lighting is a sector with great energy saving potential. At the places that have to be lightened 24 hours a day, high performance lamps can be used. Besides, some type of lamps that are put outdoors, consume lot of reactive load; as a result their performance is reduced. This issue can be addressed with the local use of capacitors for power factor correction. These could result in a 50% reduction in energy consumption.

Heating

Consuming gas for heating is a big percentage of the overall energy consumption at a hospital. The 24hour function of the building and the extra needs of the patients also increase the energy consumption.

Gas consumption for heating can be reduced by improving thermal insulation or adding insulation to a non-insulated building and by maintaining the boiler at an annual basis. The greatest savings can be achieved if oil is substituted with natural gas. Besides, taking measures

for reducing thermal loss at the pipeline is very important. Energy consumption for heating can be reduced up to 15%.

However, the most efficient way applied today in low efficiency buildings with high energy consumption is the installment of a co-generation system for producing heat and electricity.

Air Condition

The big volume of the rooms that have to be cooled makes the cooling of hospitals a very energy-consuming process. However, as temperature has to be stable and patients must feel comfortable, most hospitals have a central cooling system, which helps controlling electricity consumption by adjusting the desired temperature and the humidity at the central cooling system. However, thermal insulation improvement and the adequate maintenance of the system can reduce significantly the needs for cooling.

Electricity consumption

Electricity consumption is very high in hospitals due to the continuous operation, the large rooms, the medical equipment and the electric motors. Bying equipment with low energy consumption, replacing old motors with new ones and local use of capacitors for power factor correction help to the reduction of energy consumption.

2) Big surface of the buildings

Rooms with big volume, long corridors and the need for satisfactory ventilation are factors that increase energy consumption in hospitals. In many cases, the continuous use of artificial lighting in all these rooms is not necessary, so systems of controlling the switching of the lamps can be installed. Some systems of this type are the motion sensors and the time switches which can be applied at rooms which don't need to be lightened often, like the toilets.

3) Needs for hot water

Hot water use, which is very energy-consuming, is high in hospitals. Also, because of the big size of the buildings, there is important loss of heat in the pipeline. That's why the needs in hot water must be determined with accuracy, since they differ from one hospital to another, in order to avoid unnecessary energy consumption for water heating.

4) Need for thermal comfort

Obtaining high quality of the inside climate and assuring the thermal comfort for the patients are very helpful for the improvement of their health. However, these factors also affect the energy consumption in hospitals. That's why the rational energy management in the building is

very important. The desired thermal comfort, the use of cooling systems and the use of heating and humidity systems must be combined with the main bioclimatic principles and the adequate energy behavior from the hospital's staff.

5) Sterilization supplies

The great needs for sterilization in hospitals, demand steam networks with very long pipes. Good insulation at pipes to avoid heat losses, the use of steam and the heating of the water are measures that can save lot of energy in a hospital.

6) Energy consuming machines and equipment

Medical machines which are necessary for a hospital's operation also contribute to the high energy consumption of hospitals. The energy cost can be controlled during the purchase process by taking into consideration the life cycle cost analysis, the energy consumption, the energy efficiency etc. Besides, measures can be taken for improving the power factor through the use of capacitors for the reduction of power loss due to harmonic currents.

List of energy efficiency measures

The application of energy saving measures can be either at the shell of the building or at the electromechanical installations. The measures that were studied and selected, were divided in categories, based on the sector of energy consumption of the building where they are referred to (eg. shell, heating, lighting etc) and on the investment that is required for their implementation. With regard to the investment, the measures are divided into three categories:

1) Simple measures, that do not require special financing or capital investment.
   This measures are applied in regular basis and are included in the usual operation and maintenance of the building. Also, they are often related with the change of behaviour of the users of the building.
2) Low cost measures
   These measures concern actions that are taken once and can be financed by the existing administrator of the building. The cost of these measures may often be returned to the investor within the same administrative year and usually in less than two years
3) Reconstruction actions
   These measures concern actions that require capital investment, due to the important initial cost for their implementation and their medium or long pay-back period. For the implementation of these measures is often required a special tehno-economic study in order that the viability of the investment is examined.

In the following paragraphs the most common and advisable possibilities of energy saving measures for buildings are listed.

Measures concerning the shell of the building

Simple Measures

- ✓ Control of the use of the openings (windows and doors) between spaces in different thermic conditions
- ✓ Rational operation of the existing equipment for shading, depending on the season and the orientation of the opening that is exposed to solar radiation
- ✓ Control and repair of damaged openings and walls, of damaged mechanisms for opening the doors and windows, of damaged heat insulation
- ✓ Sealing of passages of thermic flow in shafts and stairwells, systematic use of openings, specifically during the night, for the promotion of the natural ventilation and cooling during summer

Low cost measures

- ✓ Sealing of rabbet join points with special insulating material for the improvement of the thermal insulation of the openings
- ✓ Closure of unnecessary openings with simultaneous thermal insulation of the surfaces covered for preventing unnecessary thermal losses
- ✓ Cover of useless doors with simultaneous thermal insulation of surfaces that they cover.
- ✓ Replacement of chipped or broken glass panes with new double-pane panels
- ✓ Placement of coloured and reflective devices for internal shading (louvers, curtains) in openings with undesirably high solar profit during the summer.
- ✓ Placement of mechanisms of automatic shut of doors
- ✓ Replacement of conventional metal doors having considerable heat bridges, with other of new design from materials with special protection and lower thermal conductivity.
- ✓ Adding insulation layers in areas of the external walls that are behind radiators of the central heating.

Reconstruction actions

- ✓ Thermal insulation of exterior walls, roof, floors, pilotis
- ✓ Thermal insulation of heat bridges (props, beams, dwarf walls etc.)
- ✓ Replacement of existing openings (frames, glass panes) with new ones with improved thermal and optical attributes
- ✓ Reduction of the heating/cooling volume in spaces with excessive height (integration of false roofs)
- ✓ Placement of exterior constant or mobile shading devices (awnings, shutters, vertical or horizontal sunshades etc.)

- ✓ Adding passive solar systems of heating and lighting (walls of mass Trombe, solar water heaters, "greenhouse" spaces etc.)

Group of boiler-burner

Simple Measures

- ✓ Periodic maintenance of the boiler. Regulation of the combustion air and scattering and turbulence of fuel ratio so that high degree of combustion's attribution is ensured.
- ✓ Cleaning of surfaces of thermal transaction of the boiler from deposits and non combustibles
- ✓ Control and repair of points of escape of exhaust gases and of air combustion
- ✓ Reduction of the temperature of hot water at the entrance in the network according to the reduction of the heating load (reduction of limit of hydrostat) down to the limits of maintenance of the thermal comfort and safety of boiler from possible corrosion
- ✓ Guarantee of suitable pressure of system for avoiding the boiling of water or entry of air in the network (thermal losses in ventilatories because of high pressure or not efficient operation of radiators because of low pressure)
- ✓ Reduction of the number, if more than one, of the functioning boilers depending on the reduction of the heating load (manual control, hydraulic isolation)
- ✓ Recalibration of the equipment of measurement and control
- ✓ Minimisation of variation of the heating load (review of automated schedule of operation of boiler-burner)

Low cost measures

- ✓ Repair or upgrade of the heating insulation of surfaces of boiler
- ✓ Installation of exhaust gas turbines in the air-pipes of the boiler for aid of heat transfer between hot exhaust gases and water
- ✓ Installation of blades in the hearth (optimal mixture of air of combustion with scattered fuel)
- ✓ Installation of diaphragms in the chimney for reduction of up-draught thermal losses at the intermediary intervals when the system is stopped.
- ✓ Replacement of injectors of fuel with smaller or replacement of all the boiler with similar of lower power, when the system is over-dimensioned
- ✓ Installation of permanent measurement system for the monitoring of parameters of combustion (analysis of exhaust gases, measurement of fuel, electric measurement)

Reconstruction actions

- ✓ Replacement of old burners with new multistage boilers, of double fuel (oil-natural gas), where it is feasible.
- ✓ Replacement of old boilers with new ones of high efficiency and low temperature of exhaust gases as output
- ✓ In buildings where hot water is produced from oil, installation of separate boiler for covering the needs during summmer
- ✓ Installation of a heat exchanger for heat recovery from hot exhaust gases in boilers where the temperature of the exhaust gases is high
- ✓ Installation of an automated sstem for the optimisation of the combustion and the continuous adjustment of the adequate air of combustion depending on the load
- ✓ Installation of system of periodical initiation of many boilers (sequence firing control) with adjustment of each hydrostat for a specific load
- ✓ Installation of a co-generation of heat and electricity unit or integration in a network of district heating, replacing the existing system for heating and hot water.

Cooling group of air conditioning

Simple Measures

- ✓ Periodic usual maintenance of the system. Cleaning and repair of fulfilment of refrigeration tower, surfaces of heat exchangers, ventilators etc. Restoration of leaks of cooling liquid.
- ✓ Increase of temperature limit of refrigeration of water in the cooler and pressure of suction of gas of the cooling fluid (in systems of direct expansion), up to the limits for refrigeration and dehumidification of air so that the comfort in the spaces is guaranteed.
- ✓ Reduction of temperature limit of the condensation water in the condenser and the pressure of condensation (in groups of direct expansion), via a) increase of air supply by fans in the air-cooled condenser or in the cooling tower of the refrigeration system, b) increase of water supply in the cooling tower, c) modification of the operation of the control units for continuous operation of the cooler - condenser and d) removal of condenser nearer to the compressor (reduction of energy needs for pumping)
- ✓ Pause of operation of the auxiliary equipment, of systems of interrupted operation, in moments when this is not required (circulators of water of cooler and condenser, thermal resistances etc.)
- ✓ Control and maintenance of the devices of defrosting and of the expansion valve of heat pumps

Low cost measures

- ✓ Cleanup of condenser pipes in water-cooled systems

- ✓ Reinstallment of the hydraulic connection (in parallel or in line) between parts of the system (coolers, compressors, evaporators/condensers) to balance the consumption profits of the compressor with the energy cost for pumping, in central systems with lots of units.

Reconstruction actions

- ✓ Installation of heat exchangers in the cooling water circuit of the condenser or in the hot pipeline of the cooling fluid, for heat recovery
- ✓ Cooling of the air conditioning water from exterior cold air, via an exterior heat exchanger or internal fluids in the central air-conditioning unit, in buildings with requirements of winter air conditioning in regions with very cold winters.
- ✓ Installation of central automatic system of optimisation of the overall efficiency and operation of the system
- ✓ Use of natural sources of water for the circle of condensation (rivers, lakes)
- ✓ Use of desiccating material from silica gel for the reduction of humidity of air tides. This involves the reduction of latent cooling load hence also the increase of the required temperature of the fluid that cools this load
- ✓ Installation of system for short-term or mid-term storage of cold water or ice for benefitting from night electric tariffs (cooling storage).
- ✓ Production of cold water in coolers of absorbent circle with use of recovered heat, natural gas or renewable energy sources (solar energy, biomass)
- ✓ Incorporation of more efficient control systems for the improvement of the cooling power in its operation in partial loads, (control of speed variation, cylinder discharge, control of valve angle, control of operation of circulators and fans)
- ✓ Replacement of auxiliary source of energy (e.g. oil in boiler, electric resistance), in installations with heat pumps and other system, with more economic and/or more efficient source and simultaneously modification a) of the operating procedures of pumps so that they cover the base load and b) of the initiation – pause control system of the auxiliary system.

Networks of distribution of air conditioning fluid

Simple Measures

a. Environmental conditions control systems of air conditioned spaces

- ✓ Maintenance of the suitable options of all space thermostats and hygrostats.
- ✓ Adaptation of controllers of temperature regulation for energy savings during periods of non-use of main spaces and non-used spaces

- ✓ Pause of ventilation and dehumidification equipment in periods when the spaces are not used.
- ✓ Closure of diaphragms (dampers)
- ✓ Adaptation of belts of ventilation fans

b. Network of pipings

- ✓ Control and maintenance for avoidance of air entry in the network and leaks in pipes, reservoirs, valves and pumps
- ✓ Pause of circulators when their operation is not required
- ✓ Cleaning and replacement of filters

c. Network of ventilators

- ✓ Cleanup of vanes of big centrifugal fans
- ✓ Maintenance of motive parts (synchronising engine's loads with the transmission, adaptation and replacement of belts of movement)
- ✓ Cleanup and replacement of air filters

Low cost measures

a. Environmental conditions control systems of air conditioned spaces

- ✓ Warm-up or pre-cooling without the import of fresh air with more thermal load in systems with economizers or separate system of ventilation (circle of pre-combustion)
- ✓ Adjestment of air supply, in buildings with highly variating inhabitation, via a) regulation of diaphragms, b) strangulation of fan's supply, c) control of engine's turns, d) mechanic control of revolutions, e) integration of vanes of fans with variable step etc.
- ✓ Replacement of connectors, parts of or the entire regulating air diaphragms (mixing dampers) for the avoidance of air leaks
- ✓ Installation of thermostatic valves in units
- ✓ Installation of economizer circle in central air-conditioning units with distribution capacity of 100% of fresh air
- ✓ Installation of more precise thermostats
- ✓ Removal or reinstatement after the mixture device, of the element of warm-up of central air-conditioning unit, in cases of system upgrades in order to handle larger quantities of return air.

b. Network of pipings

- ✓ Hydraulic balance of network via a) the regulation or replacement of valves in main collectors and sectors and the adaptation of the units' valves and b) the installation of regulatiory valves for automatic control of supply.
- ✓ Repair or upgrade of heat insulation of pipes and reservoirs

- ✓ Reduction of supply in cases a) of over-dimensioned systems, b) of reduction of loads and c) of increased temperature difference between the lines of presentation and return (strangulation of flow, automatic regulating valves, reduction of turns or replacement of circulator)

c. Network of ventilators

- ✓ Balance of network for the achievement of proper air supply in the spaces
- ✓ Reduction of supply in cases a) of over-dimensioned systems, b) of reduction of loads and c) of increased temperature difference between the lines of presentation and return (strangulation of flow of air, adaptation of new rollers in engines of fans, reduction of turns or circular operation of fans)
- ✓ Reduction of falls of pressure in installations with pressures of operation above 200 Pa, via a) the abstraction of dirty blocked filters and destroyed, from brought pieces, vanes of elements b) opening of diaphragms in the direction of flow, c) the installation of valves of turn in difficult turning-points d) dilation of narrow passages and e) replacement of big flexible departments with solid
- ✓ Repair of points of air leaks
- ✓ Reduction of the installed power of fans in over-dimensioned systems (installation of smaller ones)
- ✓ Repair or upgrade of heat insulation of ventilation pipes
- ✓ Installation of diaphragms preventing the export in the environment of useful in thermal power air-current during non operation of fans

Reconstruction actions

a. Environmental conditions control systems of air conditioned spaces

- ✓ Transformation of systems of distribution with final reheat (terminal reheat) and with double tube of hot-cold air (dual duct) in systems of variable volume of air (VAV) - Replacement of elements of reheat (or new addition) with VAV control boxes, transformation of boxes dual duct in operation with two engines or deactivation of hot tube with modification of cold tube.
- ✓ Installation of fans and ventilators for increase of the movement and air mixture between different thermal areas (e.g. between greenhouse and room)
- ✓ Installation of modern central system of energy management (BMS) with possibility of direct digital control via regional electronic units of data collection and processing (probably in combination with the operation of other energy systems e.g. lighting)

b. Network of pipings

- ✓ Installation of separate circulators in circuits with important differences of fall of pressure or in areas with very different requirements

- ✓ Installation of many circulators controlled in parallel or of a circulator with control of turns for pumping, in stages depending on the load
- ✓ Abstraction of useless departments of network in previously modified networks

Installations for hot water

Simple Measures

- ✓ Reduction of storage and presentation of hot water temperature down to the limit for sufficient use for cleanness and safety from bacteria and viruses
- ✓ Pause of circulators in periods where there is no demand
- ✓ Rational use of hot and cold water flow mixers in faucets

Low cost measures

- ✓ Installation of supply restrictor in pipings and of systems for flow restriction through mixture with air in faucets
- ✓ Automatic control with isolation valves or reduction of the flow pressure

Reconstruction actions

- ✓ Modification of storage reservoir's size for adaptation to the needs of use (case of over-dimensioned systems)
- ✓ Replacement of common manual faucets with faucets controlled by photocell, infra red sensors or mechanic systems
- ✓ Use of local heater for temperature increase of the final distribution's hot water, thing that involves the need of smaller reservoirs and lower storage temperatures in the central system
- ✓ Installation of measurement systems of hot water in each apartment or floor of the building.
- ✓ Installation of solar collectors
- ✓ Installation of heat pump for heating of water in central system, in combination with the use of pump for air conditioning of spaces
- ✓ Decentralisation of system for reduction of the distribution losses

Installations of steam distribution

Simple Measures

- ✓ Control and repair of steam leaks and condensates in pipings and containers
- ✓ Maintenance of steam traps

- ✓ Maintenance of chemical protection system

Low cost measures

- ✓ Repair or upgrade of heat insulation of pipings and containers
- ✓ Optimisation of system planning (lengths of pipes, restriction of sectors)

Reconstruction actions

- ✓ Heat recovery from the condensates with heat exchanger

Installation of artificial lighting

Simple Measures

- ✓ Switching-off of lamps in non-used areas
- ✓ Coordinated periodical cleaning, control and maintenance of lamps and lightning systems in holiday periods
- ✓ Cleaning of internal surfaces of walls and painting with brighter colours.
- ✓ Re-arranging of spaces for most optimal use of natural lighting
- ✓ Maintenance of low levels of lighting when the installation is used only for security reasons (night)
- ✓ Removal of lamps from over-dimensioned lightning systems or replacement of two lamps of low output effiency with a high efficiency one

Low cost measures

- ✓ Minimisation of exterior lighting and use of timers
- ✓ Modification and optimisation of the arrangement of lightning devices in the area
- ✓ Use of local lighting proportional with the type of activity in the area
- ✓ Replacement of lamps of low luminous efficiency (e.g. glow) with more efficient lamps (e.g. compact electronic lamps of fluorescence or energy saving lampss)
- ✓ Installation of covers with light reflectors in old nakedly or with plastic cover lightning equipment for optimisation of light distribution in the area
- ✓ Control of lighting with local switches, timers, dimmers and sensors of motion.

Reconstruction actions

- ✓ Installation of automatism of maintenance of constant brightness in the area in systems that can be upgrated

- ✓ Installation of automated control of the installations depending on the level of natural light with use of sensors of natural light and separate perimetric circuits.
- ✓ Replacement of lighting system with new more efficient
- ✓ Installation of modern central system of energy management (BMS) with possibility of direct digital control via regional electronic units of data collection and processing, (probably in combination with the operation of other energy systems e.g. air conditioning)

Electric Equipment

Simple Measures

- ✓ Maintenance of engines
- ✓ Balance of loads of electric phases for the improvement of engines performance
- ✓ Synchronisation of engine and transmission in systems of movement with belt
- ✓ Reduction of using lifts and automatic scales
- ✓ Use of appliances of office with energy saving features

Low cost measures

- ✓ System of automatic control of electric loads - Cut of secondary loads in peak periods that influence the tariff of the electric energy
- ✓ Installation of power factor controller of electric engines for the improvement of the efficiency in partial loads

Reconstruction actions

- ✓ Systems for improvement of the quality of the power supplied (both current and voltage) (special filters of harmonics)
- ✓ Correction of power factor (cosine) with the installation of capacitors
- ✓ Systems of controlling engine's turns
- ✓ Replacement of engines with new high efficiency ones