YANGON UNIVERSITY OF ECONOMICS
DEPARTMENT OF APPLIED ECONOMICS
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(NAY PYI TAW)

A STUDY ON SAFETY CULTURE AND SAFETY PERFORMANCE OF COMBINED CYCLE POWER PLANT

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EMPA – 31 (18th BATCH, NPT)

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A STUDY ON SAFETY CULTURE AND SAFETY PERFORMANCE OF COMBINED CYCLE POWER PLANT

A thesis submitted as a partial fulfillment of the requirements for the degree of Master of Public Administration Program (MPA)

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This is to certify that this thesis entitled **"A Study on Safety Culture and Safety Performance of Combined Cycle Power Plant"**, submitted in partial fulfilment towards the requirements for the degree of Executive Master of Public Administration (EMPA) has been accepted by the Board of Examiners.

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ABSTRACT

This study analyses the safety culture knowledge, attitudes and practice/ performance of safety management culture in a combined cycle power plant. The study employed descriptive method by using primary and secondary data. In this study, 240 respondents from four power plants are asked to collect the data and their responses are gathered through structured questionnaire with 5 point Likert- scale. It is found that employees of the power plants have a good understanding of safety culture and demonstrate positive attitudes and practice/ performance. Therefore, the power plant management prioritizes to continue the development of a positive safety culture through training programs, communication, and feedback mechanisms to improve safety.

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ADB	Asian Development Bank
ASEAN	Association of South East Asian Nations
BBS	Behavior based safety
BOO	Build Own Operate
BOT	Build Operate Transfer
BTL	Build Transfer Lease
BTO	Build Transfer Operate
CSP	Concentrated Solar Power
CSR	Corporate Social Responsibility
DEPP	Department Of Electric Power Planning
DHPI	Department Of Hydro Power Implementation
DPTSC	Department of Power Transmission and System Control
EIA	Environmental Impact Assessment
EPC	Electric Power Corporation
EPGE	Electric Power Generation Enterprise
ESB	Electricity Supply Board
ESE	Electricity Supply Enterprise
EU	European Union
GDP	Gross Domestic Product
GW	Giga Watts
GWh	Giga Watt-Hours
HFO	Heavy Fuel Oil
HSA	The Health and Safety Authority
IAEA	International Atomic Energy Agency
ILO	International Labor Organization
IPP	Independent Power Producers
JICA	Japan International Corporation Agency
JV	Joint Venture
JVA	Joint Venture Agreement

kV	Kilovolt
kWH	Kilo Watt-Hours
LNG	Liquefied Natural Gas
LSR	Life-Saving Rules
MEPE	Myanmar Electric Power Enterprise
MESC	Mandalay Electricity Supply Corporation
MIC	Myanmar Investment Commission
MOEE	Ministry of Energy and Electricity
MOEP	Ministry Of Electric Power
MOU	Memorandum of Understanding
MVA	Megavolt-Amperes
MW	Megawatt
MWh	Megawatt-Hours
O&M	Operation and Maintenance
OECD	Organization for Economic Co-operation and Development
OEM	Original Equipment Manufacture
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PV	Photovoltaic
ROR	Run-Off-River hydroelectricity
WHO	World Health Organization
WHRB	Waste Heat Recovery Boilers
YESB	Yangon Electricity Supply Board
YESC	Yangon Electricity Supply Corporation

CHAPTER I
INTRODUCTION

1.1 Rationale of the Study

Safety is of utmost importance in any industry, particularly in power plants, which involves hazardous operations. The safety of employees and the community is paramount, and any incidents can have severe consequences. Hence, it is crucial to understand the safety culture and performance of power plants to ensure the safe functioning of these plants.

Energy is the basic requirement of the modern human being. It becomes an important strategy for the growth and development of the national economy. Electricity is one form of energy. Transforming other forms of energy into electrical energy is called a generation of electricity.

Generation of electricity power plants are using other forms of energy such as natural gas, liquefied natural gas (LNG), coal, nuclear and renewable energy such as hydro, solar, and wind. In Myanmar, we got electricity from Hydro power plants, gas-fired power plants, combined cycle power plants, Gas Engine power plants, and a coal-fired power plant.

Employee safety awareness and safety culture are important things in power plants depending on the following conditions:

(i) Gas Turbine's running speed is more than 5000 rpm (revolution per minute),

(ii) Combustion Chamber Section used fuel (Natural Gas or LNG (Liquefied Natural Gas or Diesel) for firing. The combustion Chamber Section has more than 10 combustion cans. One of each can temperature is more than 1100 Degree centigrade.

(iii) Electric Generator produces Mechanical Energy to Electrical energy 11kV (1100 voltage),

(iv) Gas Turbines, Steam turbines, and their auxiliary accessories are using lube oil cooling system. The outlet temperature of lube oil is more than 70 Degree centigrade.

(v) Waste heat recovery boiler generates high pressure superheated steam to drive the steam temperature.

(vi) Handling high energy equipment such as switch yard, switch gears.

State-owned power plants under the Ministry of Electric Power (MOEP) have a safety management system, safety rules for machine operation, step-by-step procedures for machine maintenance, and safety rules for fuel use. Independent power producer (IPP) power plants also have a safety management system and rule the same as MOEP power plants. Safety management of Sembcorp Myingyan Power Co., Ltd provides safety for the protection of people, property, and the environment. All power plant employees pay attention to safety rules and procedures. This thesis shows whether all power plants have a safety culture strongly developed in their power plant or not.

The safety system will shape the environment in which people work and thus influence their behavior and attitudes to safety. Safety involves protecting employees from work injuries.

With the rising demand for energy and the need to reduce greenhouse gas emissions, combined cycle power plants are becoming increasingly popular. However, operating these plants safely requires a different approach than traditional power plants.

Although there is some research on safety culture and performance in power plants, very little has been done on combined cycle power plants. Studying safety culture and performance can help identify areas for improvement and implement measures to enhance safety performance. This can lead to a reduction in the number of incidents, injuries, and fatalities and increase the overall safety of power plants.

Therefore, conducting a study on safety culture and performance of combined cycle power plants can help fill the knowledge gap, can provide valuable insights for the industry, the unique challenges they face and ways to overcome them. This can contribute to the development of best practices for safety management in the combined cycle power plant industry.

1.2 Objectives of the Study

The objectives of this study are-

(1) To identify the current status of safety management activities of a combined cycle power plant.

(2) To measure the safety culture knowledge, attitudes and performance/practice of a working environment at the combined cycle power plant.

1.3 Method of Study

In this study, the descriptive statistics method is used to evaluate the level of Safety Management culture and performance in Power Plants. The method of the study is based on primary data and secondary data. Primary information is obtained by surveying with a structured questionnaire from the power plant employees. Secondary Data is collected relevant information from Thermal Power Department under Electric Power Generation Enterprise, Ministry of Electric Power. And other sources from journals, books, Internet websites, and presentation papers.

1.4 Scope and Limitations of the Study

The study focuses mainly on employees of 225 MW Sembcorp combined cycle power plant and Three power plants of Electric Power Generation Enterprise.

This study did not cover all power plants (IPP/BOT/JV/Rental/ Government-owned) under the Ministry of Electric Power.

1.5 Organization of the Study

This study is organized into five chapters. Chapter I introduces the various general contexts such as the rationale of the study, objectives, scope and limitations, method of study, and organization of the study. Chapter II focuses and investigates on the literature review and the previous studies related to safety management, safety culture, and safety performance. Chapter III discusses the overview of the combined cycle power plant, the history of combined cycle power plants in Myanmar, the history of Sembcorp's combined cycle power plant, safety management, safety culture, and safety performance. Chapter IV is the survey data analysis with the survey design, and analysis of the study. Chapter V presents the conclusion, which consists of findings and suggestions based on the analysis.

CHAPTER II

LITERATURE REVIEW

2.1 Type of Various Power Generation and Resources

There are two types of power generation in the power sector such as renewable power generation and non-renewable power generation.

2.1.1 Renewable Power Generation

Renewable energy is the conversion of energy from natural resources into electricity. Mostly used natural resources are sunlight, water, wind, geothermal, biomass, municipal wastes, and ocean tidal flows. Types of renewable power generation are:

(1) Hydropower Generation
(2) Solar Power Generation
(3) Wind Power Generation
(4) Geothermal Power Generation
(5) Biomass Power Generation
(6) Waste to Power Generation
(7) Ocean Tide to Power Generation (Tidal Power).

(1) Hydropower Generation

Its natural resources are water. A hydropower station converts the kinetic energy of the flowing or falling movement of water into electrical energy. Hydropower can be generated on a large scale with a hydropower dam and a Run-Off-River hydroelectricity (ROR). The run-Off-River type uses naturally flowing river water to turn buckets of turbines. In the dam's powerhouse, the turbine generator and transformer are located. By opening underwater intakes or gates of the dam, the reservoir's potential energy is converted kinetic energy into electrical energy. (Source: Science Direct)

(2) Solar Power Generation

The conversion of energy from sunlight into electricity is called solar power generation. Rooftops or ground-mounted solar farms are used solar panels which are converting sunlight directly into electric power and are called Photovoltaic (PV) systems. Using mirrors or lenses to concentrate sunlight to extreme heat to make steam which is converted into electricity by a steam turbine is called concentrated solar power (CSP). (Source: Science Direct)

(3) Wind Power Generation

Wind turbines convert the energy from the wind into electricity. There are onshore wind farms and offshore wind farms. Offshore wind farms provided a steady and strong source of energy but construction and maintenance costs are expensive costs. (Source: Science Direct)

(4) Geothermal Power Generation

Power generated by using geothermal energy through deep bore hole to generate steam powers (high-temperature 300°F to 700°F) is called Geothermal power generation. (Source: Science Direct)

(5) Biomass Power Generation

Biomass is plant-based material such as wood, agricultural residues, wood residues, energy crops, and waste from farms, industries, and households. Biomass is used as fuel to produce heat or electricity. (Source: Science Direct)

(6) Waste to Power Generation

A waste–to–energy or trash-to-energy plants are generated from municipal wastes to produce electricity. Use the method of incineration burning municipal solid waste to boil water which generates steam power generators to produce electricity. (Source: Science Direct)

(7) Ocean Tide to Power Generation (Tidal Power)

The energy of tidal flows converts into electricity by the tidal generator is called Tidal energy or tidal power. Tidal energy has a high cost and limited availability of sites. It depends on high tidal ranges or flow velocities, so not yet widely used. (Source: Science Direct)

2.1.2 Non-Renewable Power Generation

Non-renewable energy is the conversion of energy from fossil sources into electricity. Mostly used fossil sources are crude oil, heavy fuel oil (HFO), diesel, natural gas, liquefied natural gas (LNG), coal, and uranium.

(1) Thermal Power Generation (Fossil Fuel)

Thermal Power consists of burning natural gas, liquefied natural gas (LNG), coal, crude oil, heavy fuel oil (HFO), Diesel, and other substances to rotate the turbine combustion engine to convert to mechanical energy. This mechanical energy drives a generator to produce electrical energy. It is called Thermal power generation. (Source: Science Direct)

In thermal power generation, there are simple cycle power generation and combined cycle power generation.

(i) **Simple Cycle Power generation (Simple Cycle Power Plant)**

A Simple Cycle Power Plant has a Gas-fired or oil-fired turbine and a generator.

(ii) **Combined Cycle Power generation (Combined Cycle Power Plant)**

A combined cycle power plant (CCPP) is a type of power plant that uses both gas and steam turbines to generate electricity. A CCPP has one or more gas or oil-fired turbine, waste heat recovery boilers (WHRB), and a steam turbine. In combined cycle power generation, heat is produced by the use of turbine exhaust heat waste energy to boil boiler water to dry steam which is used in steam turbines to produce electricity. So no need for additional fuel in combined cycle power generation.

(2) Nuclear Power Generation (Mineral)

Nuclear energy is used uranium which is a limited supply. Nuclear fusion reactions, nuclear fission, and nuclear decay are produced by nuclear power. In a nuclear power plant, heat is produced by the use of nuclear reactions to boil boiler water to dry steam which is used in steam turbines to produce electricity. Nuclear energy power plant is safe for the environment because it does not release carbon dioxide. (Source: Science Direct)

2.2 Types of Work, Roles and Responsibilities, Competences, Attitudes, and Performance of Power Plant

All power plants are applied guidelines, rules, and procedures of the National Factories Act of 1951, the Environmental Conservation Law of 2012, Environmental Conservation Rules, National Environmental Quality (Emission), The World Bank Group, and ILO Guidelines of Environmental, Health, and Safety.

2.2.1 Types of Works

There are various types of work performed in power plants, including operations, maintenance, engineering, and management. Types of works for power plants are as follows:

(1) Hot Work

A high-risk activity due to the potential for fires and explosions, and proper safety measures must be taken to prevent accidents. This type of work involves activities such as welding, cutting, burning, grinding, or any other processes that generate heat, flames, or sparks. (Source: Science Direct)

(2) Cold Work

Examples of cold work include painting, cleaning, routine maintenance, and inspections. While cold work may not pose the same level of risk as hot work, safety measures must still be taken to protect workers from hazards such as slips, trips, and falls. (Source: Science Direct)

(3) Confined Space Work

Confined spaces (such as a tank, vessel, or pipe) pose unique risks to workers, including limited entry and exit points, poor ventilation, and potential exposure to hazardous gases or substances. Proper safety measures, such as adequate ventilation and personal protective equipment, are crucial when working in confined spaces. (Source: Science Direct)

(4) Electrical Work

This type of work involves tasks related to the installation, maintenance, or repair of electrical systems and equipment. Electrical work can be dangerous due to the risk of electrocution, burns, or fires. Workers must be trained in electrical safety and follow proper procedures to prevent accidents. (Source: Science Direct)

(5) Special Vehicle Entry

Special vehicle entry involves the use of specialized equipment, such as cranes or forklifts, to move heavy loads or equipment in and out of the power plant. This type of work requires skilled operators and careful planning to ensure that loads are moved safely and efficiently. (Source: Science Direct)

(6) Excavation Work

Excavation work involves digging or excavating the ground to install or repair underground utilities, such as pipelines or electrical cables. This type of work poses risks such as cave-ins, falls, and exposure to underground hazards. Proper safety measures, such as shoring and trench boxes, must be used to prevent accidents. (Source: Science Direct)

(7) Radiation Work

Radiation work involves tasks related to the use of radioactive materials or equipment, such as nuclear reactors or radiography devices. Workers must be trained in radiation safety and follow strict protocols to prevent exposure to radiation. (Source: Science Direct)

(8) Lifting Work

Lifting work involves the use of cranes, hoists, or other equipment to lift and move heavy loads or equipment. This type of work requires skilled operators and careful planning to prevent accidents and ensure that loads are moved safely. (Source: Science Direct)

(9) Work at Height

Work at height refers to tasks that are performed above ground level, such as on scaffolding, towers, or roofs. This type of work poses risks such as falls, slips, and equipment failure. Workers must use appropriate personal protective equipment and follow proper safety procedures to prevent accidents.

Operations involve the control and monitoring of equipment and processes to ensure the safe and efficient operation of the power plant. Maintenance involves the repair and upkeep of equipment to prevent breakdowns and maintain reliability. Engineering involves the design and implementation of new equipment and processes, as well as the optimization of existing systems. Management involves overseeing the operation of the power plant and ensuring that it operates safely, efficiently, and in compliance with regulations. (Source: Science Direct)

2.2.2 Power Plant Employee's Roles and Responsibilities

Power plant engineers and workers may be responsible for tasks such as monitoring equipment, controlling systems, maintaining safety protocols, performing maintenance and repairs, managing fuel and resources, and managing waste and environmental impacts.

According to "The safe isolation of plant and equipment (HSE Books, HSG253)" power plant workers have various roles and responsibilities, depending on their job titles and the type of power plant they work in.

(1) Responsibilities of operations manager/ operation in charge

Responsible for overseeing the day-to-day operations of the power plant, ensuring that safety protocols are followed, and overseeing the maintenance and repair of equipment.

(2) Responsibilities of the Control Room Operator

Responsible for monitoring and controlling the power generation processes from a centralized control room. Operators are responsible for controlling and monitoring equipment and processes to ensure safe and efficient operation. They are also responsible for the safe and efficient operation of the plant equipment and processes, while maintenance workers are responsible for the upkeep of the equipment. And also Responsible for the safe and efficient operation, and performing routine checks monitoring equipment of the power plant.

(3) Responsibilities of Engineers

Engineers are responsible for designing and optimizing equipment and processes to improve performance and reduce costs. They are responsible for trouble-shooting the plant processes and equipment. And also they are responsible for the maintenance of the power plant.

(4) Responsibilities of the Maintenance Team

Responsible for maintaining and repairing equipment to ensure it operates safely and efficiently. They are responsible for identifying potential issues and safety hazards, and ensuring that maintenance schedules are followed. And also responsible to prevent breakdowns and ensure reliability.

(5) Responsibilities of Management

Management people are responsible for overseeing the operation of the power plant and ensuring that it operates safely, efficiently, and in compliance with regulations. They are responsible for ensuring that the power plant meets environmental regulations and standards.

(6) Responsibilities of Administrators

Administrators are responsible for the management of the plant operations and resources, including personnel, budgets, and schedules.

(7) Some common responsibilities are as follows:

Ensuring compliance with safety regulations and standards.

(a) Maintaining and repairing equipment to ensure safe and reliable operation.

(b) Monitoring performance and making adjustments as necessary to ensure optimal plant efficiency.

(c) Communicating with other plant personnel to ensure effective collaboration and coordination.

(d) Providing training and guidance to other employees to ensure that they understand their roles and responsibilities and can perform their duties safely and effectively.

2.2.3 Competences

All employee should be understood their role and for others about the purpose, principles, and practices of safety rules and isolation procedures of the plant. They should be competent to carry out their responsibilities. They must be aware of plant site major accident hazards and their consequences.

People working at the power plant require a range of competencies, including technical knowledge, problem-solving skills, communication skills, and teamwork.

Technical knowledge is essential for understanding the complex systems and processes involved in power generation. The power plant engineers and workers need to have technical knowledge of power generation processes, equipment, and systems. They have a strong understanding of the equipment and systems used in power generation, as well as an ability to troubleshoot and repair issues as they arise.

Problem-solving and safety skills are required to identify and resolve issues that arise during operation. People working at the power plant need to be able to identify and solve problems quickly and effectively. They can identify and address problems quickly and effectively to ensure the safe and efficient operation of the plant. They know about the knowledge of safety regulations and procedures including the ability to troubleshoot and find solutions to technical issues.

Communication skills are necessary for effective collaboration and reporting. Teamwork is crucial for ensuring the safe and efficient operation of the power plant. They need to be able to communicate effectively with other team members, management, and stakeholders.

The power plant workers and engineers are needed to have a strong awareness of safety protocols and procedures to minimize the risk of accidents or injuries.

Competences for isolation activities; (HSG253, 2006)

(a)	**Hazards**	:	
	General awareness	-	Hazards represented by the plant
	Detailed understanding	-	Hazards on the plant and from the adjacent plant
(b)	**Documentation**	-	the isolation, Piping diagrams, cause and effect diagrams, and loop diagrams.
(c)	**MS&RA**	-	Method statement of the work and risk analysis with control measures
(d)	**PTW (permit-to-work)**	-	certificates of PTW system, PTW issuing procedures, and what isolations are required for identifying

(e) Isolation procedures

Good working knowledge of isolation procedures for a power plant as well as the procedures of risk assessment. Understand the importance of following procedures:

(1) How to check what are the correct isolations?
(what isolations are in place and that which are the correct isolations required.)

(2) How to test and confirm the correctness of installation?

(3) How to record isolations on an isolation certificate?

(4) Know the isolations installing/removing procedures.

(5) Know the procedures for flushing, venting, purging, and draining.

(6) Be able to assess the risks from non-standard isolations.

Everyone who specifies to carry out the isolation of plant and equipment should have proven competency within their defined role before being authorized to act as isolating authorities and signatories to isolation documentation. (HSG253, 2006)

2.2.4 Workplace Safety Attitudes

The attitudes of power plant engineers and workers are also critical for safe and efficient operation. A positive attitude towards safety and a commitment to following established procedures and protocols are necessary for preventing accidents and ensuring compliance with regulations. A focus on continuous improvement and a willingness to learn and adapt to new technologies and processes are also important for optimizing performance and reducing costs.

A workplace safety attitude refers to an employee's tendency to respond positively or negatively toward a safety goal, idea, plan, procedure, prevention, or situation. (Source: Willnevergiveup, 2018)

People working at the power plant require a safety-oriented attitude, prioritizing safety over other goals. They should also have a team-oriented attitude, working collaboratively with others to achieve plant objectives. Other desirable attitudes include a proactive and continuous improvement mindset, attention to detail, and a customer-focused attitude.

Attitude could be described as the spark that drives employee's behavior. It's a fact that their work attitude not only affects how well you do your job but also affects how safe you are you're doing it. (Source: Willnevergiveup, 2018)

Safety attitudes influence employee choice of actions and response to challenges, incentives, and rewards in the workplace. (source: safeopedia, 2018)

The following states are made up of employee's attitudes;

(1) Depending on our mental conditions, our feelings or emotions are different at any particular time.

(2) Our faith is derived from our beliefs and also our opinions.

(3) Our opinions are driven by our actions.

(4) Our actions are driven by positive or negative responses.

(a) Positive/Negative workplace safety attitudes

Positive workplace safety attitudes are attentiveness, eagerness, carefulness, alertness, seriousness, task-focused behavior, and team-oriented cooperation. It's led to: (Source: Willnevergiveup, 2018)

(1) Protection of the organization's equipment, property, and workforce

(2) Prevention of all types of accidents and near misses

(3) Preparation for any emergencies

(4) Improvement of the work environment

(5) Maintenance of workforce morale

The benefits of positive workplace safety attitudes are an accident-free work environment, higher efficiency, and best quality, employee morale raises, profit business, and goodwill.

A negative workplace safety attitude increases the cost of production, and turnover rate, and reduces employee safety, morale, quality, profitability, and business goodwill (source: safeopedia, 2018).

A negative work attitude can lead to unsafe work habits and accidents. It becomes all too easy to ignore the safety precautions that keep workers safe, thereby putting them at risk. (Source: Willnevergiveup, 2018)

Mishaps happen when workers have negative attitudes like these:

(1) Emotional acts or feelings which distract.

(2) Tiredness, slowing physical and mental reactions.

(3) Risk-taking, cutting corners, or ignoring safety procedures.

(4) Recklessness with decisions, tools, machinery, chemicals, or work procedures.

(5) Selfishness, not thinking about how one's actions may affect others.

(6) Complacency, especially if the task is habitual and workers are under pressure

(7) Being afraid to ask questions because training and work procedures have covered a lot of ground- sometimes too much to remember.

(8) Bullying by superiors causes employees to work in an unsafe manner.

2.2.5 Safety Performance

Safety performance refers to the measurable outcomes of an organization's safety efforts. Safety performance can be influenced by a variety of factors, including the physical environment, equipment, training, and organizational culture.

The safety performance of a CCPP can be measured by its safety record, which includes the frequency and severity of accidents, incidents, and near-misses. It can also be measured by the effectiveness of safety programs, such as safety training, safety audits, and safety inspections.

Successful safety development relies on all members of an organization. They buying into changes and overcoming some of the common barriers, which include the following: (Source: EKU online, 2020)

(i) Normalization of deviance

In 1996, sociologist Diane Vaughan said that “Even though people far exceed their own rules for the elementary safety, people within the organization become accustomed to a deviation that they don't consider it as deviant means that the social normalization of deviance ". (Source: EKU online, 2020)

(ii) Groupthink

Normalization of deviance can lead to groupthink. Groupthink happens when a group of people thinks and acts in a coordinated manner, shunning dissenting views and ideas. (Source: EKU online, 2020)

(iii) Complacency

Complacency occurred when workers engage in routine tasks that they've completed dozens, or even hundreds, of times. When complacent, workers pay little or no attention to the work at hand or the surrounding environment, taking shortcuts and get unnecessary risks. (Source: EKU online, 2020)

(iv) Unwritten rules

Most workplaces have a set of written rules. It was crafted by a human resources department that explains what is expected of employees and is derived from company culture and social norms. (Source: EKU online, 2020)

(v) Unclear roles and responsibilities

From the top leadership when there is a lack of commitment and resistance to change, individuals are less likely to buy into changes. Clear roles must be established and upheld for a successful safety culture to take root. (Source: EKU online, 2020)

(vi) The human factor

The human factor is "the interaction of individuals with each other, with equipment and facilities, and with management systems". The employees can get a safe behavior, they away from unsafe behaviors. (Source: EKU online, 2020)

(vii) Poor individual attitudes

Fear, mistrust, uncertainty, and general resistance to change may ffect to enhance safety performance. Unless it is presented in a way that offers individual incentives, employees may resist change. A top-down approach to change can supersede the positive impacts of safety improvements such as a climate of fear and mistrust and demonstrate. (Source: EKU online, 2020)

(viii) Lack of proper training

Inadequate training and assigning too much responsibility to one person or group can quickly disintegrate any efforts to implement a new system. When training a team, allow for plenty of time for people to ask questions and change their old habits. (Source: EKU online, 2020)

(xi) System deficiencies

When there is too much or too little structure, a lack of positive attention given to the improvements, and a failure to communicate the changes, the system can fail even before it starts. (Source: EKU online, 2020)

2.3 Safety Management

The safety management system is to manage safety elements in the workplace and also provides a systematic way to identified the hazard and control the risks as low as reasonably practicable.

The structure of safety management includes the following;

(a) Description and safety policy of the organization.

(b) Organization’s structure and step-by-step responsibilities.

(c) Management commitment toward safety culture

(d) Learning, training, and appropriateness.

(e) Procedures for Risk Management (assessment and treatment)

(f) Incident and accident reporting.

(g) Safety assurance.

(h) Procedures for Emergency Management.

(i) Safety Communication

(j) Guarantee that safety rules and safety standards are followed by the employees and are well-known in the organization

In normal, transient, and emergency, the safety management system is to improve the safety performance of the organization through the planning, control, and supervision of safety-related activities.

Safety Management System becomes part of the culture and the way people do their jobs. Safety management systems support a strong safety culture through the development and reinforcement of good safety attitudes and behavior for individuals and teams to carry out their tasks safely.

For an effective safety management system, the organization is

(a) Define how to set up to manage risk.

(b) Identify the risk from the workplace and implement suitable controls.

(c) All levels of the organization have effective communications implemented.

(d) Identify a process implement and correct this for non-conformities

(e) Implement a continual process of improvement

2.4 Safety Culture

2.4.1 Safety

Safety is an integral component of the way the whole organization is managed and must have the involvement and active participation of all staff. Safety means that the state of human psychology, health, equipment, and environment is not endangered by external risk factors. And other words it means relative freedom from danger, risk, or threat of harm, injury, or loss to personnel and/or property.

2.4.2 Culture

Culture is the way to communities for human living and how they work. It is a set of people whose attributes can be generalized among them. A culture develops as a group identifies certain attitudes and behaviors that provide common benefits to its members. In an especially sound culture, deeply held values are reflected in the group's actions, and newcomers are expected to endorse these values to remain part of the group.

2.4.3 Safety Culture

Safety culture has been defined in a variety of ways and there is no standard definition of safety culture. This is mainly because a culture of safety has diverse meanings in different industries and people may have various understandings in different situations. It is the foundation upon which all safety-related decisions are made.

Safety culture is shaped by people working together in organizational structures and social relationships in the workplace. The key attributes of organizational culture are defined as organizational communication, senior management commitment, and organizational learning. A strong safety culture is characterized by a commitment to safety at all levels of the organization, open communication, continuous improvement, and a willingness to learn from mistakes.

There is an implied moral obligation placed on an employer to ensure that work activities and the place of work are safe. It was first used by the International Atomic Energy Agency (IAEA) to describe the issues at Chornobyl nuclear reactor accident (1986).

At the time, the IAEA defined the term as the product of the individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment and the style and proficiency of an organization's health and safety management. (Source: Safeopedia, 2019)

According to OSHA, “Safety cultures consist of shared beliefs, practices, and attitudes that exist at an establishment. Culture is the atmosphere created by those beliefs, attitudes, etc., which shape our behavior.”

Organizations having a strong safety culture will have an effective safety management system with the support and ownership of all staff. However, the safety management system has a broader role in that it provides a framework utilizing which the organization ensures good safety performance throughout the planning, control, and supervision of safety-related activities.

The safety management system, in turn, provides a means by which the organization promotes and supports a strong safety culture. In particular, the system will shape the environment in which people work and thus influence their behavior and attitudes to safety.

An organization's positive safety culture is based on mutual trust. All employers and workers share the importance of safety in the same perception. They also have confidence in the preventive measures of procedures and steps put in place.

Strong safety culture has a significant impact on improving safety performance, reducing incidents, conducting a successful near-miss, and incident reporting in an organization.

The safety culture of the organization is said that "the way we do things around here". It is the mix of shared values, competencies, perceptions, patterns of behavior, and attitudes of individuals and groups of the organization. It gives and determines the style and proficiency of an organization's health and safety management.

2.5 Reviews on Previous Studies

Bjorn Nevhage and Henrik Lindahl (2008) presented a Master's thesis at Lund University's Department of Design Sciences. Their thesis aimed to develop a conceptual model, methodology, and tool to evaluate safety performance in an organization. According to their definition, safety performance is the quality of safety-related work in an organization. Improving safety performance can increase an organization's resistance and lower the risk of accidents. Conversely, poor safety performance can increase vulnerability and, therefore, the risk of accidents. Their study concludes that the proposed concept, including a safety model, methodology, and tool, provides a relatively fast and easy way to evaluate an organization's safety performance. The model, methodology, and tool can help organizations assess their safety performance and identify areas for improvement. By doing so, organizations can reduce the likelihood of accidents and increase their overall safety performance.

Mian Farooq Bila(2017) conducted a Master of Philosophy study at Superior College, Lahore, titled "Determination of Safety Climate/Culture in Power Industry Using NOSACQ". The study aimed to evaluate the safety climate/culture of the power industry in Punjab, Pakistan, and was conducted at two private power plants. The research showed a difference in the safety climate perceived by leaders and workers of the same organization, as well as variations in the safety climate/culture of the organization in comparison to international benchmarks. The study found that the leaders of the organization perceived the safety climate/culture to be much higher than the perception of the workers, who were the people executing work on the ground. The research concluded that the safety climate is the perceived or anticipated strength/weakness of a deployed EHS (Environment, Health, and Safety) management system of an organization and beyond, by the employees or people that are exposed to or are part of the running system.

Olusuyi Olusola Beatrice (2011), conducted an MSc. Management study at Aberdeen Business School, The Robert Gordon University, Aberdeen, UK, titled "Influencing safety culture in the UK Offshore Oil and Gas Industry: The importance of employee involvement." The research aimed to provide insight into attitudes and perceptions toward employee involvement in safety culture in the industry. The findings of the study showed encouraging evidence of employee involvement, particularly in areas such as employees taking responsibility for their safety and that of others, as well as the extent of employees' knowledge about safety procedures. However, barriers hindering better involvement were identified, such as training, reward and recognition, communication, and management participation and encouragement. While the research attempted to establish the influence of employee involvement on safety culture, it did not determine the exact level of employee involvement that influences a positive safety culture. In conclusion, the research underscores the importance of employee involvement in promoting a positive safety culture and highlights the need for addressing barriers to better involvement to improve safety performance in the UK Offshore Oil and Gas Industry.

Camilla Elén Bjørneide Bergersen (2003) conducted a diploma thesis in safety, health, and environment at the Department of Safety and Reliability, Sintef Industrial Management in 2003. The study titled "Tool to be used to survey and improve safety culture in the European railway industry" aimed to improve safety culture in the railway industry by creating good collaborative processes and group discussions within and between organizations. The study developed the Track to Safety Culture Questionnaire, which serves as a foundation for rich and valuable discussions related to safety and cultural issues in the railway industry. The questionnaire has the potential to foster better communication and collaboration within organizations and across interfaces. The study highlights the importance of collaborative processes and group discussions in improving safety culture and underscores the potential of the questionnaire in fostering better communication and collaboration within and between organizations.

Nayef Saad (2016) studied "The Influence of Safety Culture on Safety Performance in the Saudi Arabian Construction Industry” for Degree of Ph.D., The University of Salford The School of the Built Environment. The study revealed that a strong safety culture is necessary to achieve positive safety performance outcomes. In order to improve safety culture and performance, Saad made short-term and long-term recommendations that can be implemented continuously. The short-term recommendations include improving employee commitment to safe practices, such as using personal protective equipment (PPE), while the long-term recommendations include enhancing the commitment to safety procedures, providing proper training for construction activities, and implementing a reward management system. However, to implement these recommendations, a regulatory and standards-based framework is needed from the industry in order to localize safety culture and improve safety performance in Saudi Arabia.

IAEA experts Gómez Cobo and J. Hashmi published a report in 2000 titled "Operational Safety Performance Indicators for Nuclear Power Plants". The report proposed a framework for measuring and assessing the safety performance of nuclear power plants. The framework was presented and discussed at two IAEA workshops held in Ljubljana, Slovenia, and Shenzhen, China, in 1998. The workshops provided an opportunity for participants to share their insights and ideas, which were used to enhance the proposed framework. The IAEA expressed its appreciation for the support and contributions of all participants in these workshops. The proposed framework has since been used as a basis for developing safety performance indicators for nuclear power plants worldwide.

Binghe Chen's (2012) "Identification of safety cultural aspects on drilling rigs with the international working environment" provides a comprehensive analysis of safety culture in the drilling industry. Through an examination of HSE concepts, safety performance, training, incentives, equipment selection, and case studies, the paper identifies the key factors that contribute to a positive safety culture on drilling rigs in the international working environment. The research highlights the importance of organizational culture, personal attitudes and experience, training, communication, and other factors in shaping safety culture. The study also emphasizes the need for each drilling rig to develop a unique safety culture that takes into account the specific needs and characteristics of the rig and its workforce. Overall, the paper provides valuable insights into how drilling companies can promote a strong safety culture and improve safety performance on their rigs.

CHAPTER III
OVERVIEW OF COMBINED CYCLE POWER PLANTS (THERMAL POWER GENERATION IN MYANMAR)

3.1 Background of the Ministry of Electric Power

In 1951, Electricity Supply Board (ESB) was established on October 1st under the Ministry of Industry and complied with the Electricity Act of 1948. Electric Power Corporation (EPC) was established on March 16, 1972. On 1st April 1975, reorganized the Ministry of Industry was into two ministries as No. 1 Ministry of Industry and No. 2 Ministry of Industry. EPC came under the No. 2 Ministry of Industry. The Electricity Act was enacted by the Pyithu Hluttaw Law No. 7/1984 on 22nd October 1984.

The Ministry of Energy was expanded from the No. 2 Ministry of Industry on 12th April 1985. EPC become a branch of the Ministry of Energy. The Electricity Corporation (EPC) was reorganized on 1st April 1989 and changed its name to Myanma Electric Power Enterprise (MEPE). The Ministry of Energy expanded on 15th November 1997. At that time the Ministry of Electric Power was established.

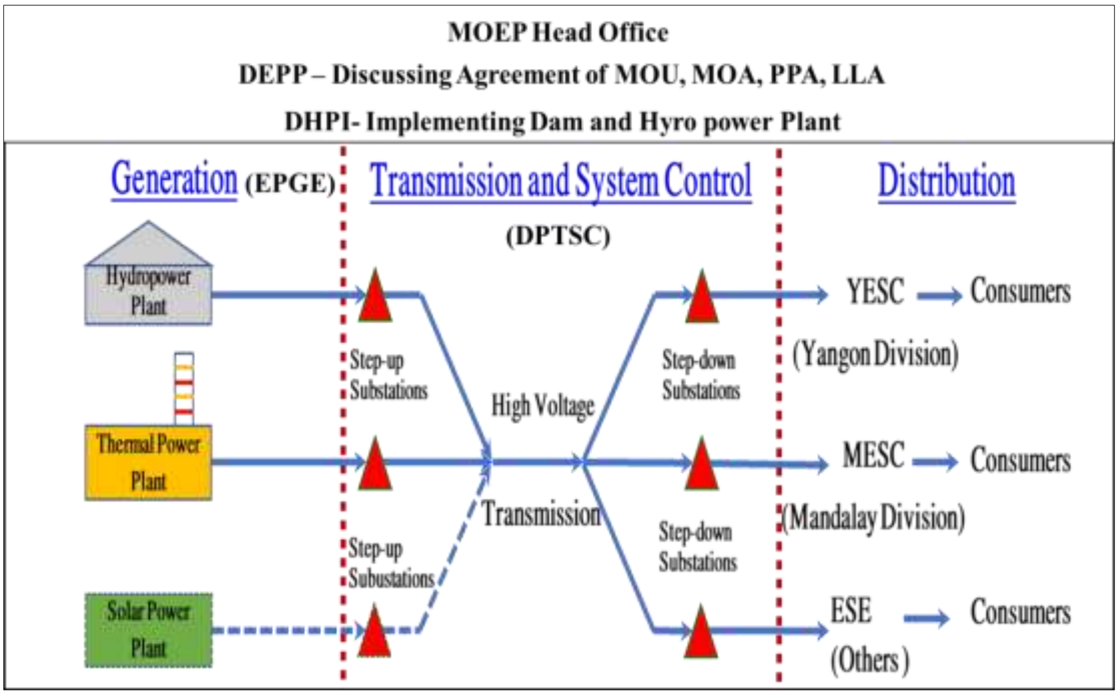
On 15th May 2006, the Ministry of Electric Power was prepared and formed into two ministries as No. 1 Ministry of Electric Power and No. 2 Ministry of Electric Power. On 5 September 2012, both ministries were composed as one Ministry as Ministry of Electrical Power (MOEP). According to the Pyidaungsu Hluttaw Law No.44/2014, the new Electricity law was enacted on 27th October 2014.

On 1st April 2016, the Ministry of Electric Power and the Ministry of Energy jointly formed the Ministry of Electricity and Energy (MOEE). After the 2021 coup, MOEE reorganized into the Ministry of Electric Power (MOEP) and Ministry of Energy (MOE) on 2nd May 2022.

The Ministry of Electric Power was organized with three Departments, two businesses, and two corporations. They are DEPP - Department of Electric Power Planning, DPTSC - Department of Power Transmission and System Control, DHPI -

Department of Hydro Power Implementation, EPGE - Electric Power Generation Enterprise, ESE - Electricity Supply Enterprise, YESC -Yangon Electricity Supply Corporation and MESC - Mandalay Electricity Supply Corporation.

Figure (3.1) Organization Structure of the Ministry of Electric Power



Source: MOEP

3.1.1 Power Generation of Ministry of Electrical Power

Electric Power Generation Enterprise (EPGE) under the Ministry of Electric Power has total 62 numbers of power plants. But two LNG IPP power plants (Tharkata (V Power) and Thanlyin (Vpower)) are not running.

Table (3.1) Power Generation of Ministry of Electrical Power

No.	Power Plant	Number of Power Plant	Installed Capacity (MW)	Unit Generated (MW)
1	Hydro Power Plant	29	3228	1406
2	Solar power plant	3	90	66
3	Coal-fired power plant	1	120	98
4	Thermal power plant	29	3773.7	1480
	Total	**62**	**7211.7**	**3050**

Source: MOEP

(i) Hydro and Solar Power Generation

Existing state-owned hydropower generation plants in Myanmar are shown in table (3.2). There are 23 numbers of Hydro power plants. During the rainy season, hydro power plants can operate at full capacity. Due to the climate change, hydro power plants cannot operate at full capacity.

Table (3.2) Hydro Power Generation of Ministry of Electrical Power (State-owned)

No.	Plant Name	Installed Capacity			Location
		MW	No.	Total MW	
1	Baluchaung (1), Lawpita	14	2	28	Kayah State
2	Baluchaung (2)	28	6	168	Kayah State
3	Kinda	28	2	56	Mandalay Region
4	Sedawgyi	12.5	2	25	Mandalay Region
5	Zawgyi (1)	6	3	18	Shan State
6	Zawgyi (2)	6	2	12	Shan State
7	Zaungtu	10	2	20	Bago Region
8	Thaphanzeik	10	3	30	Sagaing Region
9	Mone	25	3	75	Magway Region
10	PaungLaung	70	4	280	NayPyiTaw Council
11	Yenwe	12.5	2	25	Bago Region
12	Kabaung	15	2	30	Bago Region
13	KyaingTaung	18	3	54	Shan State
14	Yeywa	197.5	4	790	Mandalay Region
15	Shwegyin	18.75	4	75	Bago Region
16	Kyeeohnkyeewa	37	2	74	Magway Region
17	Kunchaung	20	3	60	Bago Region
18	Nancho	20	2	40	Shan State
19	Phyuchaung	20	2	40	Bago Region
20	Upper Paunglaung	70	2	140	Shan State
21	Myogyi	15	2	30	Shan State
22	Myittha	20	2	40	Magway Region
23	Yazagyo	4	1	4	Sagaing Region

Source: MOEP

Private owned IPP Hydro power plants and solar power plants are shown in Table (3.3). Shweli(1), Dapein(1) and Chiphwenge Hydro power plants were invested with JV and BOT basis by Foreign Direct Investment (FDI). Thaukyekhat (2) and Baluchaung(3) Hydro power plants were invested with BOT basis by local entrepreneurs. IPP Minbu, Thapyaywa and Taungtawgwin private owned Solar power plants were Invested with BOT basis by local and foreign entrepreneurs.

Table (3.3) Hydro and Solar Power Generation of Ministry of Electrical Power (IPP (JV/ BOT))

No	Plant Name	Installed Capacity			Location
		MW	No.	Total MW	
Hydro Power					
1	Shweli (1)	100	6	600	Shan State
2	Dapein (1)	60	4	240	Kachin State
3	Chiphwenge	33	3	99	Kachin State
4	Thaukyekhat (2)	40	3	120	Bago region
5	Baluchaung (3)	26	2	52	Kayah State
6.	Nantwote (small hydro)	3	1	3	Kachin State
Solar Power					
1	Minbu	40	1	40	Magway Region
2	Thapyaywa	30	1	30	Mandalay Region
3	Taungtawgwin	20	1	20	Mandalay Region

Source: MOEP

(ii) Thermal power generation

Thermal power plants are shown in Table (3.4), Table (3.5), and Table (3.6).

Table (3.4) Coal-fired Power Plant of Ministry of Electrical Power (Plant Rental to IPP)

No.	Plant Name	Installed Capacity			Location
		MW	No.	Total MW	
	Coal-Fired				
1	Tigit	60	2	**120**	Shan State

Source: MOEP

Tigit Coal-fired Power Plant installed capacity is 120MW shown in table (3.4). It is the only one coal-fired power generation under MOEP. Tigit power plant was plant rental to IPP producer. So employees of power plant are government staffs but their salary and machines maintenance are managed by IPP producer. But government staffs working periods are not more than 5 years at that Tigit power plant. After 5 years, they are back to work at MOEP power plants.

Table (3.5) show MOEP state-owned gas-fired and CCPP power plants in Myanmar.

Table (3.5) Thermal Power Plants of Ministry of Electrical Power (State-owned)

No.	Plant Name		Installed Capacity MW	No.	Total MW	Location
	Simple Cycle Power Plant					
1	Kyunchaung		18.1	3	54.3	Magway Division
2	Shwetaung		18.45	3	55.35	Bago Division
3	Myanaung		18.45	1	18.45	Ayeyarwady Division
4	Ywama		18.45	2	36.9	Yangon Division
	EGAT		120	2	240	
5	Thilawa (Dual Fuel)		32	2	64	Yangon Division
6	Thaton		18.45	1	50.95	Mon State
			16.25	2		
	Combined Cycle Power Plant (CCPP)					
	Thaton World Bank **CCPP**	GT	46	2	92	
		STG	44	1	44	
7	Ahlone **CCPP**	GT	33.3	3	99.9	Yangon Division
		STG	54.3	1	54.3	
8	Hlawga **CCPP** (GGE- ROMM)	GT	33.3	3	99.9	Yangon Division
		STG	54.3	1	54.3	
9	Tharkata **CCPP**	GT	19	3	57	Yangon Division
		STG	35	1	35	
	TM-2500	Diesel	25	1	25	

Source: MOEP

All state-owned power plants were installed over 30 years ago except Thaton (WB) CCPP power plant. All Turbines are low efficiency so most of them are not running but standby condition for emergency system breakdown. It means when system breakdown conditions state-owned standby power plants are start to produce backup power because IPP power plants don’t have black start facilities.

IPP(BOT/BOO) thermal power plants in Myanmar shown in table (3.6).

Table (3.6) Thermal Power Plants of Ministry of Electrical Power (IPP BOT/BOO)

No.	Plant Name		Installed Capacity			Location
			MW	No.	Total MW	
	Combined Cycle (CCPP)					
1	Myingyan (Sembcorp)	GT	72.8	2	230.71	Mandalay Division
		STG	85.1	1		
2	Mawlamyine (Myanmar Lighting) CCPP Phase I	GT(1+2)	98	2	230	Mon State
		STG(3)		1		
	CCPP Phase II	GT(4+5)	132	3		
		STG(6)				
3	Tharkata (UREC)	GT	80.3	1	119.73	Yangon Division
		STG	39.4	1		
4	Ahlone (Toyo Thai)	GT	47	2	121	Yangon Division
		STG	27	1		
5	Ahlone (CEEC)	GT	123	1	183	Yangon Division
		STG	60	1		
	Gas Engines					
6	Hlawga (MCP -1)		(1.05 +1.5 +9.2)	(25+ 3+1)	40.35	Yangon Division
7	Hlawga (MCP -2)		9.34	3	28.02	Yangon Division
8	Ywama (UPP)		4	13	52	Yangon Division
9	Tharkata (Max Power)		3.349	16	53.6	Yangon Division
10	Myingyan (V Power-1)		1.56	48	74.88	Mandalay Division
11	Myingyan (Vpower-2)		1.56	70	109.2	Mandalay Division
12	Kyaukse (Power Gen)		18.5	8	148	Mandalay Division
13	Shwetaung (MCM)		9.875	4	39.48	Bago Division
14	Pahtoelone (P&T)		2	7	14	Magwe Division
15	Magway (Vpower)		1.56	48	74.88	Magwe Division
16	Kyunchaung (V Power)		2.026	11	22.286	Magwe Division
17	Kyaukphyu (Vpower)		163.74	1	163.74	Rakhine State
18	Tharkata (V Power) LNG		461.2	1	461.264	Yangon Division
19	Thanlyin (Vpower) LNG		432.8	1	432.754	Yangon Division

Source: MOEP

In table (3.6), Hlawga(MCP -1), Hlawga (MCP -2), Ywama(UPP), Tharkata (Max Power), Myingyan (V Power-1), Myingyan (V Power-2), Kyaukse(Power Gen), Shwetaung (MCM), Pahtoelone (P&T), Magway (Vpower), Kyunchaung (V Power), and Kyaukphyu (Vpower) are IPP gas engines power plants. Tharkata (V Power) and Thanlyin (Vpower) are LNG gas engines power plants.

(iii) Unit Generation of power plants

Unit generation of power plants is shown in table (3.7) and table (3.8).

Depends on dam water level during the month from January to June, some Hydropower plants are not producing full load due to the climate change. When rainy season and before summer season (from July to December), all power plants producing full loads.

In tables Unit generation describes GWH (1 GWH = 1000 MWH).

Unit generation of power plants (from 2010 to 2015) shown in table (3.7). After 2013, IPP power plants were implanted so produced more unit generation.

Table (3.7) Unit Generation of Power Plants (2010-2015) (GWh)

Month / Year	2010	2011	2012	2013	2014	2015
January	520	771	856	880	1006	1142
February	485	722	840	818	951	1053
March	568	819	910	955	1153	1304
April	562	795	824	911	1136	1238
May	538	824	792	926	1205	1390
June	568	829	843	928	1137	1311
July	723	888	945	1000	1168	1307
August	767	892	950	1064	1184	1326
September	767	860	950	1040	1177	1325
October	774	892	1014	1082	1233	1366
November	773	869	974	1053	1161	1318
December	765	875	939	1025	1163	1311
Total	**7811**	**10063**	**10837**	**11682**	**13675**	**15392**

Source: MOEP

According to table (3.7), hydropower generation was main base load before 2013. At that time hydropower generation not producing full capacity in summer, so generation from January to June was declined. After 2013, IPP thermal power generation were implemented, so power generation were stable.

The unit generations of power plants from 2016 to 2021 shown in table (3.8). In 2018, installed capacity 225 MW of Sembcorp IPP power plants was implemented at Myingyan, Mandalay region.

Table (3.8) Unit Generation of Power Plants (2016-2020) (GWh)

Month / Year	2016	2017	2018	2019	2020	2021
January	1253	1467	1621	1799	1822	1930
February	1243	1377	1522	1701	1765	1662
March	1513	1589	1837	2016	2059	1918
April	1429	1519	1790	2007	1844	1931
May	1507	1760	1919	1992	2153	2252
June	1410	1638	1772	1900	2033	2040
July	1479	1644	1855	1936	2109	1926
August	1488	1718	1881	1933	2074	1993
September	1493	1712	1893	1918	2048	1994
October	1537	1714	1931	2047	1976	2107
November	1435	1661	1849	1932	1943	2030
December	1498	1616	1846	1805	1955	1872
Total	**17285**	**19416**	**21717**	**22986**	**23781**	**23654**

Source: MOEP

According to table (3.8), increased unit generation after 2018. The Sembcorp Myingyan IPP power plant produced 225 MW generation per day and IPP(BOO) gas engines power generation were implemented in Myingyan (Mandalay Region), Kyaukse (Mandalay Region) and Kyauk phyu (Rakhine Region). Therefore depends on base load of thermal power generation, total unit generation round about 1800 GWh were produced all seasons. But the other hand, tariff for unit generation cost must be higher.

Electricity consumption (rate of per capita) from 2015-2016 to 2020-2021 is shown in table (3.9).

Table (3.9) Electricity Consumption (Per Capita)

Fiscal Year	2015-16	2016-17	2017-18	2018 Mini	2018-19	2019-20	2020-21
Electricity Consumption (per capita kWh)	263	301	335	372	378	389	356

Source: MOEP

According to table (3.9), Myanmar's per capita consumption of electricity is more than 350 kilowatt- hours after 2018. But in the ASIAN regions, Myanmar's electricity consumption remains lowest.

3.2 Combined Cycle Power Plants (Thermal Power Generation) in Myanmar

A power plant has a Gas/ Steam/ Hydro Turbine for electric production and a power switchyard (Feeders and Lines) for distribution. In 1970, the first gas turbine project started in Kyaung Chaung at Magwe Division. This is Government owned simple cycle power generation of duel fuel turbine project. Turbines from JBE (John Brown Engineering, England) and control units are GE (General Electric) Mark I control. Kyaung Chaung power plant which has three gas turbines started Commercial Operation Date (COD) in 1974, March and June. In 1974, another simple cycle generation was implemented at Myan Aung, Ayeyarwady Division.

In 1980-1985, simple cycle generations were implemented in the following State and Division areas:

(1) Mann power plant which has three numbers of 18.45 MW gas turbine (JBE) with Mark II Control at Min Bu, Magwe Division,

(2) Shwe Daung power plant which has two numbers of 18.45 MW gas turbine (JBE) with Mark II Control at Bago Division,

(3) Ywama power plant which has two numbers of 18.45 MW gas turbines with (JBE) Mark II Control at Insein Township, Yangon Division,

(4) Myan Aung power plant which has two numbers of 16.25 MW gas turbine (JBE) with Mark II Control at Myan Aung, Ayeyarwady Division,

(5) Thaton power plant which has an 18.45 MW gas turbine (JBE) with Mark II Control at Thaton, Mon State.

In 1990-1995, the following simple cycle generation power plans are implemented in Yangon Division;

(1) Tharketa power plant which has three numbers of 19 MW gas turbines (Hitachi) with Mark I Control at Tharketa Township,

(2) Ahlone power plant which has three numbers of 33.3 MW gas turbines (GEC ALSTROM) with Mark V Control at Ahlone Township,

(3) Hlawga power plant which has three numbers of 33.3 MW gas turbines (GEC ALSTROM) with Mark V Control at Mingalardone Township.

In 1995, Hlawga and Ahlone power plants are implemented in Yangon Division. Each power plant has three simple cycle gas turbines for electricity production and a main switchyard for distribution.

In 2000, two gas turbines from Myanaung power plant are transferred to Thaton power plant for Myaing-ga-lay cement factory. In 2003, Japan NEDO donated a 34 MW combined cycle power plant at Ywama Power plant. In 2005, Two numbers of 60 MW coal-fired Tigypit power plant are implemented in Tigypit, Shan State.

After 2013, IPP-BOT power plants are implanted. Most IPP power plants are producing electricity by installing Gas Engines. But Toyo-Thai (Ahlone) and Myanmar Lighting (Mawlamyine), UREC (Tharketa), Sembcorp (Myingyan), and CEEC (Ahlone) power plants are combined cycle power plants.

Exhaust heat from the gas turbine of a Simple cycle generation system is used to boil water tubes of Boilers that will produce steam flow which generates a steam turbine to produce electricity by using a generator. This is called a combined cycle generation which does not need additional fuel (gas/diesel/LNG/HFO) for power production.

Depending on power generation, in 1996 Hlawga power plant expanded to combined cycle power generation which has three gas turbines, three waste heat recovery boilers, and a steam turbine. And also Ahlone power plant expands like Hlawga.

In 1997, three gas turbines of Tharketa power plant are expanded with three boilers for each turbine and a steam turbine with a condenser. Ahlone power plant expanded to combined cycle generation in 1999 same as Hlawga power plant.

Combined cycle power plants under the Ministry of Electric Power (MOEP) consist four numbers of state-owned power plants. Thaton and Hlawga combined cycle power plants are still running and producing electricity. But Tharketa power plant's steam turbine was decommissioned and plant operated in simply produces cycle generation of electricity. Ahlone power plant's steam turbine underwent major maintenance recently.

Combined cycle power plants (CCPPs) have become popular in recent years due to their higher efficiency and lower environmental impact compared to traditional power plants. Safety is a critical concern in the operation of CCPPs because they involve complex equipment and hazardous substances. Therefore, it is essential to establish a safety culture that emphasizes safety as a core value and guides the behavior of employees in a CCPP.

IPP(BOT/BOO) combined cycle power plants (CCPP)were implemented after 2013. At that time most of IPP power plants had gas engines power producing. First IPP CCPP is 230 MW Myanmar Lighting (Mawlamyine) power plant. 225 MW Sembcorp (Myingyan) power plant is the First ICB tender bidding winner.

Table (3.10) List of Combined Cycle Power Plants

No	Plant Name	Installed Capacity (MW)	Location
	State-owned		
1	Thaton World Bank	136	Mon State
2	Hlawga	154.2	Yangon Region
3	Ahlone	154.2	Yangon Region
4.	Tharketa	92	Yangon Region
	IPP(BOT/BOO)		
5	Myingyan (Sembcorp)	230.71	Mandalay Region
6	Mawlamyine (Myanmar Lighting)	230	Mon State
7	Tharkata (UREC)	119.73	Yangon Region
8	Ahlone (Toyo Thai)	121	Yangon Region
9	Ahlone (CEEC)	183	Yangon Region

Source: MOEP

The employees' safety culture and safety performance of the employees of Sembcorp Myingyan IPP power plant and also the employees of three numbers of state-owned power plants such as Thaton power plant, Hlawga power plant, and Ahlone power plant are collected and discussed in this study.

(1) Sembcorp Myingyan IPP Power Plant

The Sembcorp Myingyan Power Plant is a combined-cycle, gas-fired power plant located in the Myingyan, Mandalay division. It produces 225 MW (megawatt) per hour of electricity generation. This project was the first internationally and competitively tendered power project for an Independent power producer (IPP) in Myanmar.

In Mar 2016, Sembcorp Industries and Myanmar Electric Power Enterprise (MEPE), now Electric Power Generation Enterprise (EPGE) signed a power purchase agreement (PPA) for the purchase of 225 megawatts of power for 22 years.

Sembcorp Industries Ltd based in Singapore set up Sembcorp Myingyan Power Co., Ltd to implement the Myingyan 225 MW power plant project under the Myanmar Investment Commission (MIC) law. Sembcorp Industries is a leading in the provision of energy and also urban solutions provider.

In January 2017, The Ministry of Electricity and Energy (MOEE) and Sembcorp Myingyan Power Company Limited signed a build-operate-transfer agreement for 22 years. In October 2018, a commercial operation started.

In table (3.11) Unit generation of Sembcorp describes as GWH (1 GWH = 1000 MWH).

Table (3.11) Unit Generation of Sembcorp Power Plant (GWh)

Month / Year	2018	2019	2020	2021
January	0	159.8597	163.2208	163.2208
February	0.1271	144.3137	155.0767	155.0767
March	0	154.1308	166.0121	166.0121
April	0	139.8906	155.0107	155.0107
May	64.072	129.9977	159.4108	159.4108
June	75.7583	144.1128	152.9976	152.9976
July	64.8639	143.7405	158.0878	158.0878
August	86.9271	154.358	159.5712	159.5712

Source: EPGE

Table (3.11) Unit Generation of Sembcorp Power Plant (continued) (GWh)

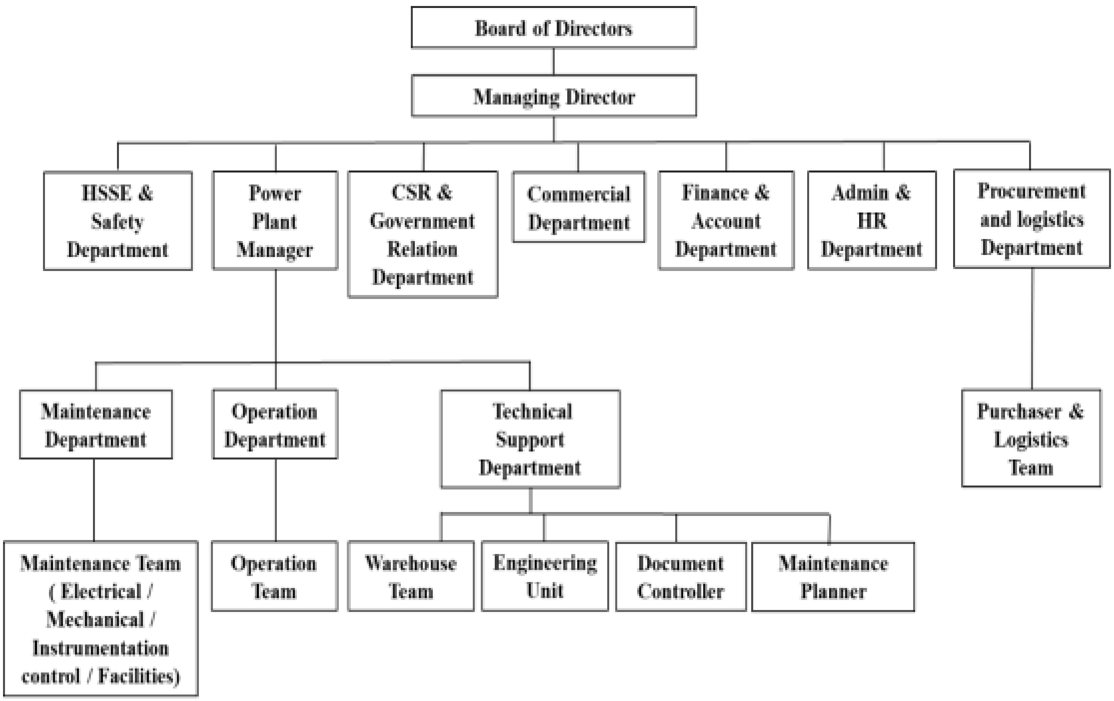
Month / Year	2018	2019	2020	2021
September	110.4961	141.8882	147.5511	147.5511
October	143.4912	71.7903	152.648	152.648
November	55.5158	160.6476	149.3342	149.3342
December	156.6979	167.7429	152.6176	152.6176
Total	**757.9494**	**1712.473**	**1871.539**	**1871.539**

Source: EPGE

According to table (3.11), Sembcorp (IPP) power plant generated around 1,700 gigawatt hours of electricity per year. Their PPA contracted power generation is hourly 225MW/day.

Organization structure of Sembcorp Myingyan Power Plant is shown in figure (3.2).

Figure (3.2) Organization Structure of Sembcorp Myingyan Power Plant



Source: Sembcorp

Under Board of Directors, managing director manage the departments of power plant and operation of power plant with the help of a plant manager. There are admin and HR department, finance and account department, procurement and logistics department, commercial department, CSR and Government relation department, and HSSE and safety department. Under a plant manager, there are maintenance, operation, and technical support departments. 72 employees are working at this power plant.

In Sembcorp Myingyan Power plant, practicing and promote safety culture based on Behavior based safety (BBS). BBS is a proactive approach on increasing safe behavior in an area. BBS focuses on reducing hazards, risks, and incidents by observing the behavior of a person and determining what follows when this behavior occurs. It involves analyzing the consequences of a particular behavior and providing proper reinforcement for a desired behavior.

Behavior based safety relies on complete trust and cooperation between the management and employees. Behavior based safety is important because it provides long-term solutions for eliminating risks and hazards. This life saving approach fosters a culture of safety in the workplace which is vital for lasting success.

The Health and Safety Authority (HSA) discussed that organizations aim to develop a total safety culture within their area of safety. This is achieved when every employee considers safety as a value and makes sure that their fellow employees are safe. This is what the BBS approach is all about, to reduce unsafe behaviors and continuously improve on safety performances.

(2) Thaton Power Plant (State-owned)

State-owned Thaton power plant located in Thaton, Mon State. This power plant has three simple cycle gas turbines but one gas turbine (18.45MW) running with a waste heat recovery boiler for steaming of Thaton Taryar Factory. Other two gas turbines (16.25 MW each) are producing electricity for Myaing-ga-lay Ton-900 and Ton-4000 cement factories. The National Grid system is connected from Kamarnat (Bago) to Mawlamyaine via Thaton 230 kV Switchyard.

In 2019, to improve the reliability and quality of power supply in the country's electricity generation, the Ministry of Electric Power launched Thaton CCPP project by supporting the World Bank. With loans from the World Bank, Thaton CCPP Project international competitive bidding winner China Energy Engineering Corporation implemented this power plant. Thaton CCGT project was the first internationally and competitively tendered power project for state-owned.

The total installed capacity of Thaton Power Plant is 186.95 MW. Nowadays Combined cycle power plant (World Bank) is continuously running and producing electricity depending on offshore gas quota from MOGE (Myanmar Oli and Gas Enterprise), Ministry of Energy. The other three gas turbines are preserved as peaking machine depending on the emergency condition of the power grid system.

Unit generation of Thaton power plant are shown in table (3.12). In table Unit generation describes GWH (1 GWH = 1000 MWH).

Table (3.12) Unit Generation of Thaton Power Plant (GWh)

Month / Year	2014	2015	2016	2017	2018	2019	2020	2021
January	28.04	18.751	18.379	18.379	7.908	20.700	60.875	46.413
February	24.212	12.837	16.323	16.322	9.833	29.155	58.356	41.406
March	29.305	15.411	14.703	14.703	10.024	21.043	82.003	46.293
April	26.998	12.002	17.523	17.523	11.592	44.155	73.516	43.601
May	25.791	9.6294	16.760	16.760	15.485	27.670	79.738	42.299
June	18.675	17.111	14.803	14.803	8.231	12.912	73.400	41.093
July	18.270	16.535	17.626	17.626	10.602	13.559	51.980	41.475
August	12.456	7.224	13.722	13.722	12.292	13.560	64.660	39.127
September	8.344	8.225	8.381	8.381	15.873	13.071	69.817	36.014
October	8.567	9.208	8.778	8.778	16.160	11.520	72.001	24.562
November	8.480	11.108	7.839	7.839	29.809	63.697	66.91	37.68
December	17.892	9.156	8.426	8.426	28.682	53.624	55.592	38.939
Total	**227.029**	**147.197**	**163.262**	**163.262**	**176.489**	**324.665**	**808.848**	**478.902**

Source: EPGE

Before 2019, Thaton power plant has only simple cycle generation of three numbers of gas turbines. After 2019, Thaton (World Bank) CCPP – combined cycle power plant started to generate power. According to table (3.12), power generation of Thaton thermal power generation was started to decreased production because hydropower generation were fully generated when rainy season starting in May. From May to November, thermal power decreased their generation but fully generated from December to May.

(3) Hlawga Power Plant (State-owned)

State-owned Hlawga power plant is located in Yangon-Pyay road, Mingalardone, Yangon Division. Hlawga power plant has 33.3 MW of Three Gas turbines, three WHRB boilers, and a steam turbine. The total installed capacity is 154.2MW. The National Grid system is connected from Kamarnat (Bago) to Yangon via Hlawga 230kV switchyard.

All machines and Auxiliaries of Hlawga power plant are Remote Operation & Maintenance Managed Service (ROMM) by GGE Company for long-term service. MCP-1 and MCP-2 two IPP power plants are located at the compound of Hlawga power plant.

unit generation of Hlawga power plant (from 2014 to 2021) are shown in table (3.13). In tables Unit generation describes GWH (1 GWH = 1000 MWH).

Table (3.13) Unit Generation of Hlawga Power Plant (GWh)

Month / Year	2014	2015	2016	2017	2018	2019	2020	2021
January	53.106	46.115	11.303	11.303	45.308	40.931	42.79	28.244
February	47.538	40.535	9.443	9.443	44.913	41.678	40.157	14.602
March	48.381	22.538	32.415	32.415	46.432	47.226	39.746	16.351
April	50.551	16.637	36.265	36.265	40.747	43.842	31.607	15.819
May	46.231	16.627	36.89	36.89	46.499	44.763	40.131	31.112
June	36.04	14.477	38.654	38.654	44.636	43.818	38.185	30.799
July	48.272	13.369	36.587	36.587	42.273	45.832	41.037	22.006
August	28.722	13.756	42.006	42.006	42.123	32.295	40.023	28.418
September	25.765	14.296	35.828	35.828	41.647	38.302	36.598	15.256
October	36.526	14.9	43.745	43.745	43.344	41.93	32.604	5.503
November	44.781	14.512	33.785	33.785	29.538	41.527	34.905	2.372
December	46.116	14.873	36.672	36.672	39.548	39.979	33.074	0.0
Total	**512.029**	**242.635**	**393.593**	**393.593**	**507.008**	**502.123**	**450.857**	**210.482**

Source: EPGE

According to table (3.13), power generation of Hlawga thermal power plant decreased production from July to October and fully generated from November to July because hydropower generation were fully generated when rainy season starting in May. Hlawga power plant is the main source received connection of the National grid system of MOEP from Hydropower plants which are located at upper Myanmar. On December 2021, Machines of Hlawga power plant are under maintenance so at that time no generation but still distribution via 230kV Main Sub-station of Hlawga.

(4) Ahlone Power Plant (State-owned)

State-owned Ahlone power plant located in Lower Kyinmyinttaing road, Ahlone, Yangon Division. It has 33.3 MW of Three Gas turbines, three WHRB boilers, and a steam turbine. The total installed capacity is 154.2MW. The National Grid system is connected to Yangon Area via Ahlone 230kV switchyard.

Thoyo-Thai and CEEC two IPP combined cycle power plants are located at the compound of Ahlone power plant. That two power plants have separate area and control by each company.

Ahlone power plant unit generation from 2014 to 2021 are shown in table (3.14). Unit generation describes as GWH (1 GWH = 1000 MWH).

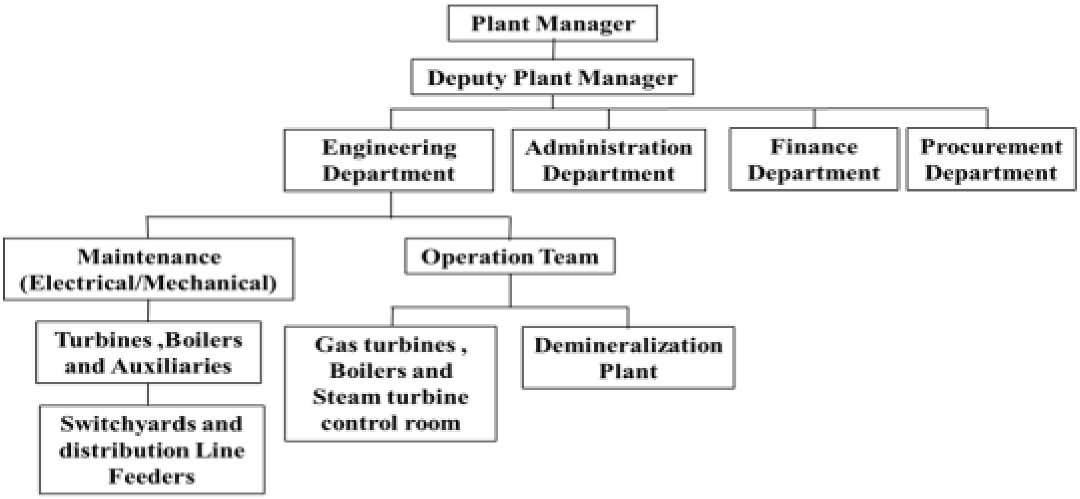
Table (3.14) Unit Generation of Ahlone Power Plant (GWh)

Month / Year	2014	2015	2016	2017	2018	2019	2020	2021
January	62.42	48.636	55.198	55.198	48.73704	47.097	31.515	2.228
February	61.158	45.321	41.28	41.28	48.12795	44.204	31.36	0.587
March	64.304	51.928	44.119	44.119	51.05873	46.413	49.372	0.149
April	77.417	25.445	42.504	42.504	44.154	34.939	42.553	0
May	74.18	49.208	36.246	36.246	51.226	44.912	20.73	0.035
June	57.916	49.208	39.95388	39.95388	33.645	47.57	13.79	3.202
July	63.164	49.208	39.7778	39.7778	30.774	43.339	16.047	0.471
August	50.643	49.208	36.85169	36.85169	39.97	39.616	16.071	2.998
September	43.033	49.208	37.50696	37.50696	40.417	45.459	18.251	0.215
October	40.89	49.208	35.60114	35.60114	34.312	35.97	19.861	0.236
November	43.382	49.208	34.73819	34.73819	38.055	42.252	23.958	0.79
December	43.193	49.208	39.4408	39.4408	46.203	34.256	25.211	0.156
Total	**681.7**	**564.994**	**483.2175**	**483.2175**	**506.6797**	**506.027**	**308.719**	**11.067**

Source: EPGE

According to table (3.14), power generation of Ahlone thermal power plant fully generated from January to August but decreased production from September to December because hydropower generation were fully generated at that time. On April 2021, Machines of Ahlone power plant were under maintenance so at that time no generation. But Ahlone power plant is situated at downtown of Yangon Area, so it is main distribution of National grid system of MOEP generation via 230kV main sub-station of Ahlone.

Figure (3.3) Organization Structure of a Combined Cycle Power Plant (Thaton/Hlawga/Ahlone)



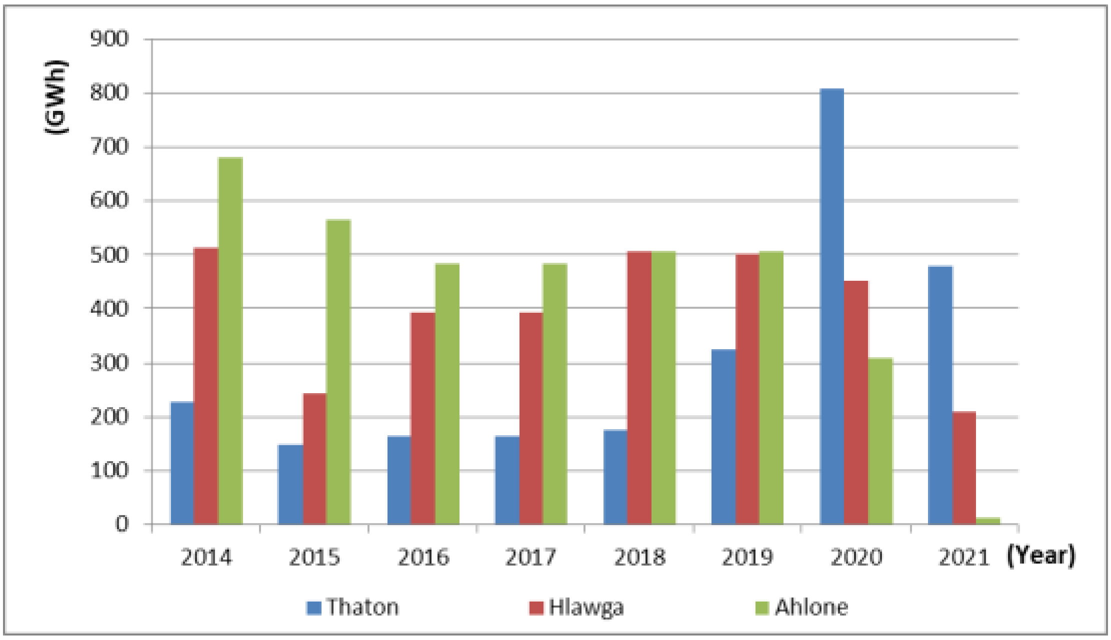
Source: EPGE

Figure (3.3) shows the organization structure of Thaton, Hlawga, and Ahlone Combined Cycle Power Plants. A plant manager is the leader of each power plant. Under a plant manager, a deputy plant manager and four departments such as Engineering department, Administration Department, Finance department and Procurement department. In engineering department, there are Maintenance (Electrical/Mechanical) and operation teams. Maintenance (Electrical/Mechanical) team are maintain for (1) turbines, boilers and auxiliaries, and (2) switchyard and distribution line feeders. Operation teams are operate and collect data of gas turbines, steam turbine and boilers control rooms ,and also in charge for demineralization plant.

Each of Thaton, Hlawga, and Ahlone Combined Cycle Power Plants has 100 employees (66% of permitted employees). Mostly engineers and technicians are working at operation and maintenance of power generation.

Comparison of yearly unit generation (from 2014 to 2021) of Thaton, Hlawga and Ahlone Power Plants are described in figure (3.4).

Figure (3.4) Comparison of Yearly Unit Generation of Thaton, Hlawga and Ahlone Power Plant



Source : EPGE

In 2014, unit generation of Ahlone power plant was higher than Thaton and Hlawga power plants. At that time, Thaton power plant has simple cycle generation by three gas turbines. But both Hlawga and Ahlone power plants had combined cycle generation. After 2019, Thaton power plant has both simple cycle generation and Thaton (WB) combined cycle power plant. So in 2020, unit generation of Thaton plant power was the highest.

3.3 Safety Management System of Power Plants under the Ministry of Electrical Power

The scope of work activities in a power plant is operational activities, maintenance activities, offices, and central control room locations, working in/ adjacent to the energized area, and working above/adjacent to water and warehouse.

For everyone who works at thermal power plants under MOEP, we want a safe working environment and always intervene where there are unsafe working conditions. So set out “dos and don'ts" rules that are clear and simple to follow by people. That is based on 12 site-based Life-Saving Rules (LSR). Everyone who works in a power plant follows rules and gets home safely. 12 site-based Life-Saving Rules (LSR) are as follows;

(1) Obtain authorization before a confined space.

(2) Protect yourself against a fall when working at a height.

(3) Conduct a gas test when required.

(4) Work with a valid permit when required.

(5) Verify isolation before work begins and use specified life-protecting equipment.

(6) Wear a personal isolation device required.

(7) Obtain authorization before overriding or disabling a safety critical equipment.

(8) Obtain authorization before excavation.

(9) Follow the prescribed lifting plan.

(10) No alcohol or drugs while working or driving.

(11) Do not work under a suspended load.

(12) Do not smoke outside designated smoking areas.

Operations of the power plants are de-energized, de-pressurized, drain/flush the equipment/ system to be worked on, and complete the instruction. According to HSG253, power plants under MOEP must be check and countercheck to ensure that:

(a) Isolation list and tags are printed out and given to the technician to carry out he isolation at field.

(b) Electrical isolation must precede mechanical isolations.

(c) After isolation is done the technician will sign against each point isolated.

(d) Shift in charge will counter sign on the isolation list.

Information or instruction signboard provides around and outside of the power plant compound. The signboards are:

(1) Prohibition sign : the color is red which means "Dangerous alarm". example: 'no access for unauthorized person'.

(2) Warning sign : the color is yellow of amber which means "be careful". example:'danger: 1100 kV electricity'.

(3) Mandatory sign : the color is blue which means "specific action". Example: 'ear / eye / foot protection must be worn'.

(4) Emergency escape : the color is green which means "No danger"/ "First-aid sign"

All power plants (state-owned or IPP) have to ensure physically check the work site as the following safety conditions ;

(a) The site is brought back to safe conditions i.e. pipelines, valves, etc. are properly secured and fixed in correct positions.

(b) Tools/equipment are maintained safely and securely.

(c) Electrical wires/cables are removed from power supply.

(d) Chemicals are kept in a safe and secure place.

(e) Housekeeping is completed.

(f) Wastes generated are removed.

Employees who are working at site before / after working time, the following steps must be checked regularly everyday:

(a) Routine operations tasks.

(b) External visual checks/ inspections escorted by supervisor.

(c) General/ toxic waste collection by contractors without operation shutdown or impact on operation.

(d) Taking of meter readings by third parties or approved contractors escorted by supervisor.

(e) Chemical delivery/loading.

(f) Goods delivery to warehouses/ offices.

(g) Labor or manual work in workshop including hot work.

(h) Work in admin building where office occupants are able to control hazards; e.g. housekeeping, working on PC, servicing office machines, pest controls.

(i) Routine building cleaning services which do not involve electrical work (with exception to equipment's like vacuum cleaner, low pressure jet floor cleaning, etc.) and working at height (below 1.8 meters).

(j) Grass cutting at non-process area.

(k) Ship or barge operation at the jetty.

(l) Vehicle Entry (vehicles, forklift, diesel engine operation).

The checking procedures of planned work methods, hazards involved and required control measures to workers to ensure work is carried out safely.at power plant are shown in Table (3.15).

Table (3.15) Procedures of Planned Work Methods, Hazards Involved and Required Control Measures of Power Plant

Category	Control measures
Fire / Explosion	➢ Purge / Blind source of Flammables materials ➢ Remove combustible materials ➢ Conduct gas test ➢ Provide fire blanket ➢ Deploy fire Watchman ➢ Standby fire extinguisher
Fall from height	➢ Comply to Fall Protection Plan ➢ Proper safe work platform (with access/egress) ➢ Barricade open edges and flooropenings ➢ Adequate anchorage point ➢ Wear safety harness
Asphixiation/ Presence of Toxic gas	➢ Conduct gas test ➢ Purge confined space ➢ Provide adequate ventilation ➢ Implement Lock Out Tag Out (LOTO) Procedure
Drowning	➢ Provide barricade and warning signs ➢ Use life Jacket ➢ Standby rescue buoys with nylon rope
Struck By Lighting	➢ Workers aware of nearest lightning shelter
Traffic	➢ Adhere to speed limit ➢ Competent driver / operator ➢ Assign banksman for each mobile plant / vehicle ➢ Designated travel route and parking area
Chemical contact	➢ Display Safety Data Sheet (SDS) on site ➢ Users attended required external /in-house training ➢ Wear proper Personal ProtectiveEquipment (PPE)
Noise	➢ Display warning sign ➢ Enclose noisy equipment ➢ Wear ear plugs / muff
Dark Environment	➢ Use clear safety glasses ➢ Provide adequate lighting

Source: EPGE and Sembcorp

Table (3.15) Procedures of Planned Work Methods, Hazards Involved and Required Control Measures of Power Plant (Continued)

Category	Control measures
Stored Energy	➢ Implemented LOTO (log-0ut-Tag-out) procedure ➢ Equipment / machine de energised ➢ Provide standby watchman
Dust	➢ Spray water mist to minimise dust ➢ Workers wearing dust mask
Heat	➢ Provide drinking water station ➢ Stagger exposure hours
Structure Collapse	➢ No overloading ➢ Do not remove structural member
Pinch Point	➢ Machine guard in place ➢ Do not position limbs in line of fire
Slip, Trip and Fall	➢ Safe passage way ➢ Proper housekeeping
Rotating Parts	➢ Machine guard in place ➢ Use electrical tool with 'dead-man' switch
Falling Objects	➢ Barricade area underneath work area ➢ Provide overhead protection ➢ Provide container to store small items ➢ Secure hand tools with tools lanyard
Electrical Current	➢ Earth generator / transformer ➢ Use approved type Socket Outlet Assembly(SOA) ➢ Use electrical device with Residual-Current ➢ Circuit Breaker (RCCB) ➢ Valid LEW sticker on electrical hand tools / ➢ equipment ➢ Elevate cables and connectors
Struck by object/ mobile machine	➢ Barricade work area ➢ Provide overhead protection ➢ Competent machine operator ➢ Assign banksman for each machine ➢ Provide safe passage way

Source: EPGE and Sembcorp

CHAPTER IV
SURVEY ANALYSIS

This chapter describes and analyzes data collected on the safety culture and safety performance of the combined cycle power plant of Electric Power Generation Enterprise, Ministry of Electrical Power in Myanmar. The survey area is conducted on Sembcorp Myingyan IPP power plants and three state-owned power plants (Thaton, Ahlone, and Hlawga power plants).

The analysis of various data was collected through the use of structural questionnaires as per the objectives of the study. There are four power plants with a combined membership of 342 individuals. In order to conduct a survey, it has been decided to distribute questionnaires to a sample size of 60 members from each power plant, resulting in a total sample of 240 individuals.

4.1 Survey Design

The survey questionnaire data were collected from the third week of December 2022 to the third week of January 2023. The study is undertaken to find out the power plant engineers, staff, and workers' behavior on safety culture by using qualitative research methods based on primary survey data.

The study will use a survey questionnaires approach to gather data from the power plant employees. The survey design is to gather quantitative data on safety culture and safety performance. Observation will be used to verify the data collected through the survey.

The survey questionnaires are divided into two parts. The first portion is asked for the socio-demographic data of the respondents. The second portion is about the safety culture knowledge, safety attitudes, and safety practice/performance. Firstly a sample of 20 employees from the power plant was taken for the pre-test. These testing results were useful for the final survey questionnaire. The survey analysis in the study consisted of simple percentages for each category in the questionnaire item.

4.2 Analysis of the Study

According to survey questionnaires, the survey findings are presented in four sections:

(1) Socio-demographic characteristics of the respondents,

(2) Attending safety training conditions of the Respondents

(3) About the safety culture knowledge, safety attitude, and safety practice/performance.

4.2.1 Socio-Demographic Characteristics of the Respondents

Following is the analysis of the collected data for the Socio-Demographic characteristics of the respondents from four power plants.

(i) Characteristics of Respondents

Characteristics of respondents such as age, gender, marital status, education, Occupation Status, Work experiences, and Monthly income are shown in table (4.1).

Among 240 respondents, 234 respondents answered their gender but 6 respondents are chosen "other". According to table (4.1), the male and female percentage of working conditions is fair so no issue of gender discrimination in the production of electricity generation.

Mostly 141 respondents of 240 respondents are married. Respondents answered marital status with open-minded such as single, married, widowed or divorced, but 9 respondents choose "Not answer".

In education qualification of respondents, most of the power plant employees are Bachelor's Degree holders but some employees are knowledgeable of Read and write words level primary school level and middle school level. It shows that the difference education level between state-owned power plants and IPP power plant.

IPP power plants are invested from private sector, so their basic education requirement for employees at least diploma/ Bachelor Degree holders. Depending on the IPP / state-owned power plants their salary are different.

The age of the respondents was considered to be important in finding the impact of the working environment on employees' performance at the power plant. According to the Civil Service Personal Law, “a person who is 18 years old he or she can be a civil servant, and all civil servants must be retired when he or she is 62 years old.

Depending on the roles and duties of the respondents, most of the respondents are from the operation team and maintenance team of the power plant.

According to survey results, working experience of state-owned power plant employees are more than IPP power plant employee. But some of government staffs and engineers are job transferred to IPP power plants because of salary and living standards facilities.

Table (4.1) Characteristics of Respondents

Descriptions	Category	Number	Percentage
	Total	**240**	**100**
Age	18-27	19	7.9
	28-37	90	37.5
	38-47	92	38.3
	48-57	35	14.6
	58-67	4	1.7
Gender	Male	116	48.1
	Female	118	49.4
	Other	6	2.5
Marital Status	Single	65	27.1
	Married	141	58.8
	Divorced	8	3.3
	Widowed	17	7.1
	Not Answer	9	3.7
Education	knowledge of reading and writing words	2	0.8
	Primary School	1	0.4
	Middle School	1	0.4
	High School	20	8.3
Education	Diploma / Certificate	40	16.7
	Bachelor Degree	114	47.5
	Post Graduate Diploma/ Degree	16	6.7
	Master Degree	35	14.6
	PhD	11	4.6

Source: Survey Data (2023)

Table (4.1) Characteristics of Respondents (Continued)

Descriptions	Category	Number	Percentage
	Total	**240**	**100**
Occupation Status	Administrative Staff	46	19.2
	Finance Staff	8	3.3
	Procurement Staff	6	2.5
	Worker (Operation)	29	12.1
	Worker (Maintenance)	19	7.9
	Supervisor	22	9.2
	Operation Engineer	43	17.9
	Maintenance Engineer	32	13.3
	Planning Engineer	29	12.1
	Procurement Engineer	6	2.5
Work experiences (Years)	1 year to 5 years	41	17. 1
	6 years to 10 years	76	31.7
	11 years to 15 years	51	21.3
	16 years to 20 years	35	14.6
	Over 20 years	37	15.6
Monthly income	Under 160,000 and 160,000	6	2.5
	160,000 to 210,000	14	5.8
	210,000 to 250,000	29	12.1
	250,000 and 300,000	39	16.3
	300,000 and 340,000	46	19.2
	340,000 and 370,000	7	2.9
	370,000 and 400,000	13	5.4
	400,000 and above	41	17.1

Source: Survey Data (2023)

4.2.2 Training Conditions for safety

Safety pieces training is good for safety skills for workers and managers. They can easily access safety information and work-related injury insurance training.

Attending safety training conditions are shown in Table (4.2).

Table (4.2) Training Conditions of the Respondents

Sr. No.	Descriptions	Numbers	Percentage
1.	I have completed the necessary safety training, which is essential for preventing workplace accidents and ensuring safety in the workplace.	103	42.9
2.	We participate in safety training that is tailored to the specific needs of our plant, which aligns with our job responsibilities and meets all relevant legal and occupational safety and health (OSH) requirements.	162	67.5

Source: Survey Data (2023)

According to survey results, 103 respondents out of a total of 240 respondents (42.9%) received the needed safety training and 162 of 240 respondents (67.5%) attended plant-specific safety training.

This result shows that the employees think they receive their benefits such as problems solving skills and work expertise are getting from on -job training program. But depends on the situation of power plant, on-job training or off-job training programs are different.

Organization sunk time and a lot of money for them in training program. Employees consider morally right to stay in their organization. Because they received their profits such as their problem solving skill, knowing rule, and expertise and regulation of inspection etc. Moreover,

4.2.3 Knowledge, Attitudes, and Practice / Performance of Safety Culture

The second part of the survey questionnaire was designed to collect knowledge, attitudes, and practice/ performance of safety culture.

Five-point Likert scale question format is constructed to select data for the topics of Safety culture knowledge, Safety culture attitudes, and Safety culture practice/ performance. The scores on each scale are given as 1= Strongly Disagree, 2= Disagree, 3= Neutral (neither agree nor disagree), 4 = Agree, and 5 = Strongly Agree.

Best (1977) provided a guideline for interpreting mean values of five-point Likert scale items as follows:

Mean score between 1.00 and 1.80: strongly disagree

Mean score between 1.81 and 2.60: disagree

Mean score between 2.61 and 3.40: neutral

Mean score between 3.41 and 4.20: agree

Mean score between 4.21 and 5.00: strongly agree

These guidelines are commonly used in research to interpret the results of surveys or questionnaires that use Likert scales to measure attitudes, perceptions, or beliefs.

4.2.4 Safety Knowledge

The knowledge of the safety culture concept of 240 respondents is shown in table (4.3).

Table (4.3) Safety Culture Knowledge of the Respondents

Sr. No.	Descriptions	Mean	Standard Deviation
1.	I understand a general awareness of the hazards represented by the accessories of the power plant.	3.45	0.954
2.	I understand the documentation of power plants such as piping diagrams, loop diagrams, cause and effect diagrams, and power supplies applicable to the isolation of the plant.	3.37	0.950
3.	I already know the procedures for issuing Permit-To-Work and for identifying what isolations are required.	3.40	0.959
4.	I understand how to check what isolations are in place and which are the correct isolations required.	3.34	0.994
5.	We know that the words “SAFETY FIRST” have a significant meaning for all sector safety.	3.67	1.107
6.	I understand that the equipment which we operate is consistently maintained in safe working conditions is important.	3.53	1.050
7.	I truly understand that regular safety-related communications are effective with other parties involved in the work for working safely	3.58	1.032
	Overall	**3.48**	**1.007**

Source: Survey Data (2023)

According to Table (4.3), overall mean value is 3.48 and overall standard deviation is 1.007. The mean score for safety culture knowledge indicating a moderate level of knowledge about safety protocols and procedures among employees. However, the standard deviation of 1.007 showed that there is a wide range of knowledge levels among employees, with some employees having a low level of knowledge.

The statement of "We know that the words "SAFETY FIRST" have a significant meaning for all sector safety" has the highest mean scores 3.67 which indicating most of the respondents are agree for this knowledge. But the standard deviation of 1.107 indicates that some respondents rated it lower and some rated it higher.

4.2.5 Safety Attitudes

The attitudes toward the safety culture concept of each respondent are shown in table (4.4).

Table (4.4) Safety Attitudes of the Respondents

Sr. No.	Descriptions	Mean	Standard Deviation
1.	Safety is always important even when we get busy.	3.65	1.102
2.	If I didn't follow the safety instructions and also don't know the documentation of the power plant, that action may affect others' safety.	3.66	1.078
3.	Safety procedures and permit-to-work guide us on what to do and how to follow regarding safety matters.	3.52	1.055
4.	If we don't know how to test and confirm the correct installation of isolations, that not work out all the jobs/tasks in the area that have safety risks	3.60	1.039
5.	Safety is the priority. Positive safety culture makes us aware of safety issues and greater ability to initiate effective safety policies.	3.60	1.062
6.	Good working knowledge of isolation and risk assessment procedures for the plant is to maintain a best practice that cannot fall into safety problems.	3.60	1.030
7.	All employees take pride in doing their jobs professionally and safely.	3.62	1.020
	Overall	**3.61**	**1.055**

Source: Survey Data (2023)

According to table (4.4), the employees have a moderate level of safety culture attitudes with overall a mean score of 3.61 and a standard deviation of 1.055. It shows that there is a wide range of attitudes towards safety among employees but some employees having a less positive attitude towards safety. There is some variability in their perceptions.

The statement of "Safety procedures and permit-to-work guide us on what to do and how to follow regarding safety matters" has the lowest mean scores 3.52 which indicating most of the respondents are general agree for this. But depends on difference in job roles or experience levels of the respondents, some employees having a less positive attitude towards safety.

4.2.6 Safety Practice/Performance of the Respondents

The Practice/Performance of the safety culture concept of each respondent is shown in table (4.5).

Table (4.5) Safety Culture Practice/Performance of the Respondents

Sr. No.	Descriptions	Mean	Standard Deviation
1.	If I see someone working in unsafe conditions or manners, I will remind them to work safely.	3.61	1.041
2.	I feel that I am making important contributions to my work in my organization.	3.65	1.049
3.	I feel fortunate that I can be a part of my organization. So I am motivated and look forward to going to work.	3.55	1.013
4.	I take responsibility for my safety and that of other workers around me.	3.61	1.029
5.	I feel that strong safety culture gives us to maintain best practices that cannot fall into safety problems.	3.62	1.024
6.	The safety management system is to improve the safety culture and safety performance of the organization through the planning, control, and supervision of safety-related activities.	3.63	1.031
7.	Safety culture is "the way we do things around here," and reflects how we collectively value safety.	3.60	1.030
	Overall	**3.61**	**1.031**

Source: Survey Data (2023)

According to table (4.5), with a overall mean score of 3.61 and a overall standard deviation of 1.031. It indicates that while employees may have a positive attitude towards safety but there may be areas where they are not consistently following safety-protocols.

The statement “I feel that I am making important contributions to my work in my organization” has the highest mean value 3.65 and standard deviation 1.049. It shows that a positive safety culture and improved safety performance. When employees feel valued and that their contributions are important, they are more likely to take ownership of their work and pay attention to safety practices.

CHAPTER V
CONCLUSION

5.1 Findings

The electricity generation sector is the essential for development and growth of the country. The electricity generation of Myanmar depends on total 62 numbers of state-owned and IPP (BOT/BOO/JV/Rental) power plants; 29 numbers of Hydro Power Plants, 3 numbers of Solar power plants, a coal-fired power plant , and 29 numbers of thermal power plants. IPP thermal power plants were implemented after 2013. In an early generation, the electricity base load depends on Hydropower generation but due to climate change thermal power generation has changed to the base load in the current situation.

The male and female percentage of working conditions among 240 respondents is fair so no issue of gender discrimination in the production of electricity generation.

In the results, some workers of state-owned power plants have education level of knowledge of reading and writing words level, Primary School, Middle school, and high school. But mostly the respondents of state-owned power plant are graduated. Staff and workers of IPP power plant education level needed at least a Diploma / Certificate or Bachelor Degree. It shows that the education level is affected to the level of safety knowledge, attitude and performance.

Most 30 years to 40 years old residents are working on the operation or maintenance team of the power plant. Depending on the roles and duties of the respondents, the age of the respondents is important for the impact of the working environment on employees' performance at the power plant.

Results of work experiences, most of the respondents from IPP power plants are brain drain from our state-owned power plants because the salary and other facilities are different.

Safety pieces training is good for safety skills for workers and managers. They can easily access safety information and work-related injury insurance training.

The safety culture knowledge of the power plant employees have a good level of safety culture knowledge, which is essential for maintaining a safe and secure work environment. They understand the importance of positive safety culture in ensuring a safe working environment and overall safety management system performance of the plant. However, there is a wide range of knowledge levels among employees, with some employees having a low level of knowledge.

A positive safety culture is essential for ensuring a safe working environment and overall safety management system performance of the combined cycle power plant. While the power plant had a foundation for a positive safety culture, there was room for improvement to achieve a strong safety culture that could lead to better safety management system performance

The respondents' safety culture attitudes and practice/ performance were higher than safety culture knowledge. It identified that the need for improvement in safety culture knowledge and highlighted the importance of communication, training, and leadership in promoting a positive safety culture.

So safety culture is positively correlated with safety performance in a combined cycle power plant. The findings of this study can be valuable in developing strategies to improve safety culture and performance in the power plant industry.

5.2 Suggestions

A positive safety culture is essential for ensuring a safe working environment and improving safety performance in the Combined Cycle Power Plant. Employees of the power plants have a good understanding of safety culture and demonstrate positive attitudes and practice/ performance.

This can be achieved through ongoing safety training and education, promoting open communication about safety issues, and fostering a sense of shared responsibility for safety among all employees. By addressing areas for improvement identified by the survey results, the combined cycle power plant can create a safer work environment for its employees and reduce the risk of accidents or injuries.

Management level should take proactive measures to address safety culture factors, such as communication, leadership, and trust, which can affect the safety performance of the plant. And also consider implementing targeted interventions to address specific areas of weakness and promote a stronger safety culture overall.

Regular training and education programs should be provided and employees should be encouraged to report any safety concerns or hazards without fear of retaliation.

Therefore, the power plant management prioritizes to continue the development of a positive safety culture through training programs, communication, and feedback mechanisms to improve safety.

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APPENDIX

SURVEY FOR SAFETY CULTURE AND SAFETY PERFORMANCE OF POWER PLANT

Section A - Socio-Demographic by respondents

1. Gender
   - o Male
   - o Female
   - o Other
2. Age (years)

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3. Marital Status
   - o Single
   - o Married
   - o Divorced
   - o Widowed
   - o Not Answer
4. Level of Education
   - o knowledge of Read and write words
   - o Primary School
   - o Middle School
   - o High School
   - o Diploma / Certificate
   - o Bachelor Degree
   - o Post Graduate Diploma/ Degree
   - o Master Degree
   - o PhD
5. Occupation Status
   - o Administrative Staff
   - o Finance Staff
   - o Procurement Staff
   - o Worker (Operation)
   - o Worker (Maintenance)
   - o Supervisor

- Operation Engineer
- Maintenance Engineer
- Planning Engineer
- Procurement Engineer

6. Work experiences in current organization

   ----

7. Monthly Income (Kyat)-
   - Under 160,000 and 160,000
   - 160,000 to 210,000
   - 210,000 to 250,000
   - 250,000 and 300,000
   - 300,000 and 340,000
   - 340,000 and 370,000
   - 370,000 and 400,000
   - 400,000 and above

Section B

12. I have completed the necessary safety training, which is essential for preventing workplace accidents and ensuring safety in the workplace.
    - Yes
    - No
13. We participate in safety training that is tailored to the specific needs of our plant, which aligns with our job responsibilities and meets all relevant legal and occupational safety and health (OSH) requirements.
    - Yes
    - No

Safety Culture Knowledge

Directions: Please thinking about your current job, how often does each of the following statements describe how you feel?

1 = STRONGLY DISAGREE;

2 = DISAGREE ;

3 = NETURAL;

4 = AGREE ;

5 = STRONGLY AGREE

Safety Culture Knowledge

Sr. No.	**Descriptions**	**1**	**2**	**3**	**4**	**5**
14.	I understand a general awareness of the hazards represented by the accessories of the power plant.					
15.	I understand the documentation of power plants such as piping diagrams, loop diagrams, cause and effect diagrams, and power supplies applicable to the isolation of the plant.					
16.	I already know the procedures for issuing Permit-To-Work and for identifying what isolations are required.					
17.	I understand how to check what isolations are in place and which are the correct isolations required					
18.	We know that the words “SAFETY FIRST” have a significant meaning for all sector safety.					
19.	I understand that the equipment which we operate is consistently maintained in safe working condition is important					
20.	I truly understand that the regular safety-related communications are effective with other parties involved in the work for working safely					

Safety Attitudes of the Respondents

Sr. No.	Descriptions	1	2	3	4	5
21.	Safety is always important even when we get busy.					
22.	If I didn't follow the safety instructions and also don't know the documentation of the power plant, that action may affect others' safety.					
23.	Safety procedures and permit-to-work guide us on what to do and how to follow regarding safety matters.					
24.	If we don't know how to test and confirm the correct installation of isolations, that not work out all the jobs/tasks in the area that have safety risks.					
25.	Safety is the priority. Positive safety culture makes us aware of safety issues and greater ability to initiate effective safety policies.					
26.	Good working knowledge of isolation and risk assessment procedures for the plant is to maintain a best practice that cannot fall into safety problems.					
27.	All employees take pride in doing their jobs professionally and safely.					

Safety Practice/Performance

Sr. No.	Descriptions	1	2	3	4	5
28.	If I see someone working in unsafe conditions or manners, I will remind them to work safely.					
29.	I feel that I am making important contributions to my work in my organization.					
30.	I feel fortunate that I can be a part of my organization. So I am motivated and look forward to going to work.					
31.	I take responsibility for my safety and that of other workers around me.					
32.	I feel that strong safety culture gives us to maintain a best practices that cannot fall into safety problems.					
33.	The safety management system is to improve the safety culture and safety performance of the organization through the planning, control, and supervision of safety-related activities.					
34.	Safety culture is "the way we do things around here," and reflects how we collectively value safety.					