KLM Technology Group Practical Engineering Guidelines for Processing Plant Solutions	KLM Technology Group Engineering Solutions Consulting, Guidelines and Training www.klmtechgroup.com	Rev: 01 Rev 01 Oct 2021
KLM Technology Group P. O. Box 281 Pejabat Pos Bandar Johor Bahru, 80000 Johor Bahru, Johor, West Malaysia	Kolmetz Handbook Of Process Equipment Design ENERGY MANAGEMENT OF BUILDINGS (ENGINEERING DESIGN GUIDELINES)	Co Author Rev 01 Apriliana Dwijayanti Author / Editor Karl Kolmetz

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(Random and Structured Packing, Trays, Demister Pads)
7) Commissioning Assistance

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INTRODUCTION

SCOPE

The consumption of energy is increasing at a fast pace while available resources remain limited. The global need for energy is increasing by more than 2 % a year. Energy consumption has a significant impact on our natural environment. Recently, a consensus has arisen that there is clear evidence that climate change is caused by human activity, mostly related to the use of energy. Hence, energy and environmental management has become a strategic issue that has to be dealt with at the highest level within an organization.

Energy management is a program planned and carried out systematically to utilize energy effectively and efficiently by carrying out planning, recording, monitoring, and evaluating continuously without reducing the quality of production and service. Energy management includes the planning and operation of consumption and energy related production units to actively manage efforts to save energy and reduce energy costs. The concept of an energy management system that builds systems and processes managerially and technically to manage energy use rationally.

The goals of energy management are saving resources, climate protection, and cost savings. For consumers, energy management makes it easy to get access to energy according to what and when they need. Energy management is related to environmental management, production management, logistics, and other business related functions

There are several different uses of energy in buildings. The major uses are for lighting, heating, cooling, power delivery to equipment and appliances, and domestic hot water. The amount that each contributes to the total energy use varies according to the climate, type of building, and time of year.

GENERAL DESIGN CONSIDERATION

Energy management and conservation are the keys to using fuel and electrical energy in the most efficient way. Proper energy management can lead to big savings on the operating costs of a plant or a building. If fuel and electrical energy consumption are reduced, money will be saved as a result. Most of residential, industrial, and commercial buildings have already undergone changes that have resulted in the savings of both energy and money. Any process plant or building can be made more energy efficient when proper energy management procedures are applied.

Energy management is a program planned and carried out systematically to utilize energy effectively and efficiently by carrying out planning, recording, monitoring, and evaluating continuously without reducing the quality of production and service. Energy management includes the planning and operation of consumption and energy related production units to actively manage efforts to save energy and reduce energy costs.

The goals of energy management are saving resources, climate protection, and cost savings. For consumers, energy management makes it easy to get access to energy according to what and when they need. Energy management is related to environmental management, production management, logistics, and other business related functions.

While energy conservation is the application of rules in energy management not only to reduce energy consumption but also to implement efficient operating patterns, installation of additional equipment improve system performance so that energy consumption is lower but does not reduce comfort and productivity. In essence, energy conservation is a guide on how to conserve energy properly and contains methods and tools that can be used to save energy without reducing productivity and comfort.

Energy Management standards:

1. Guide the company in using energy better.

2. As a guide in determining benchmarks, measurements, documentation, reporting energy intensity, and the benefits of implementing energy projects to reduce the impact of green building emissions (GHG emissions).

3. Establish open communication between cross divisions in energy management.

4. Promote successful cases in energy management and encourage good energy management behavior.

5. Guide companies to evaluate and implement new technologies in energy efficiency.

6. Provide a framework for promoting energy efficiency in all utilization channels in the company.

7. Facilitating the improvement of energy management in relation to GHG emission reduction.

Energy Management System Concepts

The concept of an energy management system that builds systems and processes managerially and technically to manage energy use rationally. The concept of an energy management system both management and technical consists of 4 processes known as PDCA processes namely planning, doing, checking, and acting. The energy management system concept scheme can be seen in Figure 1.

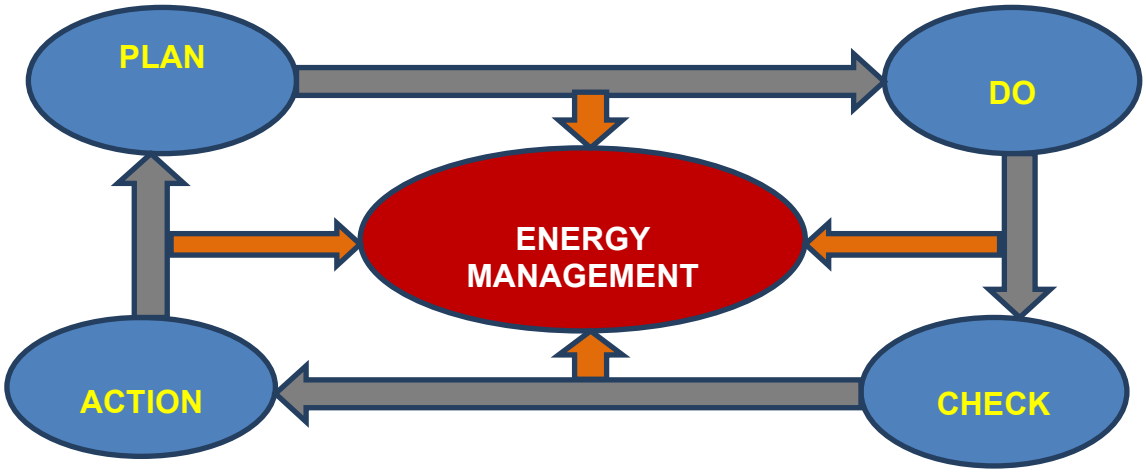

Figure 1. Energy Management System Concept Scheme

Table 1. Description of Energy Management System Concept

MANAGERIAL	TECHNICAL
Plan - Policy - Government	Plan - Energy Data Managements - Assessments
Do - Training - Communication - System and Procedure	Do - Energy purchasing - Design - Projects - Verification
Check - Corrective - Internal Audit	Check - Correcting - Measurement
Action - Management review	Action - System performance

Developing an Energy Management Program

It is important for building owners and operators to develop effective energy management programs. Energy management programs, when administered properly, can effectively reduce the amount of energy used in a building. The effort will not only save money but it will conserve our national or world fuel resources. Energy conservation, by itself, is not energy management. Energy conservation is doing what is easy and economical in the short term. Energy management, in contrast, is the long-term commitment of one or more individuals.

Major objectives of an energy management program for any residential, commercial or industrial building should be:

1 To reduce energy use without making impractical financial investments.

2 To maintain a comfortable living or working environment.

3 To assure that the building meets federal and state regulations pertaining to energy use.

4 To improve the efficiency of equipment and reduce the operating costs.

There are several suggestions that building owners and operators should consider when developing an energy management program.

1 Plan the program with care.

2 Hire or contract with an energy specialist to make an analysis of energy use in the building.

3 Delegate someone dependable to supervise the overall energy management effort.

4 Collect and analyze data on fuel and energy cost.

5 Maintain control over the way in which energy is used in the building (develop a “policy” regarding energy use).

6 Hire professional consultants (if it is financially feasible) to analyze energy use in the building and make recommendations for modifications that will save energy.

7 Maintain accurate records of equipment operating schedules and room occupancy.

8 Urge employees to help in the conservation effort by turning off lights, using as little hot water as possible, closing doors, and maintaining proper thermostat settings.

9 Conduct periodic checks to evaluate the effectiveness of the energy management program and suggest ways of improvement.

There are several systems of a building that should be checked as part of an energy audit.

Table 2. Systems of a building checked

Conduct a lighting survey.	• Determine the number and types of lighting fixtures. • Determine the footcandles of light in each area. • Check the switching methods used to turn lights on and off. • Determine the average hours of light usage in each area. • Review current IES guidelines for lighting systems
Conduct a building utilization survey.	• Determine how each area of the building is actually used. • Determine the hours of use of each area. • Determine the needs for HVAC system use in each area. • Determine the approximate numbers of people who occupy each area and how these numbers vary over a 24-hour period.
Conduct a survey of the building envelope	• Check condition of walls, roofs, floors, ceilings, and entries • Determine if adequate insulation is used in all areas. • Check areas for air infiltration

Conduct a survey of electrical equipment	• Check electricity bills for demand charges and determine equipment utilization schedule. • Check transformer ratings and loading. • Check the power factor of the electrical system. • Determine loading of all large electric motors.
Conduct a survey of steam and hot-water systems.	• Check the general condition of steam and hot-water distribution systems. • Make boiler efficiency tests. • Determine utilization of equipment on a daily and seasonal basis. • Check to determine the adequacy of insulation of steam and hot water distribution systems.
Conduct a survey of the HVAC systems	• Determine the most energy-efficient temperatures for system operation throughout the heating and cooling seasons. • Check exhaust air fans, supply- and return-air systems, and outdoor air quantities and keep operating data for daily and yearly periods. • Make operational checks to determine if systems are operating at maximum efficiency.
Conduct a survey of special-purpose energy-consuming systems.	• Check temperature of the hot water in the domestic hot-water system (105°F or less is recommended). • Check special-purpose process equipment utilization.

Energy Assessment Tips:

- Check the insulation in attic, exterior and basement walls, ceilings, floors, and crawl spaces.
- Check for air leaks around walls, ceilings, windows, doors, lighting and plumbing fixtures, switches, and electrical outlets.
- Check for open fireplace dampers.
- Make sure appliances and heating and cooling systems are properly maintained.
- Study lighting needs and look for ways to use controls—like sensors, dimmers, or timers—to reduce lighting use.

Preventive maintenance performed on equipment can make a significant contribution to energy savings. This is particularly true for electrical and mechanical systems, whose condition affects their operating efficiency. Preventive maintenance (PM) procedures are used to take corrective action on equipment before breakdown occurs. PM should be done on a scheduled basis. In many cases, PM can be computerized for large buildings with a maintenance staff. PM can save companies money because precise scheduling of maintenance activities increases the operating efficiencies of equipment and increases the lifetime of equipment. Increased efficiency of equipment will reduce the amount of energy used.

Table 3. Checklist for Energy Management Systems

Items to check	Corrective action
Building room temperature during occupied periods. Accurately check the temperatures of each room in the building to see if they are too high in the winter or too low in the summer. Keep records of the temperatures maintained in each room. (It is estimated that on the average, a 1-degree change in temperature will cause a 2% change in energy use.)	Adjust thermostat settings to proper level for energy conservation (recommended 68°F for heating and 78°F for cooling); install covers or locks to prevent adjustment of thermostats by unauthorized personnel; replace old thermostats with ones that have a limited range of an adjustment for heating and cooling seasons; install computerized energy management system to control building temperatures
Building temperature during unoccupied periods. Determine actual hours when the building is occupied; check to see if building temperatures are changed to allow energy conservation during unoccupied periods.	Decrease temperature setting by at least 10°F in winter and turn off cooling system at night and on weekends and holidays when the building is not occupied; install timers or computerized energy management systems to control the times when the heating and cooling systems operate
Storage rooms and unoccupied spaces. Check to see if storerooms or other unoccupied areas in the building which are ordinarily heated or cooled; see if doors from heated or cooled areas to unheated or uncooled areas are allowed to stay open for extended periods of time.	Adjust the temperature of unoccupied spaces to a proper level in the heating season (55°F recommended); turn off the heat in areas where there is no need to keep items from freezing; use portable heaters in large areas where there are few people working; turn off the cooling system to all unoccupied spaces and storage areas; place automatic door closers on all

	doors between areas that are heated or cooled and areas that are not; install a computerized energy management system.
Building activity schedule. Check the schedule of activities for the building to see if there are rooms used unnecessarily during off-hours or for intermittent activity during work hours	Attempt to schedule activities in the building during off-hours only as necessary; and when activities are necessary, schedule them so that only minimum floor space must be heated or cooled; schedule building maintenance activities to take place during regular hours when possible; install a computerized energy management system to control the temperatures in all parts of the building according to the occupancy
Heating and cooling system operation. Check to see if the heating or cooling system is operated continuously	Turn on the heating or cooling system less than 1 hour before personnel arrive at the building and turn it off before personnel leave the building (try different startup and turn-off times until minimum energy usage is reached); install a timing system or computerized energy management system to reduce heating time during unoccupied periods and turn the cooling system off at night
"Energy awareness" of employees. Determine whether or not personnel who use the building are aware of the need to conserve energy and proper methods to accomplish conservation.	Make sure that all personnel contribute to the overall energy conservation effort by using written or verbal communication (use signs or reminders when and where appropriate).
Thermostat settings. Accurately measure	When necessary, calibrate existing

room temperatures and compare with thermostat settings to see if thermostats work accurately and are positioned in a location to accomplish accurate control.	thermostats to accomplish accurate control; replace thermostats when necessary with a type that offers limited range control during heating and cooling seasons
Relative humidity of rooms. Check the relative humidity of rooms to see if the proper levels are maintained during summer and winter seasons.	Adjust existing humidification equipment accordingly; install new humidification or dehumidification equipment to make conditioning of the air in the building more efficient
Hot-water temperature. Check the temperature of domestic hot water to see if the temperature is too high	Adjust temperature of water to proper level (55°F recommended); if the building uses dishwashers, for which high-temperature water is needed, consider installing a booster heater for the dishwasher
Hot-water use. Check to see if hot water is conserved to the maximum extent; check for drips or leaks in the system.	Install flow restrictors where practical; remove standard water faucets and replace with a self-closing type that has a flow restrictor; repair all leaky pipes, faucets, pumps, or storage containers.

DEFINITIONS

Absolute Pressure - Zero-referenced against a perfect vacuum, using an absolute scale, so it is equal to gauge pressure plus atmospheric pressure.

Atmosphere - A layer or a set of layers of gases surrounding a planet or other material body, that is held in place by the gravity of that body.

Atmospheric pressure - The force per unit area perpendicular to a surface determined by the weight of the vertical column of atmosphere above that location.

AFUE – Annual Fuel Utilization Efficiency. A measure of furnace efficiency obtained by comparing the heat delivered to energy supplied to the furnace.

Air infiltration – The leakage of air into or out of a building (dependent on outside temperature compared to inside temperature) through cracks and around doors and windows.

Alternating current (ac) – The type of electrical power that is produced at electrical power plants and distributed to buildings and industrial and commercial buildings. Single-phase ac is used for buildings and other lower-power applications. Three-phase ac is used for higher-power industrial and commercial applications.

Ampacity – The electrical-current-carrying capacity of a conductor used for electrical wiring.

Ampere (A) – The fundamental unit of current

Ambient temperature – The environmental temperature in which a solar energy system operates.

Auxiliary system – Equipment that uses some form of energy other than solar to supplement the output of a solar system. This provides the necessary backup during periods of low solar output.

Building envelope – The external surfaces of a building structure which are exposed to the climate. These parts of the building including the roof, walls, doors, and floors

Calorie – The amount of heat needed to raise the temperature of 1 gram of water 1 degree Celsius

Cooling load – A measure of the amount of energy needed to cool a building. It can be determined on a monthly, yearly, or seasonal basis. It is calculated by multiplying the overall U-value (thermal conductance) of a building by the total surface area of the building times 24 hours per day times the number of cooling degree-days of the time period being calculated.

Control – The part of a system that manually or automatically regulates the system

Current – The movement or flow of charged particles, called electrons, through a conductor.

Cooling load – A measure of the amount of energy needed to cool a building. It can be determined on a monthly, yearly, or seasonal basis. It is calculated by multiplying the overall U-value (thermal conductance) of a building by the total surface area of the building times 24 hours per day times the number of cooling degree-days of the time period being calculated.

Degree–day (cooling) – The degree-day value for any particular day is the difference between the average daily temperature and a temperature of 65°F. For example, for an average daily temperature of 82°F, the number of cooling degree-days is 17 (82°F – 65°F).

Degree-day (heating) – The degree-day value for any particular day is the difference between 65°F and the average daily temperature. For example, for an average daily temperature of 45°F, the number of heating degree-days is 20 (65°F–45°F). Heating degree-days provide an indication of how severe the weather has been for the winter season.

Efficiency – The ratio of the illumination of an area to the electrical energy used to light the area.

Electric heating - A process in which electrical energy is converted to heat energy. The heating element inside every electric heater is an electrical resistor, and works on the principle of Joule heating: an electric current passing through a resistor will convert that electrical energy into heat energy.

Electrical circuit – An arrangement of electrical devices which has a voltage source, a closed wiring path (conductors), and a load that converts electrical energy into another form of energy.

Energy – The ability to do work. For example, electrical, mechanical, light, and heat energy.

Energy conservation - The efficient use of systems that consume energy

Energy audit – A method by which a person or persons go through a building and identify energy and/or cost savings that would result if energy conservation changes were made in the operation or if modifications could also be called an energy assessment.

Energy conservation – The efficient use of systems that consume energy

Energy management – A continuous planning process which is used to accomplish the efficient use of energy in a building or system.

Energy Service - The ratio between achieved performance or the profits from services, goods or energy, and the energy used to achieve this.

Energy Management - the predictive, organized and systematic coordination of the procurement, conversion, distribution and use of energy to cover requirements while taking account of eco- logical and economic aims.

Fuel oil - also known as heavy oil, marine fuel or furnace oil is a fraction obtained from petroleum distillation, either as a distillate or a residue

Fossil fuels – Fuels, such as coal, oil, natural gas, and propane, which are derived from fossil deposits in the earth.

Furnace - A device used to heat and melt metal ore to remove gangue

Gas – Matter that has no definite volume or shape and little cohesion between molecules taking its form from its container. Typical examples of gas are oxygen, hydrogen, and neon

Graywater – Water drained from some sinks, showers, tubs and washing machines for non-potable uses such as water for plants.

Ground – There are two types of grounds: system grounds and equipment grounds. System grounds are current carrying conductors used for electrical power distribution. Safety grounds are not intended to carry electrical current but to protect individuals from electrical shock hazards.

Heat – A form of energy that is considered to be a measure or an indication of quantity. It is generally measured in British thermal units (Btu).

Heat exchanger – A unit used to transfer thermal energy from one medium to another.

Heat gain – The amount of heat a building gains due to several sources such as air infiltration, people inside of the building, lights, and sunlight. This heat is usually removed from occupied buildings by the cooling or ventilation system.

Heating load – A measure of the amount of energy needed to heat a building during a monthly, yearly, or seasonal period. It is found by multiplying the overall U-value of a building times the total building surface area times 24 hours per day by the number of heating degree days per time period being calculated.

Heat loss – The amount of heat a building loses due to several sources, such as around doors, windows, through walls, floors, and ceilings.

Horsepower – The basic unit of mechanical power. A single horsepower is equivalent to 550 foot-pounds per second or 746 watts (about 3/4 of a kW)

Humidity – A measure of the amount of water vapor in the air.

Insulating glass – Two or more panes of glass separated by air space.

Insulator – A material that will not conduct electrical current under normal conditions.

Load – Part of a system that converts one form of energy into another form of energy. An example of a load is an electric motor. The motor converts electrical energy into mechanical energy.

Lumen – The amount of light falling on a unit surface, all points of which are a unit distance from a uniform light source of 1 candela. Essentially, it expresses the amount of light output from a source.

Luminaire – A fixture designed to hold lamps and produce a specific lighting effect on the area to be lighted.

Management - concerned with optimizing and controlling the use of company resources in order to achieve specified objectives. The most important resources are knowledgeable. Main management tasks:

Planning - Deciding on how to use resources in order to achieve given targets.

Coordination - Communication between the company's functional units.

Organization - Organizing people to get the best out of their potential.

Staffing - Hiring, motivating and developing people as the most valuable company resource.

Controlling - Supervising, supporting, communicating, motivating and guiding people in order to achieve required performance.

Budgeting - Planning and securing the financial means for company operation

Reporting - Enabling the flow of information and control of policy implementation

Parallel circuit – An electrical circuit that has all components connected across the power source and in which the voltage is the same across each component.

Performance - an ability to complete a task or operation according to a specified standard. The standards may be defined as measures, yardsticks or benchmarks for assessing the deviations of actual performance as compared to preset requirements, as a basis for managerial control.

PSI – Abbreviation for pressure per square inch

PSIG – Abbreviation for pressure per square inch gauge. This term refers to the psi reading of a particular gauge.

Power – The rate at which work is done or energy is converted

Pressure – A force that is exerted on a specific area

Radiation – A process by which heat is transferred through the motion of waves. For example, heat radiates from the sun in waves.

Relative humidity – A measure of the moisture in the air at a certain temperature compared with the amount that it could contain if it were saturated. A relative humidity value of 100% indicates that the air is fully saturated with moisture. The abbreviation for this term is RH.

Resistance – The opposition to flow. The opposition may refer to electrical current, fluids, or mechanical motion.

Source – Part of a system that supplies energy to other parts of a system. Examples of a source are: (1) an emergency generator that supplies electrical energy to a building in case of power failure, or (2) a battery that supplies energy to start an automobile.

Temperature – Level of the intensity of heat. It is measured on a definite scale in Fahrenheit or Celsius.

Therm – A measure of gas fuel equal to 100,000 Btu.

Thermal energy – Heat contained in a material which is caused by the movement of molecules.

Transmittance – The ability of a transparent or translucent material to pass solar radiation. This can be done directly, through glass, or be diffused.

Trap – A fitting or device that provides a liquid seal to prevent the emission of sewer gases without altering the flow of liquid sewage.

True power (watts) – The amount of power that is converted to another form of energy in a circuit or system. It is measured with a wattmeter

Valve – Control devices designed to stop, start, check, or throttle the flow of water through pipes and fixtures. Float valves, cock valves, cutoff valves, and flow control valves are commonly used in water systems.

Voltage – The potential difference or electrical pressure across two points in a circuit.

Volt – The basic unit of voltage or potential difference in an electrical circuit.

Watt – The basic unit of electrical power. The amount of power converted when 1 ampere of current flows under a pressure of 1 volt.

Watt-hours (Wh) – A measure of power consumed in a building for a given number given number of hours.

Watthour meter – A meter that monitors electrical energy used over a specific period.

Water distribution - A part of water supply network with components that carry potable water from a centralized treatment plant or wells to water consumers in order to adequately deliver water to satisfy residential, commercial, industrial and fire fighting requirements

Wattmeter – A meter used to measure the electrical energy that is converted in a circuit or a system.

Work – Work is accomplished when an applied force moves a body or mass through a measurable distance.

NOMENCLATURE

R	Thermal resistance (ft^2.F.h/btu).
W	Watts
U	Coefficient of heat transfer, (Btu/ft^2/hr/°F)

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