



**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES  
MASTER OF SCIENCE IN SUSTAINABLE ENERGY TRANSITIONS  
END OF SEMESTER EXAMINATION**

**MSSET 8202: ENERGY MANAGEMENT AND STANDARDS**

**DATE: 9<sup>th</sup> December 2024**

**Time: 18:00-20:30 Hours**

**Instructions**

1. This examination consists of **FOUR** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

**QUESTION ONE**

**(Total: 20 Marks)**

- a. Evaluate the role of energy audits as a strategic tool in reducing carbon emissions and enhancing environmental sustainability. In your answer, address the following:
  - i. Discuss how energy audits can identify both direct and indirect carbon emission sources and explain why addressing indirect emissions may be challenging. (3 Marks)
  - ii. Provide at least two examples of specific energy audit recommendations that could lead to significant carbon emission reductions. For each example, describe the expected environmental benefits and any potential challenges in implementation. (4 Marks)
- b. After conducting an energy audit for a manufacturing company, you have found that the company consumes a significant amount of electricity, leading to high monthly energy bills. Based on the audit findings, you recommend that the company invests in a renewable energy, solar photovoltaic (PV), system to reduce energy consumption costs. The initial investment required for installing the solar PV system is KES 3,500,000. The expectation is that the system will generate the annual savings in electricity costs over the next 5 years as shown in table 1.

*Table 1*

<b>Year</b>	<b>Savings in Energy Costs (KES)</b>	<b>Inflation Rate (%)</b>
1	600,000	3
2	650,000	3
3	700,000	3
4	750,000	3
5	800,000	3

In addition to the energy savings, it is projected that the company will receive a salvage value of KES 500,000 at the end of Year 5 from the renewable energy system. Given a rate of return of 8% and inflation of 3% per year;

- i. Adjust the annual savings for inflation over the 5-year period. (3 Marks)

- ii. Calculate the Net Present Value (NPV) of investing in the renewable energy system, considering the adjusted savings, initial investment, and the required rate of return of 8%. (5 Marks)
  - iii. Discuss the potential financial impact of this recommendation on the company, taking into account inflation and the salvage value. Should the company proceed with the investment based on the NPV result or not? Discuss (1 Mark)
- c. “Energy is sustainable if it meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable energy solutions seek to provide universal access of clean, safe, reliable, and affordable energy.” Discuss this statement in relation to the environment to underscore the relationship between sustainable development goals, energy, and environment. (4 Marks)

## QUESTION TWO

(Total: 15 Marks)

- a. According to the draft Energy (Energy Management) Regulations 2020, a facility that consumes more than 180,000kWh/ 648,000Mj per year is required to conduct an energy audit once every four years. Highlight any FOUR provisions in the Regulations that these facilities should comply with. (2 Marks)
- b. Discuss the significance of considering parasitic losses when carrying out an energy audit for industrial systems. (2 Marks)
- c. A factory replaces an older 7.5 kW motor with an efficiency of 75% with a new high-efficiency motor rated at 7.5 kW with an efficiency of 90%. The motor runs an average of 8 hours per day, 300 days a year, with an average CO<sub>2</sub> emission factor of 0.3 kg per kWh. Calculate the annual reduction in carbon dioxide emissions (in metric tons) resulting from upgrading to the more efficient motor. (6 Marks)
- d. A conveyor belt system operates with a motor rated at 20 kW and is designed to transport materials at a speed of 2 meters per second. During an energy audit, it was observed that the system runs continuously for 8 hours per day, but the actual load on the conveyor is only 60% of the motor’s capacity.
  - i. Calculate the effective energy used per day by the conveyor belt system. (2 Marks)
  - ii. Determine the daily efficiency of this conveyor belt system. (2 Mark)
  - iii. Based on your result, suggest one recommendation to improve energy efficiency. (1 Mark)

## QUESTION THREE

(Total: 15 Marks)

- a. A manufacturing plant operates with an average power factor of 0.85, which is below the minimum threshold of 0.9 set by its utility provider. According to the utility’s policy, the plant incurs a penalty of 2% on its monthly energy bill for every 0.01 power factor below 0.9. Additionally, an incentive of 1% is available for every 0.01 improvement above 0.95, up to a maximum power factor of 1. The plant’s current monthly energy bill is Ksh 1,200,000.
  - i. Calculate the current penalty cost incurred by the plant due to the low power factor of 0.85. (2 Marks)
  - ii. Determine the monthly cost savings if the power factor is improved to the minimum required level of 0.9. (1 Mark)

- iii. Calculate the additional monthly incentive if the plant further improves its power factor to 0.96. (2 Marks)
  - iv. Discuss two operational benefits the plant might achieve from improving the power factor to above 0.95, beyond cost savings. (2 Marks)
- b. A diesel generator uses 0.3 liters of diesel fuel to generate 1 kWh of electricity. If the diesel contains 86% carbon by weight and has a density of 0.85 kg per liter, calculate the amount of CO<sub>2</sub> emissions per kWh of electricity generated under complete combustion. (*Note: Carbon has an atomic mass of 12, and oxygen has an atomic mass of 16.*) (3 Marks)
- c. An office building with over 200 employees consumes a considerable amount of energy to heat water for handwashing and cleaning purposes. As part of an energy audit aimed at promoting efficiency and reducing environmental impact, you are tasked with assessing the building's hot water heating system.
- i. What specific areas would you prioritize in the audit, and why? Discuss two areas to prioritize (2 Mark)
  - ii. Recommend THREE strategies for improving energy efficiency in the water heating system. Provide both technological upgrades and operational adjustments, explaining how each can reduce energy consumption and operational costs. (3 Marks)

#### QUESTION FOUR

(Total: 15 Marks)

- a. A given manufacturing plant operates for 20 hours a day, 6 days a week, consuming an average of 120,000 kWh of electricity per month. The maximum demand recorded during the month is 200 kW. *Assume 30 days in the month for calculations.*
- i. Calculate the load factor for the plant during the month. (3 Marks)
  - ii. Discuss the significance of the load factor in an energy audit and how it can be used to recommend energy-saving measures. (2 Marks)
- b. A steam pipe of 100mm diameter is insulated with mineral wool. As a part of energy saving measure, the insulation is upgraded with efficient Calcium silicate insulation. Calculate the percentage reduction in heat loss due to above measure given the following data; (5 Marks)
- Boiler efficiency: 80%
  - Surface temperature with mineral wool: 95°C
  - Surface temperature with calcium silicate: 55°C
  - Ambient temperature: 25°C
- c. Energy audits are essential for identifying opportunities to improve the energy efficiency of various industrial systems. Systems such as lighting, motors and drives, HVAC, compressed air/gas, refrigeration, fan and pump systems, boiler plant systems, water heating systems, and steam/process heating systems, among others, play significant roles in energy consumption. As an energy auditor, you are tasked with recommending strategies to enhance energy efficiency and reduce operational costs. Select one system from this list and answer the following questions.
- i. Describe, in detail, the energy audit process for the system you selected. (3 Marks)
  - ii. Highlight two significant challenges you might encounter when carrying out an energy audit for your selected system in an industrial facility. (1 Mark)
  - iii. Discuss how you will evaluate the efficiency of this system. (1 Mark)