KLM Technology Group Practical Engineering Guidelines for Processing Plant Solutions	KLM Technology Group Engineering Solutions Consulting, Guidelines and Training www.klmtechgroup.com	Page : 1 of 146 Rev: 02 Rev 01 Nov 2019 Rev 02 Sept 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 PROCESSING PLANTS (ENGINEERING DESIGN GUIDELINES)	Co Author Rev 01 Faulina Popy Puspita Rev 02 Apriliana Dwijayanti Author / Editor Karl Kolmetz

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INTRODUCTION

SCOPE

Energy management is an activity that is carried out using management principles, with the aim of energy conservation, so that energy costs as a component of production / operating costs can be reduced as low as possible. Energy conservation itself means efforts to use energy rationally but still maintain productivity and meet company management requirements. Rational energy use includes savings and energy efficiency.

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 to 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.

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 in 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 the proper energy management guidelines and procedures are applied.

GENERAL DESIGN CONSIDERATION

Definition of Energy Management

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

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Energy Management standards:

1. Guide the company in utilizing 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 greenhouse 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.

A definition of energy management is - a proactive activity, organized and systematic procurement of goods, conversion, distribution and use of energy that meets the needs, taking into account environmental and economic goals. The objectives of energy management in the industry are as follows:

1. Optimizing the utilization of energy and energy resources.

2. Increasing the efficiency of energy use and energy resources.

3. Take advantage of opportunities to improve the company competitiveness.

Good energy management in process plants and buildings will also help to conserve our valuable natural resources. Money savings and conservation are the two major benefits of energy management. A few other important results are less dependence on imported oil and other sources plus the longer life of some equipment. This guidelines deals primarily with energy management and conservation.

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.

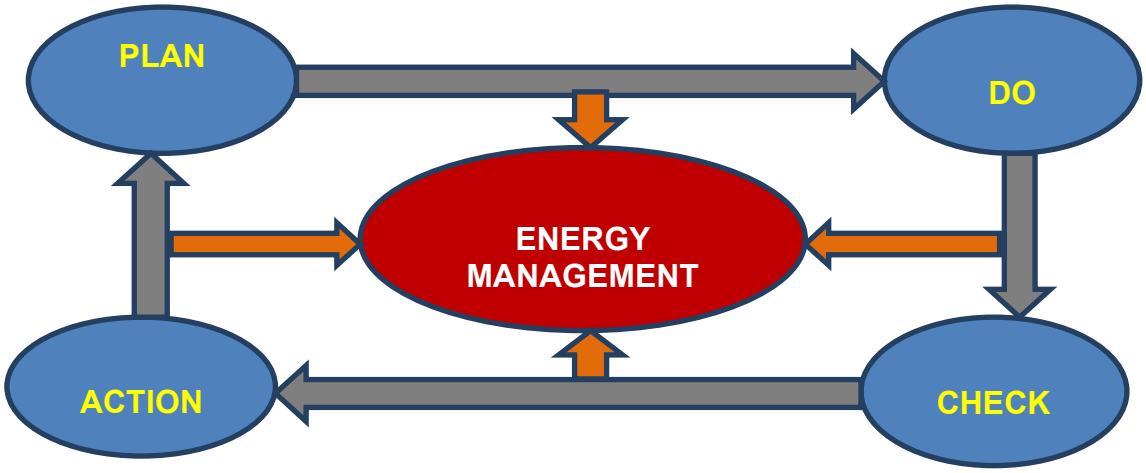

Figure 1 : Energy Management System Concept Scheme

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	Action
- Management review	- System performance

1. Energy Planning (Plans), includes:

a. Selection or determination of company targets

b. Determination of strategies for planned objectives:

1) Project to be implemented

2) Funds needed

3) Equipment needed

4) Organization and employees needed

2. Implementation (Do) includes:

a. Programming consists of:

1) Projects to be implemented

2) Targets to be achieved with the project

3) The strategy you want to use

4) Required organizational structure and personnel

5) Costs required

b. Program Implementation, consists of:

1) Increase employee awareness about the importance of the program face to face, leaflets, posters and stickers

2) Conduct training for personnel who will directly take part in implementing the program

3) Develop SOPs and implementation reporting formats

4) To test the implementation of the program that has been set

5) Conduct pilot briefings, supervision and monitoring

6) Prepare the equipment and make modifications

3. Monitoring and Evaluation (Check), includes :

a. Get an overview / pattern of energy use, production, production waste, GHG emissions, etc.

b. Database availability

c. Energy development

d. Ease of finding sources of inefficiency

e. Effective and efficient energy management.

f. Develop an energy saving culture for all levels of employees.

4. Repair and Adjustment (Action), consists of:

a. Priority grade of monitoring and treatment results.

b. The focus of energy monitoring and analysis on energy saving opportunities starts from the largest.

c. Ease of decision making and actions related to efficiency improvements.

Energy Management System and Implementation

Energy management is very important to be integrated into the organizational structure of companies which the energy consumption is very large so that energy management can be implemented. The role of energy management in various operational functions is facility management, logistics, energy purchasing, production, production planning and control, and maintenance.

1. Facility Management

Facility management plays an important role in energy management because it has a very large proportion (around 25 percent) of operating costs is energy costs. An important goal of energy management is to reduce the energy costs of buildings and facilities without interrupting work processes. Energy Star is an example of the biggest program in determining energy-efficient homes. Energy Star certified homes save at least 15% of energy compared to standard houses.

2. Logistics Management

Logistics is management that regulates the flow of resources from the starting point to the destination point to fulfill a request. Transporting goods can save costs and protect the environment through efficient energy management. The factors that influence it are the type of transportation, the duration and distance of transportation, and cooperation with logistics service providers. Logistics has caused more than 14% of CO2 emissions worldwide. So the term Green Logistics becomes important. Some things you can do to get to green logistics are:

a. Using environmentally friendly goods transportation such as railways and waterways.

b. Route and load optimization.

c. Formation of a corporate network connected by logistics.

d. Optimization of physical logistics processes by providing sophisticated information technology assistance.

Besides transportation of goods, human transportation is also an important part of the company's logistics strategy. It is necessary to consider whether a business trip needs to be carried out if telephone or video conferencing is useful enough.

3. Purchase of Energy

Energy prices always turn up and turn down to affect the energy costs of industry. Poor energy purchase decisions can create high costs. Organizations can regulate and reduce energy prices by taking proactive and efficient steps in buying energy. Changing the source of energy used can also be a profitable and environmentally friendly solution.

4. Production

Production is an activity to produce outputs such as goods or services that have value to contribute to their use. The main production process depends on the type of company. The industry has more facilities that consume more energy. Service companies do not need a lot of raw materials, the energy focus is only on facility management or Green IT. Then the focus relating to energy needs to be identified first, then evaluated and optimized.

5. Production Planning and Control

Production is a sector that uses high energy so that production planning and control becomes very important. This is related to all operational processes, temporary management, planning and control needed to produce goods and commodities. Production designers should be able to facilitate energy-efficient production processes. Production processes that use large amounts of energy may be done at night to avoid peak times which have higher prices. Production planning and control must overcome the problem of limitations in energy storage. There are ways to store electricity using chemical examples such as lithium-based electrochemical storage areas used in electric cars / to control electricity networks.

6. Maintenance

Maintenance is a combination of all technical and administrative activities, includes supervisory activities, to obtain / return an item in order to perform the required functions. Maintenance is carried out to support energy management so that leakage and increased costs can be avoided.

Energy Management Program

There are many methods by which an energy management program can be developed or implemented, the approach below is somewhat generic in an effort to let each user customize the model presented here to suit the needs of the varying areas of need.

While many energy management programs exist, many follow this simple seven-step process listed below. In some instances the steps may be combined or blurred, other applications may require the steps be performed in a slightly different order. The primary steps are:

1. Identification of the need
2. Assessment of the needs
3. Develop an action plan
4. Implement an energy team
5. Execute the plan
6. Evaluate the plan
7. Spread the word

i. Identification of the Need

Just as with many projects, the identification of the needs is the place to begin an energy management program. Either by using suggestions from this chapter, or a list provided by a third-party vendor or the government, begin identifying areas in which energy savings could be realized. Leave nothing out, heating and cooling, building structures, lighting, water, landscaping, look at everything. Identify all areas that could improve energy efficiencies and log each. At this point, do not assess each change for economical efficiency, which is step number two.

ii. Assessment of the Needs

After all the needs have been identified, assess each for potential energy savings, costs of implementation, and other variables associated with correcting the need identified in step number one. Approach this as a feasibility study. Generate estimates of costs to install the proposed change, and estimate the cost savings. Prioritize each need based on the estimated payback. Recall that some projects will have impacts on other projects, so be sure the assessment includes these secondary effects, positive or negative. Likely those projects or needs with a greater payback should be placed higher in priority on an action plan, if monies (existing or requiring financing) to implement the change are available. It is also possible that other needs identified will cost more to

correct than the estimated cost of the loss, and it may be decided to remove these items from the action plan.

iii. Develop an Action Plan

Once a prioritized list of needs have been established, an effective plan of action will insure the list is implemented properly. In addition to identification of the needs, the action plan should include timelines or goals for implementation, persons or departments responsible for the changes, and other project management decisions.
This process step will vary depending upon the size of the organization, and the number of needs identified and assessed. Should the action plan represent a large project, there are several software tools to aid in scheduling tasks.

iv. Implement an Energy Team

The concept of an energy team is to allow easier facilitation of the changes in the action plan to be implemented. If the project is small in scale, this step may be eliminated, or if the project is larger, this step may need to be moved up in the process. It may require a team to identify the needs in a large facility. Should an energy team be needed, a director or manager with the power and authority to implement the action plan should lead such a team. Be certain that other stakeholders are represented on the team.

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.

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

Biomass – An alternate energy fuel source. Examples of this are wood, methane, gasohol. Any fuel derived from a biological source

Boiler - A closed vessel in which fluid (generally water) is heated. The fluid does not necessarily boil.

Chiller – A mechanical refrigeration unit that contain a compressor, condenser, control valve, and evaporator coil.

Coagulant – A chemical that forms a small, fluffy mass called a floc in natural water. Floc particles are like snowflakes that float around in water during the purification process. These particles are used in removing suspended matter in water and carry it to the bottom of the sedimentation tank

Combustion – The process of changing a fossil-fuel into heat.

Compressor – A unit in a mechanical refrigeration system that contains a pump used to remove refrigerant vapor from the evaporator coil

Carbon dioxide (CO2) - An odorless, colorless gas formed during respiration and by the decomposition of organic substances. Carbon dioxide is also produced when fuel is burned.

Carbon monoxide (CO) - An odorless gas produced when fuel is burned. Carbon monoxide is one of the six criteria pollutants for which the EPA has established National Ambient Air Quality Standards

Conduction - The process by which heat is transferred from the flame to the cold end of the bar is called conduction.

Condensation – The resulting effect when a vapor or gas is changed into a liquid

Condenser – The segment of a mechanical refrigeration unit that helps passage of cool air. Air forced to pass around the outside of a coil in the condenser removes heat from a gaseous refrigerant that circulates inside of the coil. Lowering the temperature of the gas causes it to change into a cool liquid that is circulated through the system.

Conduction – The transmission of heat or of electrical energy by the motion of particles of the conductor. For example, if one end of a solid metal bar is placed in a flame, it will not take long for the other end of the bar to become hot

Convection - Convection is the process of transmitting heat through a fluid such as a liquid or a gas.

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

Convection – The process of transmitting heat through a fluid such as a liquid or a gas. For example, water boiling on a stove top

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.

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

Demand factor (DF) – The ratio of average electrical power used to the maximum of electrical power used over a specific period of time. DF = average per (kW)/peak power (kW)

Dew point - The temperature to which air must be cooled to become saturated with water vapor.

Disinfection – A water purification operation designed to keep water from carrying infectious diseases. It can be accomplished by heating or adding chemicals to water. Chlorine is commonly used to disinfect drinking water.

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.

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 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.

Energy performance - efficiency and is expressed by a dimensionless output/input ratio. The energy performance of an activity is expressed by the ratio of energy units and the quantified results or aspects of this activity.

Enthalpy – A term used to express the total heat content of the air in units of Btu per pound

Environmental impacts - any change to the environment, whether adverse or beneficial, wholly or partially resulting from the activities, products or services of a company.

Filtration - A physical, biological or chemical operation that separates solid matter and fluid from a mixture with a filter medium that has a complex structure through which only the fluid can pass. Solid particles that cannot pass through the filter medium are described as oversize and the fluid that passes through is called the filtrate.

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

Generator – A system of machine used to convert mechanical energy into electrical energy.

Gauge pressure - Zero-referenced against ambient air pressure, so it is equal to absolute pressure minus atmospheric pressure. Negative signs are usually omitted.

Gas turbine - A rotating machine that converts the chemical energy of fuel into mechanical energy. Basic elements of a gas turbine are the compressor, combustion chamber, and turbine. In operation, fresh air is drawn in by the compressor and forced into the combustion chamber. Inside the combustion chamber, the compressed air mixes with the fuel, and combustion occurs. During combustion, the chemical energy in the fuel is released to produce high-temperature combustion products that expand through the turbine and cause rotation

Heat - Energy in transfer to or from a thermodynamic system, by mechanisms other than thermodynamic work or transfer of matter.

Heat exchanger - A system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes

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

Heat pump - A device that transfers heat energy from a source of heat to what is called a thermal reservoir. Heat pumps move thermal energy in the opposite direction of spontaneous heat transfer, by absorbing heat from a cold space and releasing it to a warmer one.

Higher heating value (HHV) - The standard measure of the energy released during combustion of a fuel, assuming the product water is in the liquid state. For natural gas fuel, the HHV is approximately 10% higher than the lower heating value (LHV).

High-pressure - Area, high, or anticyclone, is a region where the atmospheric pressure at the surface of the planet is greater than its surrounding environment.

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 - The concentration of water vapor present in air.

Latent heat - **E**nergy released or absorbed, by a body or a thermodynamic system, during a constant-temperature process.

Liquid pressure - The increase in pressure at increasing depths in a liquid. This pressure increases because the liquid at lower depths has to support all of the water above it.

Liquid – Matter that has a definite volume but does not have a specific shape. It conforms to the shape of the container that it is placed. Common examples of liquids are water, oil, alcohol, and gasoline.

Liquefaction – The conversion of low-grade coal into liquid fuel which has a higher heat content and burns more cleanly.

Liquid receiver – Part of a refrigeration system that is basically a storage tank for a pressurized refrigerant.

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.

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

Mechanical refrigeration – A process that uses components in an interconnected system to transfer heat from one object or space to another.

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.

Refrigerants – Chemical compounds that are used as the heat-transfer media in mechanical refrigeration systems. They are alternately compressed and condensed into a liquid or vapor during the refrigeration cycle. They should have a low boiling point, mix well with oil, and be nontoxic.

Refrigeration – A process by which unwanted heat is removed from a selected space or object and kept at a temperature that is lower than its surroundings. This can be achieved with ice, snow, chilled water, or mechanical refrigeration.

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.

Reverse osmosis (RO) - A water purification process that uses a partially permeable membrane to remove ions, unwanted molecules and larger particles from drinking water.

Sensible heat – Heat added to or removed from a substance that causes a change in temperature but not a change in state.

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

Specific heat capacity - The heat capacity of a sample of the substance divided by the mass of the sample. Informally, it is the amount of energy that must be added, in the form of heat, to one unit of mass of the substance in order to cause an increase of one unit in its temperature.

Steam - Water vapor, which is water in the gas phase.

System - a collection of functional components interacting in order to achieve an objective or to perform a task within defined boundaries.

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.

Vacuum – A space containing no matter. A space in which all of the air or other gases has been removed.

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.

Venturi – A burner mixing tube of reduced diameter located in a natural gas burner of a furnace.

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

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

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.

Water purification - The process of removing undesirable chemicals, biological contaminants, suspended solids, and gases from water.

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

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

NOMENCLATURE

A_t	Flare tip area, ft^2
C	Drag coefficient (Dimensionless)
d_j	Pipe/Tip inside diameter, ft
D	Particle diameter, in
g	Acceleration due to gravity, 32.2 ft/s^2
H	Heat of combustion gases, Btu/lb
h	Distance, in feet
k	Ratio of specific heats (C_p/C_v)
L_f	Flame length, ft
Mach	Mach number at pipe outlet
M_j	Gas molecular weight
m	Mass flow rate, lb/s
P	Maximum header exit pressure, in lb/in^2g
P_j	Pipe outlet pressure, in lb/in^2 (absolute)
Q_f	Heat release, Btu/hr
q_f	Heat intensity ($Btu/hr/ft^2$)
R	Gas constant, 10.7 (British unit)
R_f	Distance from the midpoint flame (ft)
T_j	Absolute temperature, in ^oR
U_d	Maximum allowable vapor velocity for vertical vessel, ft/s
U_∞	Design wind velocity
V	Volumetric flowrate, ft^3/s
W	Gas flow rate, in lb/hr
W_{stm}	Mass flow rate of steam, lb/hr
Z	Compressibility factor, dimensionless

Greek letters

ε	Emissivity, (dimensionless)
ρ	Sealing liquid density, in lb/ft^3
ρ_L	Density of liquid, lb/ft^3
ρ_V	Density of vapor, lb/ft^3

REFERENCES

1 K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, Safety in Process Equipment Design, Engineering Design Guidelines, 2014

2 K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, Process Safety Management, Engineering Design Guidelines, 2015

3 K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, Safety Risk Management and Loss Prevention, Engineering Design Guidelines, 2016

4 K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, Process Integration with Pinch Analysis, Engineering Design Guidelines, 2016

5 K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, Project Management, Engineering Design Guidelines, 2016

6 International Energy Conservation, International Code Council, USA, 2009.

7 Energy Conservation Guidebook, The Fairmont Press Inc, USA, 2007.

8 Energy Management and Energy Optimization in the Process Industry, Siemens,Germany,2011.

9 Industrial Heat Pumps for Steam and Fuel Savings. Industry Technology Program, U.S Industry,2003.

10 Improving Pumping System Performance (Second Edition). Industry Technology Program, U.S Industry,2006.

11 Steam Pressure Reduction : Opportunities and Issues. Industry Technology Program, U.S Industry,2005

12 Industrial Steam System Heat Transfer Solution. Industry Technology Program, U.S Industry,2003.

13 Management Energy System, Sriwijaya Polythecnic,Indonesia,2016.

14 U.S. Department of Energy. Waste Heat Reduction and Recovery for Improving Furnace Efficiency, Productivity and Emissions Performance. Washington, DC. 2004

15 C. B. Oland. Review of Orifice Plate Steam Traps. Oak Ridge National Laboratory. 2001

16 J. C. Cone. Pump Energy Conservation Techniques. Proceedings of The Ninth Turbomachinery Symposium

17 Kevin Westerling. 10 Tips To Save Energy On Pumping Systems. https://www.wateronline.com