MODE TO PREDICT THE DAILY ACTUAL GROSS HEATING VALUE OF LIQUID NATURAL GAS THAT PT. BEKASI POWER RECEIVE FROM TWO SUPPLIERS BY USING FORECASTING METHOD

By

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ACADEMIC ADVISOR
RECOMMENDATION LETTER

This internship report is created and submitted by **Muhammad Rifqi Shadiqin** in partial for fulfillment the requirement for the degree of bachelor degree in the faculty of engineering has been reviewed and found to have satisfied requirement for a report to be examined.

Cikarang, Indonesia, 17 September 2015.

Ir. Hery Hamdi Azwir, MT.

COMPANY'S SUPERVISOR RECOMMENDATION LETTER

This internship report is created and submitted by **Muhammad Rifqi Shadiqin** in partial for fulfillment the requirement for the degree of bachelor degree in the faculty of engineering. Therefore I recommend this report to be examined.

Cikarang, Indonesia, 14 August 2015.

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INTERNSHIP REPORT IN PT. BEKASI POWER

(POWER PLANT), CIKARANG, INDONESIA

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ABSTRACT

PT. Bekasi Power is a gas and steam power plant. In this company kind of gas that used to produce power is liquid natural gas from 2 suppliers, they are Perusahaan Gas Negara (PGN) and PT. Bayu Buana Gemilang (BBG) subsidiary of PT. Pertamina. The system of gas supply is through underground pipes way. Talking about the efficiency, in this power plant there are several parameters. One of parameter must be controlled to keep the efficiency of company is GHV of liquid natural gas. GHV doesn't have relation with the heat to heater something, but GHV is the *capability of LNG to give high temperature* after the LNG done on heating process in the gas turbine. Heat that resulted from complete heating can be different, it's depend on the gas pressure (BTU) that liquid natural gas have /mm^3. Company was given the parameter of gas that used to produce electricity, the parameter of gas is >1000 BTU/SCF. It is caused with those GHV, the residue of gas from gas turbine process can reach temperature more than 515.0^{0}C, and it can be exploited to heat water in the steam turbine. So company will maximize of gas use from supplier who gave the LNG with gas pressure >1000 BTU/SCF, or which one have the GHV bigger one between PGN and BBG that will be checked daily. The information of the gas pressure (BTU/SCF) that received from two suppliers can be known from the data that supplier give to the company via e-mail or fax. PGN can give data of actual GHV information daily to the company, but BBG only can give or send the data weekly, where the data is needed daily. By do the forecasting, the actual GHV from BBG can be predict for the next seven period with the right method. In the conclusion the forecasting by using double moving average (DMA) method with moving average (MA) 5 must be used to predict the actual gross heating value from BBG daily cause have smallest standard error.

Key Words; Gross heating value (BTU/SCF), combined cycle, aggregate planning, and double exponential smoothing and forecasting.

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LNG	Is come from the liquid natural gas. Liquid natural gas it self as the raw material to produce electricity through gas turbine machine.
Gas	Gas is the liquid natural gas that already has pressure. The pressure of liquid natural gas is from the compressor process.
GHV	GHV or gross heating value is the capability of liquid natural gas to produce residue of gas from heating process with high temperature. Its mean the residue of gas will have high temperature after gas is heated.
BTU	BTU is international unit for the gross heating value of the liquid natural gas.
SCF	SCF is the unit of liquid natural gas volume in international unit mm^3.
Residue Gas	It is the gas remain from gas turbine process.
HRSG	Heat Recovery Steam Generator is the tool for the residue of gas way from gas turbine to the steam turbine where the residue of gas is for heating process in the steam turbine. And also the HRSG for the water without mineral ways to the steam turbine.
Power	Power is the total electricity that can be produce by company. And usually in term of MW, kW, or W.
MW, kW, and W	W is the international unit for the power in electricity, that come from Watt. Then MW is mega watt its mean the total

	of power is multiply by ten thousands and kW multiply the total power in watt with a thousand.
Gas Gate Valve	It is like the door of gas to come into the production process in power plant. If the gas is opened small the gas flow to the production process will small too and opposite.

CHAPTER I
INTRODUCTION

1. 1. Background

PT. Bekasi Power is a private company where the business is focus on the power plant industry that can produce electricity or power until 130 MW established on 2007. PT. Bekasi Power is one of power plant that use gas and steam to produce electricity (Gas and Steam Power) or in Bahasa is called PLTGU. The system in this company is using combined cycle with close cycle. The system to produce electricity basically first is heat the gas, then heat water by exploit the heat from the residue of gas heating process. Gas that company use is liquid natural gas (LNG) that supplied from two companies they are PGN (Perusahaan Gas Negara) from station gas at Rawamanju, and BBG (Bayu Buana Gemilang) one of subordinate of PT. Pertamina. And the other raw material that needed by company to produce the electricity is water. Water that company used is supplied from Jababeka Water Treatment. With standard international tools that company have and big number of gas supply, company enactive Uninterruptible Power Supply (UPS) with competitive price that will help to support national energy and growth industry sector.

Power that PT. Bekasi Power produce is output from two gas turbines with power output is 40 MW/turbine and one steam turbine with power output 50 MW. This combine cycle that company use can increase the efficiency of plant. But the efficiency is not constant value, sometimes can be increase or can be decrease. The calculation of efficiency is from material that used (gas) divided by energy that company can be produced. To keep the efficiency is stabile, company give parameter for the some units, such as parameter for gas, parameter of heat that needed, etc.

In order to get the efficiency, one of the parameter should be controlled is gross heating value. Gross heating value (GHV) is about capability gas to give high temperature of gas as the residue of heating process in the gas turbine. Caused the system in the company is combine cycle, those gas from the residue of heating process in the gas turbine, will be exploited for water heat process in the steam turbine. By exploit the heat of gas, company can increase the value of efficiency. The company was determined the parameter of gas that will be used in this gas and steam power plant is the gas with value of BTU/SCF >1000. With gas that has pressure more or equal 1000 BTU/SCF, the temperature from residue of gas from heating process in the gas turbine can be around 515.0^0 C. Gas with this temperature can be exploited to heat the water in the steam turbine.

System transport of LNG from supplier to the company is through underground pipes way. And each of them (BBG and PGN) has own gate valve or in bahasa usually is called meteran. The gate function is to open or close the way of gas, if it closed so the gas will be unused or stop, if the gate is opened the gas will be run and the bill of gas automatically is run and counted by supplier. Gas that supplier sent to the company is not gas with constant gross heating value, so the gas pressure that company receive from supplier can be >1000 BTU/SCF or < 1000 BTU/SCF. This situation will decrease efficiency value that company get, cause if the GHV is <1000 BTU/SCF, amount of gas for heating process in the gas turbine is increasing and it will be effect to the cost of gas used/SCF. Company know the actual GHV value from the report that supplier give daily as the guidance for open-close gas gate valve. But the *problem here* is only PGN that can send the report about actual GHV daily, and BBG only can give the report weekly in term average value during a week. So the open-close gas gate valve system is based on the PGN actual GHV data, and it is a gambling, when the actual GHV from PGN is more than 1000 BTU/SCF, the gate of PGN will be opened maximally and BBG will be minimally, and opposite.

1. 2. Problem Statement

The problem statement in this research is;
How to know and predict the actual Gross Heating Value of liquid natural gas from BBG daily and know the average of actual GHV for the next seven period?

1. 3. Objectives of the Research

The objective of this research is to get a prediction of actual gross heating value daily and know the average of actual gross heating value for the next seven period from PT. Bayu Buana Gemilang, that can be used as the guidance for the open-close gas gate valve system in PT. Bekasi Power, and not only use one report as the guidance again that like a gambling.

1. 4. Scope of Research

The scope in this research are, the data that needed for this research is taken only from PT. Bekasi Power where the data is from PGN and BBG. Then all of the data that needed is focused on the actual value of gross heating value from three months before that supplier give to the company in term report. The report of actual GHV value that will be forecast is only from one supplier that able give the report to company weekly it is PT. Bayu Buana Gemilang (BBG). The actual gross heating value for next seven period will be collected as the guidance to proof the research.

1. 5. Assumption

The assumption that use in this research in order to cover the project, which are;

- Actual Gross Heating Value in the data analysis is assume as the Demand
- The daily actual GHV from BBG will be same each day in a week, appropriate with the average GHV that supplier give.
- The unit of 1 m^3 of gas is assume as the SFC

1. 6. Research Outline

Chapter I Introduction

This chapter consists of the background in the case found, problem statement as the issue needs to be solved, objective to be meet in the research as the goal of the research, scope as the limitation, assumption is the information of all the thing that assumed, and research outline as the systematic way of writing.

Chapter II Literature Study

This chapter delivers the previous study about the basic principle all thing that related with this research that coming from books, journals, thesis, and expertise works use as reference that support the researcher.

Chapter III Research Methodology

The flow and step of how to finish this research and project is explained.

Chapter IV Company Profile

In this chapter will introduce the company profile where the problem in the research is got, that consist of introduction, company history, advantage of company, power plant description, and organization structure, in order to explain the business in the company.

Chapter V Data Collection and Calculation

In this chapter explain how the data observation is processed, what kind of data that needed and calculation will be reported to be analysis in order to get the objective of this research.

Chapter VI Conclusion and Recommendation

This chapter will give the conclusion result of the research, and also recommendation for the solving the problem in this research. The conclusion must aim to the how to solve the problem statement to get the objectives.

CHAPTER II
LITERATURE STUDY

2. 1. Power Plant

Power plant is company that producing electricity from several natural resources. Those natural resources such as wind, water, steam, gas, coal, etc. will be changed to be an electricity force. In process to produce electricity, there are several machines that needed to support the process like machine turbine, generator, etc. the supporting tool is depend on type of machines and the raw material that used. For example in the gas power plant, the machines that use are gas turbine, generator, and then supporting tool is compressor, etc.

2. 2. Steam and Gas Power Plant

Steam and Gas Power plant is a power plant that producing electricity from gas and steam. In this power plant usually is consist of two kind of machine turbine, gas turbine and steam turbine, condenser, compressor, generator or het recovery steam generator, feed water pump, gas turbine generator, switchyard, switchgear, voltage regulator, and transmission. In the steam and gas power plant usually is called combined cycle power plant. Combined cycle power plant is consist of two kind of system which are, open combined cycle system and close combined cycle system. But to increasing the value of efficiency close cycle system is prefer.

2. 3. Turbine

2.3. 1. Definition Turbine

The turbine is a rotating machine that takes energy from fluid flow. Simple turbines have one moving part, "rotor-blade assembly". Fluid moving makes rotating propellers and generate energy to drive the rotor. Examples of early turbines were windmills and water wheels. A turbine that works in reverse so-called turbo compressors or pumps.

Gas turbines, steam and water usually has a "casing" around the blades that focuses and controls the fluid. "Casing" and propeller may have a variable geometry that can make an efficient operation for some fluid flow conditions. Energy is obtained in the form of power "shaft" spin.

2.3. 2. Function of Turbines

The most common use of the turbine is in produce electricity process. Almost all electricity produced using turbines of certain types. Sometimes turbine is part of a larger engine. A gas turbine, for example, can point to the internal combustion engine which contains a turbine, compressor, "combustor", and alternator.
Turbines can have a power density ("power density") outstanding (compared with the volume and weight). This is due to their ability to operate at very high speeds. The main engines of the Space Shuttle using turbo pumps (machines consisting of a pump which is driven by a turbine engine) to provide propellant (oxygen liquid and liquid hydrogen) into the engine combustion chamber. Liquid hydrogen turbo pump is slightly larger than a car engine and producing 70,000 hp (52.2 MW). Turbine is also a major component of a jet engine.

2. 4. Steam Turbine & Gas Turbine

2.4.1. Steam Turbine

Definition

The steam turbine is a first mover that converts potential energy into kinetic energy and then steam kinetic energy is converted into mechanical energy in the form of shaft rotation. Turbine shaft connected to the driven, ie generator or other machine tools, using a gear transmission mechanism. Based on these definitions, the steam turbine including a rotary machine is a machine back and forth (reciprocating) .Engine drive where water vapor, water, gas or air that rotate the shaft by pushing blade which angled like a fan. There are two pairs of blades, STATOR (no air movement) and ROTOR (rotating). Rotating turbine shaft can be connected to the generator power plant. Turbine including a machine that produces large

The steam turbine is used to drive an electric generator at Station plant and ship propeller. Water turbines and a steam turbine-like gas turbine used (mostly) as activator aircraft as a jet engine, and also sometimes as a driver of the machines in the industry.

Differences in Steam Turbine Machine with Steam

a. The Steam Engine

The energy conversion in steam engines are based on the vapor pressure. This vapor pressure pushing the piston in the cylinder, so that the resulting forces on the piston. By this stylish drive shaft forwarded to the head of the cross and by the rectilinear motion of the piston rod is converted into a rotating motion. So the energy conversion of potential energy into mechanical energy in steam engines through several tools, which are tools that do not require maintenance easy. As an example of the lining / shoe divider steam valve and cross head, every time must be change so as not to give rise to an extension that is not jammed / cause too much wear and tear on moving parts too. Relative velocity is zero moves at a constant pressure.

b. The Steam Turbine

Steam turbine blades in power conversion in top speed of steam. At first steam pipe in expansion into the transmitter, ie by changing the high vapor pressure steam into a very fast pace. With the speed of steam is used to drive the blade. As a result, the steam turbine will spin and rotation is forwarded to the turbine shaft. In the steam turbine does not require much equipment, but requires only a few simple parts. The relative speed of the blade is used to push, working with dynamic energy.

Advantages Steam Turbine If Compared with Steam Engines

There are several advantages of steam turbine compared by steam engine, as follows:

- Equipment in the turbine is not much variety / simpler
- The resulting motion is quieter because only the rotary motion only.
- Swivel motion directly, without intermediaries
- The torque generated at the larger portion.
- There is no frictional losses in the rotation.

- Compared premises machine horizontal steam, then steam turbines do not require a foundation that is so great.
- The same size steam turbine with the steam engine, the Steam turbine obtain greater power.
- Arise due to many rotary motion only, the vibration caused smaller than the steam engine.

Disadvantages When Compared With Steam Turbine Steam Engines

- Expansion steam needed for special equipment that is pipeline transmitter.
- Pipe transmitter requires meticulous planning
- Because steam is in use to push the blade, blade when the only road open pieces is necessitating the turbine housing is very tight and strong, so that no steam leaks arise while the steam engine of the above does not require a very important concern.

2.4.2. Gas Turbine

Gas turbine is a gas turbine with a working fluid gas is derived from the combustion of liquid fuels are flammable. System simplest gas turbine consists of three main components, namely the compressor, combustor and turbine, which is compiled into a compact system. The gas turbine engine is characterized by its relatively low capital cost compared with steam power plants. It has environmental advantages and short construction lead time. However, conventional industrial engines have lower efficiencies especially at part load. One of the technologies adopted nowadays for improvement is the combined cycle. Hence, it is expected that the combined cycle continues to gain acceptance throughout the world as a reliable, flexible and efficient base load power generation. Combined-cycle systems utilizing the

Brayton Cycle gas turbine and the Rankine Cycle steam system with air and water as working fluids achieve efficient, reliable, and economic power generation. Flexibility provided by these systems satisfies both utility-power generation and industrial-cogeneration applications.

Current commercially available power- generation combined-cycle plants achieve net plant thermal efficiency typically in the 50–55% LHV range. Further development of gas turbine, high-temperature materials and hot gas path, metal surface cooling technology show promise for near-term future power generation combined-cycle systems capable of reaching 60% or greater plant thermal efficiency. Additional gas turbine technological development, as well as increases in steam-cycle pressure and temperature and steam-turbine stage-design enhancement, is expected to achieve further STAG™ combined-cycle efficiency improvement.

Current General Electric STAG (trade name designation for the GE product line of combined- cycle systems) product line offerings, combined-cycle experience, and advanced system development are used to demonstrate the evolution of combined-cycle system technology.

The use of a gas turbine system in a wide range of power, among others:

a. With a large power turbine
    1. As the power station (power plant)
    2. To move the aircraft
    3. As a marine power plant. To move large ships.
    4. As the locomotive driving the gas turbine system
b. While the small power system widely used gas turbines as small transportation among others buses, trucks, auto car, small plane, boat motors. Three fundamental processes that occur in a gas turbine to produce energy that is:
    1. The process of compressing the air
    2. Process air + fuel combustion.
    3. Process development or expansion of combustion gases.
    4. The principal component of the gas turbine system

In accordance with the working process there are 2 basic components in a gas turbine system, namely:

1. *Compressors (K)*

The compressor is a device used to suck the air and for subsequently compressed or compressed to increase the pressure. There are some compressors that we know:

- Piston compressors, namely piston compressors that use as a tool to compress air in the cylinder.
- Centrifugal compressors, ie compressors that use a propeller (fan, the blades) as a means to increase the pressure. Instead of a cylinder piston compressor is in the form of houses or worms.

There are two kinds of centrifugal compressors

- Radial flow centrifugal compressors
- Axial flow centrifugal compressors.

2. *The Combustion Chamber (RP)*

To obtain the energy required for combustion gas turbine fuel with the air which has been compressed by compressor. The fuel that has been compressed so that the resulting energy is burned rapidly heat energy is expansion in the heating pipe and directly to rotate the turbine blades. Rotor rotation of the turbine then the resulting mechanical energy that can play a compressor. Compressor to suck and compress air into the combustion chamber.

There are three types of the combustion chamber in use, namely:

a. Tubular (Can) combustor
b. Annular combustor
c. Can annual combustor

Expansion the hot of gas from the combustion engine. Due to the heat in the form of particles - particles of gas, turbine blades ranging driven by gas pressure fluid. Sudu belonging to the turbine rotor drive shaft with the radial direction. If the pressure generated from the combustion chamber is constant, the rotation of the turbine will occur continuously at a high rate of speed. Please note that the compressor turbine shaft with one connection. After pass through the blades of the turbine exhaust gases exit through the high pressure so thrust will be appear. The higher the vapor pressure then thrust resulted is greater. Usually needs a big thrust force used on the machines Turbo aircraft. Missal rocket propulsion which uses a turbojet as a driving force.

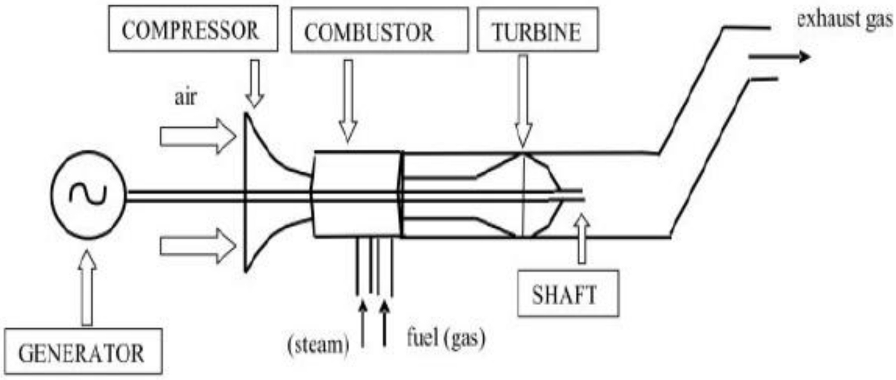


Figure 2.1 Gas Turbine

2. 5. Open Cycle and Combined Cycle Power Plant System

Open-cycle gas turbines (OCGT) for electricity generation were introduced decades ago for peak-load service. Simple OCGT plants consist basically of an air compressor and a gas turbine aligned on a single shaft connected to an electricity generator. Filtered air is compressed by the compressor and used to fire natural gas in the combustion chamber of the gas-turbine that drives both the compressor and the electricity generator. Almost two-thirds of the gross power output of the gas-turbine is needed to compress air, and the remaining one-third drives the electricity generator. OCGT plants have relatively low electrical efficiency ranging between 35% and 42% (lower heating value, LHV).

Aero-derivative gas-turbines provide efficiency of 41–42%, but their size is limited to 40–50 MW. Since the early 1990s, combined-cycle gas turbines (CCGT, Fig. 1) have become the technology of choice for new gas-fired power plants (IEA, 2008). CCGT plants consist of compressor/gas-turbine groups – the same as the OCGT plants – but the hot gas-turbine exhaust is not discharged into the atmosphere. Instead it is re-used in a heat recovery steam generator (HRSG) to generate steam that drives a steam-turbine generator and produces additional power. Gas-turbine exhausts then leave the HRSG at about 90°C and are discharged into the atmosphere. CCGT plants commonly consist of one gas turbine and one steam turbine. Approximately two-thirds of the total power is generated by the gas turbine and one-third by the steam turbine. Large CCGT power plants may have more than one gas turbine. State-of-the-art CCGTs have electric efficiency of between 52% and 60% (lower heating value, LHV) at full load. Figure 2 shows the efficiency of CCGT plants compared with pulverised coal (PC) power plants as a function of the maximum cycle temperature.

Current supercritical coal-fired power plants (left hand) may reach a full-load efficiency of 45–46% (2010) while (right hand) the current full-load efficiency of CCGT power plants is close to 60%. Technological developments aim to increase the CCGT efficiency by raising the gas-turbine inlet temperature and simultaneously decreasing investment cost and emissions. Figure 2 shows the efficiency as a function of the gas turbine inlet temperature. According to Ishikawa et al. a CCGT plant with a 1700°C class gas-turbine may attain an electrical efficiency of 62–65% (LHV). Thus, the CCGT efficiency is expected to increase from today's 52%–60% to a maximum of 64% by 2020. OCGT efficiency is also expected to rise from its current 35%–42% (LHV) to 45% by 2020.

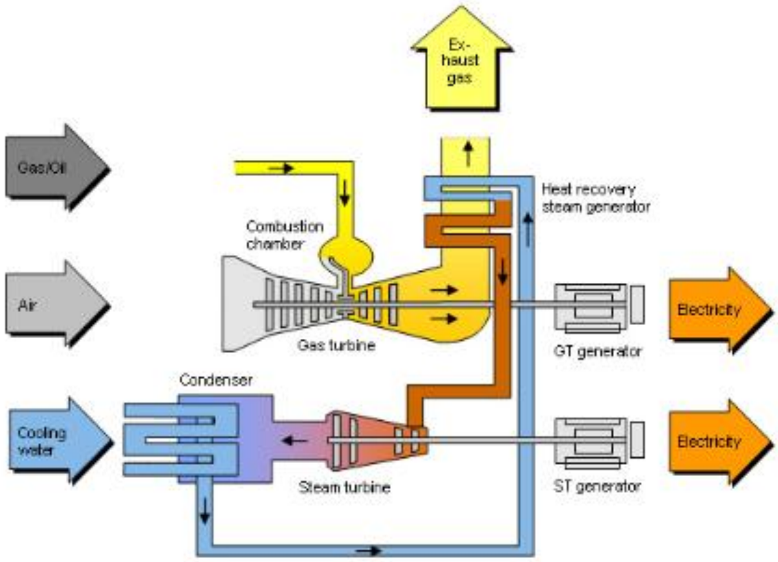


Figure 2.2 Combined Cycle System

Power plants can be defined by functional type (e.g. base load, peak load, or combined cycle). Each has advantages and disadvantages. Base load power plants have the lowest operating cost and generate power most in any given year. There are several different types of base load power plants. The resources available typically determine the type of base load plant used to generate power. Coal and nuclear power plants are the primary types of base load power plants used in the Mid-West United States.

There are four types of base load power plants:

1. High efficient combined cycle plants fueled by natural gas.
2. Nuclear Power Plants.
3. Conventional steam power plants fueled primarily by coal.
4. Hydropower plants.

Peak load power plants are simple cycle gas turbines that have the highest operating cost but are the cheapest to build. They are operated infrequently and are used to meet peak electricity demands in period of high use and are primarily fueled with natural gas or oil. The high efficient combined cycle power plant will be the focus of this project. Gas turbines have increased in capacity over the last 25 to 45 years. Gas Turbines with rated outputs of 40 to over 350 MW that have increased specific power has led to the parallel development of highly efficient economical combined cycle power generation systems. Each combine cycle (CCGT) power-generating system consists of a gas turbine, Heat Recovery Steam Generators (HRSGs), generators, controls, and a steam turbine. Combined cycle systems typically are an optimized system of high technology power generating equipment, software, and services that are integrated into the utilities ancillary equipment to create an economical and stable power generating facility. Combined cycle systems encompass a large range of capabilities for both 50 and 60 Hz operation. Combined cycle systems are versatile allowing for many different configurations to satisfy the requirements of individual applications.

There are two major categories of combined cycle systems:

1. Oil or natural gas fired systems for power generation.

2. Combined cycle cogeneration systems and coal or oil fired integrated gasification combined cycle (IGGG) power generation systems.

There are many configurations for combined cycle systems. A significant portion of the systems contain an electrically controlled diverter damper, seal air fans, position indicators, and some type of control systems that integrates these components. It is the intent of this project to describe one such system that the author helped design, install, verify, and commission. The duration of the project, located in the Mid Atlantic region of the United States, was over 24 months in duration. The construction phase was in two parts. The first phase consisted of installation of three 100 MW rated turbines, ancillary equipment and commissioning of simple cycle operation while the HRSGs were being completed. This was completed in a relatively short period of approximately twelve months. The commissioning of the combined cycle systems is happening as this paper is being prepared (May 2002).

2. 6. Heat Recovery Steam Generator (HRSG)

HRSG or Heat Recovery Generator is a basic tool of gas and steam power plant that have function to exploit the rest of gas from gas turbine process that still have kalor or heat value with the big number to produce steam with high pressure especially superheated steam. Kalor that moved from rest of gas turbine process move by convection to the water in the pipe, and the rest of gas will be move to the HRSG equipment and heat it, start from superheater, then to the evaporator, economizer, and preheater, and the last flow will be leave through chimney or exhaust.

2.6.1. Part of HRSG are:

1. PREHEATER

Preheater is a heat exchanger that as a preheater for the condensate water from condensation in the condenser before it is ready to be the fillers water in deaerator. Preheater is used to improve the efficiency of the HRSG itself. Preheater is at the end or top of the HRSG to absorb the lowest energy of the exhaust gas.

With this operation, the preheater deaerasi process water in the deaerator filler will require less LP Auxiliary Steam, so that energy can be used in a steam turbine.

2. ECONOMISER

Economiser a preheater for water filler HRSG (feed water), in which the filler water will flow from the deaerator to the steam drum. At this Economiser processes that occur are sensible heating, which raises the water temperature without changing phase. In the economiser pipes maintained in order to avoid evaporation (reached the point of moisture) or in the language of plants is maintained to prevent steaming. In the Gas Turbine burdens low it can cause to happen steaming, so the need for Economiser Recirculating to keep in order to avoid evaporation.

3. EVAPORATOR

Evaporator or boiler bank is a heat exchanger where it will produce saturated steam (saturated) from the feed water. At Vertical HRSG with forced circulation which use the circulating pump, which still form the liquid phase and the phase of saturated steam.

4. SUPERHEATER

Superheater is a heat exchanger on the HRSG heat generating further steam (superheated steam). Superheater can consist of one or a heat exchanger, as in PLTGU Grati superheater there are 2 phases of its primary and secondary superheater. In the superheater typically comes equipped with a temperature control which keeps the temperature of steam coming from the superheater so as not to exceed the high temperature limit, the system is called a desuperheater. This desuperheater function keeping the temperature out of HRSG into the turbine (HP turbine) in order not to exceed the set temperature turbine materials.

5. EXHAUST DAMPER (DIVERTER DAMPER)

Exhaust damper is steering the flow of hot exhaust gas from the gas turbine. When the Open Cycle (Simple Cycle), the flue gas will be wasted through the bypass stack while the hot gas system Combine Cycle will be directed by the exhaust damper into the HRSG by closing the path towards the by-pass stack.

The heat energy contained in the exhaust gas (exhaust) gas turbines where the temperature is still quite high (about 500 OC) flowed into the HRSG to heat water in the heating pipes, then exit to the chimney with a temperature of about 150 OC. The water in the pipes coming from the heating drum gets heating from the hot gas, most of which will turn into steam and the others are still in the form of water. The mixture of water and steam is then entered back into the drum.

Steam which has been separated from the water is then used to drive a steam turbine, while water vapor does not become re-circulated into the heating pipes together with a new filler water. Similarly, this process takes place continuously for the unit to operate.

In principle, the HRSG and boiler are the same, which is a device used to convert water into steam with the aid of hot gas. Which is fundamental in this difference is the heat source used to generate steam.

The main heat source is used to generate steam coming from the heat energy contained in the gas turbine exhaust gas that flowed into the HRSG to heat the heating pipes.

Sangkan on Boiler, heat source is used to generate steam from the combustion of fuel in the combustion chamber, can be either solid fuels (coal), liquid (oil) or gas. So the HRSG no combustion system (combustion chamber)

The HRSG can be found in the power generation Power Plant Gas and Steam (PLTGU). HRSG will inservice if PLTGU in operation mode Combine Cycle. So between Open Mode Combine Cycle and Cycle will be controlled by the Exhaust Damper (Diverter Damper). As the Combine Cycle Power Plant for the first permisive start to be exceeded or fulfilled first. Although not as much on the process of Combine Cycle Power Plant in PLTGU of Block Start (from zero) until the Sync 3-3-1 or 2-2-1 (depending on its system Combine) take a long time as well. Approximately 10 hours to complete the process at the time of the HRSG and ST him in a state of Cold. To determine the parameters of Cold, Warm or Hot is both HRSG and ST different parameters.

Gas turbines with heat-recovery – steam generators (HRSGs) can be found in virtually every chemical process industries (CPI) plant. They can be operated in either the cogeneration mode or the combined-cycle mode (Figure 1). In the cogeneration mode, steam produced from the HRSG is mainly used for process applications, whereas in the combined-cycle mode, power is generated via a steam turbine generator. Gas turbines have several advantages as a power source: they can be started up quickly; they come in packaged modules, with power outputs ranging from 3 MW to 100 MW, that can be easily assembled and erected; they have high efficiencies of 25% to 35% (on a lower heating value [LHV] basis); and they require little or no cooling water. Recent developments include large-capacity units of up to 250 MW, with low emission characteristics (less than 10 ppmv NOx), as well as high combustor operating temperatures (in the range of 2,200°F), which results in efficiencies higher than 35%; the exhaust gas temperature is also higher, which helps to generate high-pressure/high-temperature superheated steam, making the Rankine cycle efficient. The HRSG forms a major part of the steam system. In the combined-cycle mode, the efficiency of the combined gasturbine-plus-HRSG system can reach 55-60% (LHV basis) with today's advanced machines, while in the cogeneration mode, system efficiency can be as high as 75-85%.

The HRSG generates steam utilizing the energy in the exhaust from the gas turbine. However, some plants also have the capability of producing steam when the gas turbine is shutdown. This is done using a separate forced-draft fan along with a burner to generate hot gases, which are then used to generate steam. An isolating damper system (also called a bypass damper) with seal air fans is required in these units to ensure that hot gases do not leak to the fan when the gas turbine is running and that maintenance can be performed on the gas turbine when the fresh air fan is operating. Bypass dampers are also used in some units to ensure that the gas flow to the HRSG can be modulated in order to match steam generation with steam demand. However, if fresh air firing is not used, an isolating damper is not required. Recent trends in HRSG design include multiple-pressure units for maximum energy recovery, the use of high temperature super heaters or re-heaters in combined cycle plants, and auxiliary firing for efficient steam generation. In addition, furnace firing is often employed in small capacity units when the exhaust gas is raised to temperatures of 2,400-3,000°F to maximize steam generation and thus improve fuel utilization. This article highlights some of the basic facts about gas turbine HRSGs. This information can help plant engineers, consultants, and those planning cogeneration projects make important decisions about the system and performance related aspects.

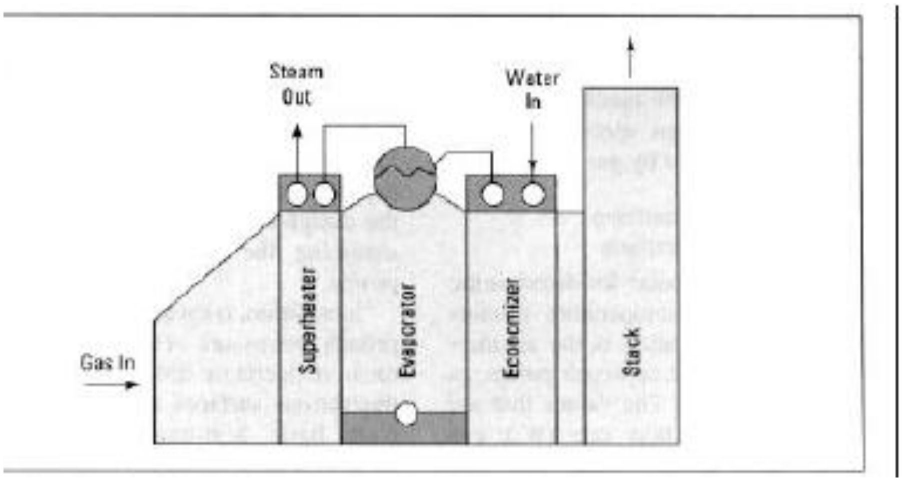


Figure 2.3 HRSG

2.6.2. Module of HRSG

The Heat Recovery Steam Generator (HRSG) is a key component in the most efficient large scale power generation technology available today - the combined cycle plant. Safely maintaining optimum plant efficiency requires close attention by the operating staff for proper coordination of gas turbine and HRSG operation. **EtaPRO**'s **HRSG Performance Module** provides operators and engineers with a profile of actual and expected performance, including HRSG efficiency, expected steam generation and outlet temperatures, and heat transfer section effectiveness. Overall HRSG efficiency and heat transfer effectiveness calculations are based upon ASME PTC 4.4, *Gas Turbine Heat Recovery Steam Generators*. Efficiency is also determined by an energy balance of the HRSG. When compared to the Loss Method efficiency, the input/output efficiency is useful for evaluating steam and fuel flow measurement accuracy. Expected steam generation and outlet temperatures are determined from design data and changes in gas turbine exhaust flow, temperature, and moisture content. Performance comparisons may be made at standard conditions or at current operating conditions. This module is applicable to fired or unfired heat recovery steam generators.

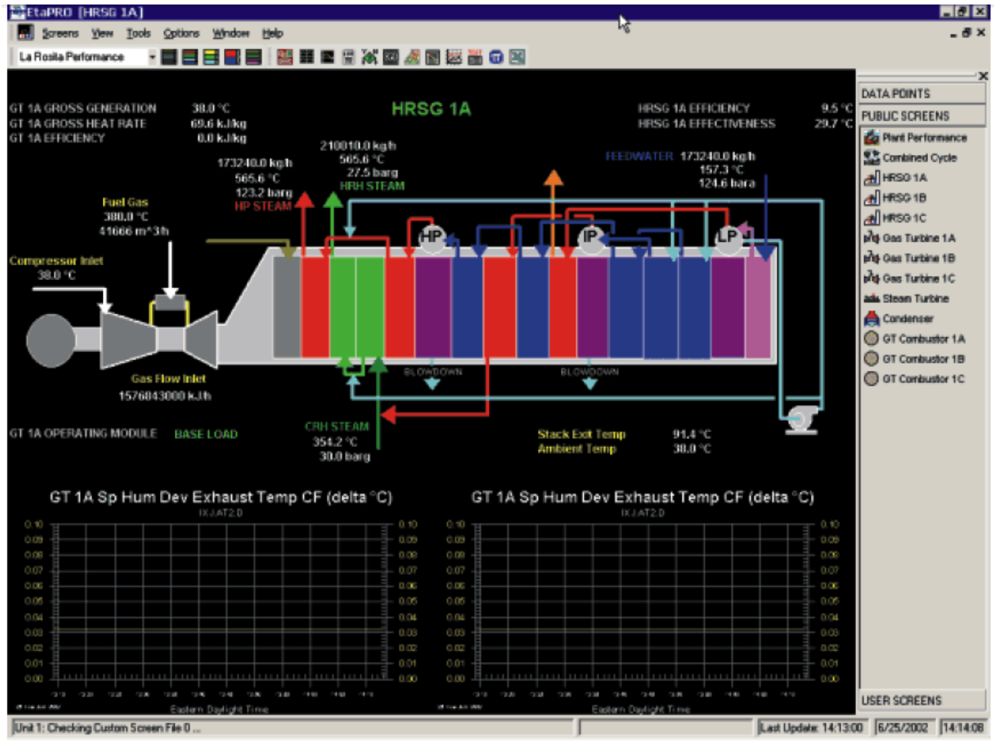


Figure 2.4 Software That Used for Control HRSG

2.6.3. Condenser

Definition Condenser

The condenser is one type of engine heat exchanger (heat exchanger) that serves to condense the working fluid. In the steam power system, the main function of the condenser is to restore the exhaust steam from the turbine to the melting phase to be pumped back to the boiler and reused. In addition, the condenser also serves to create a low back pressure (vacuum) in the exhaust turbine. With a low back pressure, the efficiency of the turbine cycle and employment will increase.

2. 7. Forecasting and Aggregate Planning

Aggregate planning is a method of planning the production of the right amount of a product, at the right time, at the lowest cost, using available equipment and workers. **(Cambridge Dictionary)**

1. Types of aggregate planning
   a. Level Aggregate Plans:
      - Maintains a constant workforce
      - Sets capacity to accommodate average demand

- Often used for make-to-stock products like appliances
- Disadvantage- builds inventory and/or uses back orders

b. Chase Aggregate Plans

- Produces exactly what is needed each period
- Sets labor/equipment capacity to satisfy period demands
- Disadvantage- constantly changing short term capacity

2. Aggregate Planning Options

a. Demand-based options

- Reactive: uses finished goods inventories and backorders for fluctuations.
- Proactive: shifts the demand patterns to minimize fluctuations e.g. early bird dinner prices at a restaurant.

b. Capacity-based options

- Changes output capacity to meet demand
- Uses overtime, under time, subcontracting, hiring, firing, and part-timers – cost and operational implications

3. Regular time cost is the cost of producing a unit on a regular time.

$$\textbf{Regular time cost} = \textbf{Regular time output x Cost per unit}$$

$$a = \frac{\sum_{t=1}^{n} A_t - b\sum_{t=1}^{n} t}{n}$$

$$b = \frac{n\sum_{t=1}^{n} tA_t - \sum_{t=1}^{n} A_t \sum_{t=1}^{n} t}{n\sum_{t=1}^{n} t^2 - (\sum_{t=1}^{n} t)^2}$$

Figure 2.5 Formula of Aggregate Planning Method

Forecasting Method

a. Last Period Demand
    - Type the data of demand
    - Divide last period demand into two which are forecast demand and absolute demand
    - Calculate the data of forecast demand by using Microsoft excel
    - Calculate the data of absolute demand by using Microsoft excel
    - Calculate MAD
b. Arithmetic average
    - Type the data of demand
    - Divide arithmetic average into two which are forecast demand and absolute demand
    - Calculate the data of forecast demand by using Microsoft excel
    - Calculate the data of absolute demand by using Microsoft excel
    - Calculate MAD
c. Single Moving Average
    - Type the data of demand
    - Divide Moving average into two which are forecast demand and absolute demand
    - Calculate the data of forecast demand by using Microsoft excel and its n 2 and 3
    - Calculate the data of absolute deviation by using Microsoft excel
    - Calculate MAD
d. Weighted Moving Average
    - Type the data of demand
    - Choose the number of forecast demand WMA with 2 and 3
    - Calculate the forecast demand March for WMA 2 and April for WMA 3
e. Double moving average
    - Type the data of demand

- Determine the forecast demand from January 2013 until December 2014
- Calculate the St’, St’’, a_t, b_t, and forecast demand by using Microsoft excel

f. Single exponential smoothing
- Type the data of demand
- Determine the forecasts demand from January 2013 until December 2014
- Calculate the forecast demand by using α : 0.1 and 0.5

g. Double exponential smoothing browns
- Type the data of demand
- Determine the forecasts demand from January 2013 until December 2014
- Calculate the St’ (with α : 0.1 and 0.5), St”, at , bt, and forecast demand by using Microsoft excel

h. Double exponential smoothing holt
- Type the data of demand
- Determine the forecasts demand from January 2013 until December 2014
- Calculate the St’ (with α and y : 0.1 and 0.2), St”, at , bt, and forecast demand($F_{t+m} = a_t + b_t(m)$) by using Microsoft excel

i. Simple linear regression
- Type the data of demand
- Find and calculate t.dt and t^2 by using Microsoft excel
- Find the forecast demand from January 2013 until December 2014.

Error evaluation

a. MAD
- Type the demand and forecast demand
- Calculate the absolute demand
- Divide the absolute demand by n

b. MSE
    - Type the demand and forecast demand
    - Calculate the absolute square demand
    - Divide the absolute square demand by n
c. MAPE
    - Type the demand and forecast demand
    - Calculate the absolute per demand
    - Divide the absolute per demand by n

Validation

a. Verification
    - Type the forecast demand and actual demand for each method
    - Calculate MRT for each method by using Microsoft excel
    - Calculate MR for each method by using Microsoft excel
    - Calculate the UCL and LCL
b. Tracking signal Brown
    - Type the forecast demand and actual demand
    - Find and calculate $d_t - d_t'$, Cumulative RSFE, absolute error, cumulative absolute error, MAD or MAE and tracking signal for each method
c. Tracking signal Tigg
    - Type the forecast demand and actual demand for each method
    - Find and calculate dt – dt' , absolute error, cumulative absolute error, MAD or MAE and tracking signal for each method.

Forecasting is the prediction, projection, or estimation of the occurrences of uncertain future events or levels of activity.

Advantages of forecasting:

In Make to Stock Industry (MTS), forecasting is used as the basic to decide:

- Acquisition of plant and equipment
- Manpower planning
- Purchasing of materials

- Scheduling of production

1. Characteristics of good forecasting:
   - Accuracy :

     The main objective of forecasting is to predict accurately. The forecasting which is too weak will cause the lack of stock out, back orders, lost sales, lost profits, and lost customers. In the other side, the forecasting which is to strong will make mounting inventories and cash shortages.
   - Cost
   - Response :

     It has to show a stable forecasting; where a change happens the forecasting should be able to show the changes sooner.
   - Simplicity :

     Forecasts have to be easy to make, understand and use.
2. Forecasting Methods can be classified into two major groups :
   1. Qualitative methods rely on human judgment and experiences. These techniques are primarily based upon judgment and intuition and especially when sufficient information and data is not available so that complex quantitative techniques cannot be used.
   2. Quantitative methods are formal procedures that employ mathematical models and past data to project the future. A statistical technique for making projections about the future which uses numerical facts and prior experience to predict upcoming events. The two main types of quantitative forecasting used by business analysts are the explanatory method that attempts to correlate two or more variables and the time series method that uses past trends to make forecasts.

Qualitative Vs Quantitative;

Qualitative forecasting techniques are subjective, based on the opinion and judgment of consumers, experts; they are appropriate when past data are not available. They are usually applied to intermediate- or long-range decisions. Examples of qualitative forecasting methods are informed opinion and judgment, the Delphi method, market research, and historical life-cycle analogy.

Quantitative forecasting models are used to forecast future data as a function of past data; they are appropriate when past data are available. These methods are usually applied to short- or intermediate-range decisions. Examples of quantitative forecasting methods are last period demand, simple and weighted N-Period moving averages, simple exponential smoothing, and multiplicative seasonal indexes.

Formula of Quantitative methods:

- Simple Linear Regression :

$$b = \frac{n\sum_{t=1}^{n} h_t.d_t - \sum_{t=1}^{n} h_t \sum_{t=1}^{n} d_t}{n\sum_{t=1}^{n} {h_t}^2 - \left(\sum_{t=1}^{n} h_t\right)^2}$$

$$a = \frac{\sum_{t=1}^{n} d_t}{n} - b\frac{\sum_{t=1}^{n} h_t}{n}$$

$$d_t' = a + b.h_t$$

Where,

d_t : The number of fixtures sold in month t

h_t : The number permits issued in month t-1

- Last Period Demand (LPD)

  The Last Period Demand (LPD) technique simply forecasts for the next period the actual demand that occurred in the previous period.

$$d_t' = d_{t-1}$$

Where,

d_t' : Forecast demand for period t

d_{t-1}: Actual demand in the previous period (period t-1)

- Arithmetic Average (Average Method)

  The arithmetic average simply takes the average of all past demand in arriving at a forecast.

$$d_t' = \frac{d_1 + d_2 + \cdots + d_n}{n} = \frac{\sum_{t=1}^{n} d_t}{n}$$

Where,

d_t' : forecasted demand for period t

dt : actual demand in period t

n : number of time periods

Single Moving Average

The moving average technique generates the next period's forecast by averaging the actual demand for the last N time periods.

$$d_t' = \frac{d_{t-1}+d_{t-2}+\cdots+d_{t-n}}{N} = \frac{\sum_{i=1}^{N} d_{t-i}}{N}$$

Where,

d_t' : Forecasted demand for period t

d_{t-1}: Actual demand in period t-i

N : Number of time periods included in moving Average

Weighted Moving Average (WMA) is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles. The threshold between short-term and long-term depends on the application, and the parameters of the moving average will be set accordingly. For example, it is often used in technical analysis of financial data, like stock prices, returns or trading volumes. It is also used in economics to examine gross domestic product, employment or other macroeconomic time series. Mathematically, a moving average is a type of convolution and so it can be viewed as an example of a low-pass filter used in signal processing. When used with non-time series data, a moving average filters higher frequency components without any specific connection to time, although typically some kind of ordering is implied.

$$WMA(N) = d_t' = \frac{C_{t-1}d_{t-1}+C_{t-2}d_{t-2}+\cdots+C_{t-N}d_{t-N}}{\sum C} = \frac{\sum_{i=1}^{N} C_{t-i}d_{t-i}}{\sum C}$$

C : Weight of Period

Double Moving Average. A technical indicator which consists of a single exponential moving average and a double exponential moving average. Developed by Patrick Mulloy, the double exponential moving average is more responsive to market changes than the simple moving average.

$$a_t = S_t' + (S_t' - S_t'') = 2S_t' - S_t''$$
$$b_t = \frac{2}{(N-1)}.(S_t' - S_t'')$$
$$F_{t+m} = a_t + b_t.m$$

Exponential Smoothing is Statistical technique for detecting significant changes in data by ignoring the fluctuations irrelevant to the purpose at hand. In exponential smoothing (as opposed to in moving averages smoothing) older data is given progressively-less relative weight (importance) whereas newer data is given progressively-greater weight. Also called averaging, it is employed in making short-term forecasts. The 'wait-and-see' attitude to changes around them is the intuitive way people employ exponential smoothing in their daily living. Exponential smoothing divided into two kinds; Single Exponential Smoothing and double exponential smoothing.

- Single Exponential Smoothing (SES)

$$d_t' = \alpha.d_{t-1} + (1-\alpha).d_{t-1}'$$

Where,

α : coefficient smoothing : $0<\alpha<1$

Relationship between α and N :

$$\alpha = \frac{2}{N-1}$$

Double Exponential smoothing is divided into two method, browns and holt.

1. Double Exponential Smoothing (DES)-Method Browns

$$First\ Smoothing : S_t' = \alpha d_t + (1-\alpha)S_{t-1}'$$
$$Second\ Smoothing : S_t'' = \alpha S_t' + (1-\alpha)S_{t-1}''$$
$$a_t = 2S_t' - S_t''$$
$$b_t = \frac{\alpha}{1-\alpha}(S_t' - S_t'')$$

$$F_{t+m} = a_t + b_t.m$$

2. Double Exponential Smoothing (DES) is a technique that can be applied to time series data, either to produce smoothed data for presentation, or to make forecasts. The time series data themselves are a sequence of observations. The observed phenomenon may be an essentially random process, or it may be an orderly, but noisy, process. Whereas in the simple moving average the past observations are weighted equally, exponential smoothing assigns exponentially decreasing weights over time. This Double Exponential Method Holt;

$$S_t = \alpha d_t + (1-\alpha)(S_{t-1} + b_{t-1})$$

$$b_t = \gamma(S_t - S_{t-1}) + (1-\gamma)b_{t-1}$$

$$F_{t+m} = S_t + b_t m$$

Mean Square Error (MSE). An estimator is one of many ways to quantify the difference between values implied by an estimator and the true values of the quantity being estimated. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. MSE measures the average of the squares of the "errors." The error is the amount by which the value implied by the estimator differs from the quantity to be estimated. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate.

$$MSE = \frac{\sum_{t=1}^{n}(d_t - d_t')^2}{n}$$

Where,

d_t : Actual demand on t period

d_t’: Forecasting demand on t period

n : Total Period

Standard Error of Estimate (SEE). Is the standard deviation of the sampling distribution of a statistic. The term may also be used to refer to an estimate of that standard deviation, derived from a particular sample used to compute the estimate. For example, the sample mean is the usual estimator of a population mean. However, different samples drawn from that same population would in general have different values of the sample mean. The **standard error of the mean** (i.e., of using the sample mean as a method of estimating the population mean) is the standard deviation of those sample means over all possible samples (of a given size) drawn from the population. Secondly, the standard error of the mean can refer to an estimate of that standard deviation, computed from the sample of data being analyzed at the time.

$$SEE = \sqrt{\frac{\sum_{t=1}^{n}(d_t - d_t')^2}{n-f}}$$

Where,

d_t : Actual demand on t period

d_t': Forecasting demand on t period

n : Total Period

f : Degree of freedom

Mean Absolute Percentage Error (MAPE). Also known as **mean absolute percentage deviation** (**MAPD**), is a measure of accuracy of a method for constructing fitted time series values in statistics, specifically in trend estimation. It usually expresses accuracy as a percentage, and is defined by the formula:

$$PE_t = \left(\frac{d_t - d_t{'}}{d_t}\right) x100\%$$

$$MAPE = \frac{\sum_{t=1}^{n}|PE_t|}{n}$$

Where,

PE :Error Percentage

d_t : Actual demand on t period

d_t': Forecasting demand on t period

n : Total Period

Mean Error (ME).

$$ME = \frac{\sum_{t=1}^{n}(d_t - d_t')}{n}$$

Mean Absolut Error (MAE)/ Mean Absolut Deviation (MAD). Is a quantity used to measure how close forecasts or predictions are to the eventual outcomes. The mean absolute error is a common measure of forecast error in time series analysis, where the terms "mean absolute deviation" is sometimes used in confusion with the more standard definition of mean absolute deviation. The same confusion exists more generally.

$$MAE = \frac{\sum_{t=1}^{n}|d_t - d_t'|}{n}$$

- Verification Testing

$$M\bar{R} = \frac{\sum_{t=2}^{n} MR_t}{n-1}$$

$$MR_t = |(d_t' - d_t) - (d'_{t-1} - d_{t-1})|$$

$$UCL = +2.66\,\overline{MR}$$

$$LCL = -2.66\overline{MR}$$

- Tracking Signal Testing-Brown

  The limitation value of tracking signal – Brown is ±4 until ±6

$$Tracking\ Signal = \frac{RSFE}{MAD} = \frac{\sum_{t=1}^{n}(d_t - d_t')}{\frac{\sum_{t=1}^{n}|d_t - d_t'|}{n}}$$

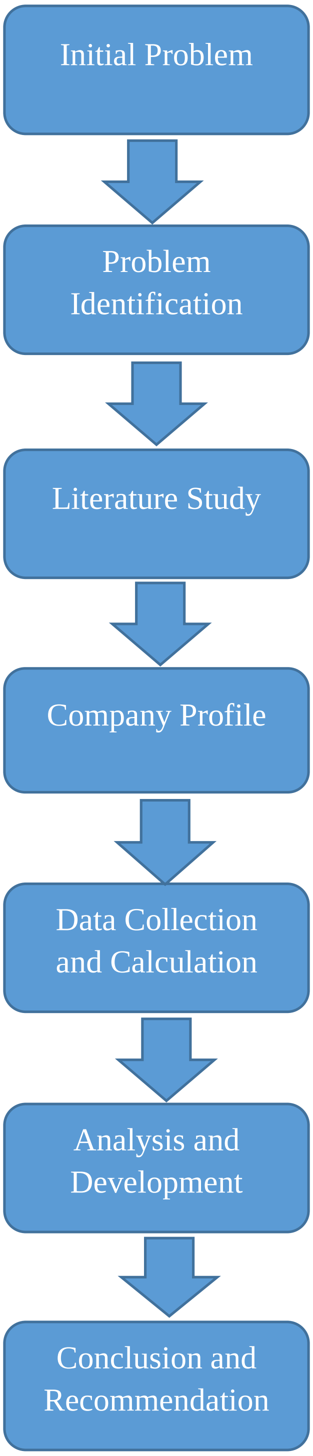
Tracking Signal-Trigg : In statistics and management science, a **tracking signal** monitors any forecasts that have been made in comparison with actuals, and warns when there are unexpected departures of the outcomes from the forecasts. Forecasts can relates to sales, inventory, or anything pertaining to an organization's future demand. One form of tracking signal is the ratio of the cumulative sum of forecast errors (the deviations between the estimated forecasts and the actual values) to the mean absolute deviation.

$$Tracking\ Signal = \frac{(d_t - d_t')}{\frac{\sum_{t=1}^{n}|d_t - d_t'|}{n}}$$

CHAPTER III

RESEARCH METHODOLOGY

The project method can be described through following figure.



Initial Observation

- Knowing how the processing of plant, factors that influence the quality and efficiency, observation of supply chain, parameter of plant, and gas gate valve system.

Problem Identification

- Determine the problem statement
- Define the objectives
- And determine the scope

Literature study

- Power Plant especially gas and steam force
- Process in Power Plant
- GHV
- Forecasting

Company Profile

- Introduce the company profile, how the business, and the structure organization of the company.

Data Collection and Calculation

- Phase I : Data observation and gathering.
- Phase II : Data tabulation and calculation.

Analysis and Development

- Analyze and develop the actual GHV value by using three method and choose the best one based on forecasting with best standard error.

3. 1. Initial Observation

The initial observation is conducted of collect the data and information about what factors that influence the efficiency in the plant, and which system in the plant that still have or can make loss in order to keep the efficiency

3. 2. Problem Identification

The problems that are occurred should be marked and then identified. Understanding the main problem and finding what method should be used are also become the problems that have to be solved. The system gate valve of gas in the plant that still using approximation based on the one daily GHV report can make the number percentage of loss is big.

3. 3. Literature Study

Literature study must be conducted prior to the stage of data collection and calculation, and also stage of analyze and develop data. Literature study will be helpful to determine what kind of data should be gathered, calculate the data, and what method should be used.

3. 4. Company Profile

In this chapter the company profile as the guidance to know the initial problem resources. This chapter also will be introduce how the business run, how the production system, what product that will be produce and what kind of machine in the company. Then at last the organization structure in the company will be presented.

3. 5. Data Collection and Calculation

There are two phases in this data collection and calculation stage; data gathering and observation, data tabulation and calculation. In this step the method that will be used for the data calculation using three method, which are; aggregate planning, double moving average with MA is equal 5, and double moving average with MA is equal 7.

3. 6. Analysis and Development

After having data collection and calculation, the crucial criteria that have to be fixed should be determined. The criteria that are found should be analyzed and fixed.

Finally, development of those criteria should be conducted to the company. By conducting the development, the new strategy is appear to reducing percentage of loss that can be occur.

3. 7. Conclusion and Recommendation

Conclusion will affirm whether the result of analysis and development stage achieve the objectives or not. After concluding, recommendation for future research should be provided.

CHAPTER IV
COMPANY PROFILE

4.1. Introduction

PT. Bekasi Power is a private company where the business is focus on the power plant industry that can produce electricity or power until 130 MW. This company is one of the subordinate PT. Jababeka, Tbk. Established in 2007. Caused the prediction of power demand in this modern era will be increasing, so this company is established to fulfill the power demand in industry area. But while process of the business PT. Bekasi Power have a corporation with PT. PLN, where the PLN buy the power that Bekasi Power produce then distribute it for power demand in sector Bali-Java since 2011. The business is Bekasi Power will supply power 118.8 MW to PLN and the other power is about 20 kV to the other customer which is not in the PLN Business sector.

PT. Bekasi Power is one of power plant that use gas and steam to produce electricity (Gas and Steam Power) or in Bahasa is called PLTGU. The system in this company is using combined cycle or close cycle. The system to produce electricity basically first is heat the gas, then heat water by exploit the heat from the residue of heat gas process. Gas that company use is liquid natural gas (LNG) that supplied from two companies they are PGN (Perusahaan Gas Negara) from station gas at Rawamanju, and BBG (Bayu Buana Gemilang) one of subordinate of PT. Pertamina. And the other raw material that needed by company to produce the electricity is water. Water that company used is supplied from Jababeka Water Treatment. With standard international tools that company have and big number of gas supply, company enactive Uninterruptible Power Supply (UPS) with competitive price that will help to support national energy and growth industry sector.

PT. BEKASI POWER

Figure 4.1 PT. Bekasi Power

Jl.Tekno 8, Kawasan Industri Gerbang Teknologi Cikarang Kota Jababeka, Cirakang, Bekasi

Tel:(021) 89842698, **Fax: (**021) 89842699, csbp@jababeka.com

4.2. Company History

In order to improve the power demand in industrial sector and the other area, PT. Jababeka, Tbk starting to build a Power Plant with power 130 MW, that operation by subordinate of company it is PT. Bekasi Power. Jababeka was predict the demand of power in the future is still increasing and growth.

Bekasi Power Plant consists of two frame 6B gas turbine high level, which is produced by General Electric Energy with a capacity of 40-42 MW per turbine installed according to ISO ratings. In addition, there are two Heat Recovery Steam Generator (HRSG) of Thermax Babcock and Wilcox Limited. Combined-cycle steam turbine equipped with Shin Nippon with a capacity of 46-50 MW, which is driven by high-pressure steam temperature of the two HRSGs burned by using the exhaust gas from the gas turbine. Total installed capacity totaling 130 MW powered and later plans to double the capacity for 2 x 130 MW power in the coming years.

A Joint Operation Agreement between PLN and Bekasi Bekasi Power Power enables to not only increase the electrical energy and infrastructure Kota Jababeka by providing special services to customers from around the industry, but also directly supports the mission PLN to strengthen the electricity system, especially in the industrial area of Bekasi and Karawang ,

With international standard equipment and excess gas supply, Bekasi Power ensures an Uninterruptible Power Supply (UPS) at competitive prices which will help support the national power grid Indonesia and growth of the industry for many years to come.

4.3. Advantage of PLTGU 130 MW for Bekasi Power

The results of this feasibility study shows that the proposed PLTGU will provide substantial financial for PT Bekasi Power. The following is a benefit for the project sponsor:

- With PLTGU operation, the power needs of the industry in the area of Phase III will be fulfilled.
- Through PLTGU operations, the company will generate revenue that is useful for the operation.

4.4. Advantage for Jababeka Industrial Sector

The advantages of this project for the Jababeka Industrial Estate is as follows:

a. Develop a power plant will provide much needed support to advance the Phase III area, due to the availability of reliable and sufficient electricity will motivate the development of new industries.
b. Construction of the power plant will optimize the use of public facilities.

4.5. Advantage for Regional Economy

Projects and local economic relations as well as the surrounding community is quite large in the development of this project. Development of a large facility will open lab dream job: many new opposition in the companies will need workers from the surrounding area. The operation of plant will increase the new working field. Local products can increase productivity and directly improve regional gross product.

4.6. Power Plant Description

4.6.1. Power Plant Location

Power plant Location as well as the total area of which is still not utilized is determined by the following things:

- The location provided having an area of approximately 5,720 hectares
- Location can be patch up to 2 blocks PLTGU with a capacity of 130 MW for each unit
- All the infrastructure required by PLTGU will build at this location

The choice of location is determined by considering the following factors:

- The distance to the center of the load
- Availability of cooling water
- Total development costs low

4.6.2. Project Design

In order to achieve a low investment cost, specification of electrical and mechanical equipment must meet certain criteria. The equipment is particularly reliable and economical flow, with a modern design for ease of operation, and can reduce pollution to a minimalize tool mechanism.

Gas turbines used is the type of GE turbine heavyweight PG6581B with a capacity of approximately 42.100MW. The gas turbine is designed using a tendon cooler with the following conditions:

- Tendon Air Temperature To the turbine : 15˚C
- Humidity atmosphere in : 60%
- Turbine gas GE PG6581B : 42.100 MW (net)
- Net Heat rate : 2,679 kcal/kWh (net)
- Efficiency : 32.1%
- Gas heating Value : 1,000 BTU/SCF

- Fuel Consume : 21.5 MMSCFD for 2 Gas Turbine

Gas with high temperature that comes out from the gas turbine will be heading to the HRSG to generate steam. HRSG used a type of dual pressure: high and low pressure. Technical data of the HRSG, are:

4.6.3. HRSG without adding combustion;

- Temperature goes to *flue gas* HRSG : 589.31˚C
- Temperature of *flue gas access* : 158.0 ˚C
- Steam Pressure : 52.0 kg/cm^2
- Steam Temperature : 515.0 ˚C
- Amount of Steam : 149.0 t/h (2 HRSG)

4.6.4. Steam Turbine

The steam turbine has a small capacity, and therefore can be used single-shaft, single cylinder, without additional heating, and turbine type of condenser. Technical data from steam turbine are:

- Power/ Capacity : 47500KW
- Steam Pressure : 49.92 K/cm^2
- Temperature Steam : 500 ˚C
- Total Steam : 149 t/h

<u>Combined Cycle</u>

- (Gross Power) : 130.7 MW
- NPO (Net Power Output) : 123.381 MW
- NHR (Neat Heat Rate) : 1726kcal/kWH
- Calorie : 1000BTU/SCF
- Gas Consume : 21.5 MMSCFD

<u>Condenser</u>

- Steam Pressure : 0.09 bar
- Steam Temperature : 43.41 ˚C

- Total Steam : 149 t/h

4.6.5. Equipment of Electrical

There are several electrical equipment CCPP (*Combined Cycle Power Plant)* with capacity 130 MW as seen below;

1. *Generator*

   This generator has a capacity of 2 x 41.6MW

   (55 MVA), 11.5 kV with two cylindrical rotor poles, moved at a speed of 3000 rpm with a frequency of 50 Hz, with the cooling water.

2. *Generator Transformer*

   Generator transformers are Delat connections () or (Y), ith high voltage (HV) with solid earthed neutral.

3. *Protection*

   Protective equipment provided to protective generators and other equipment from damage and incorrect operation of these tools.

4. *Measurement*

   Measuring equipment consists of:

   - MWh / KWh meter
   - Ampere meter
   - Volt meter
   - Cost meter
   - Frequency meter

5. *Instrumentation*

   Equipment is provided for process control instrumentation power plant using mikrolomputer of the building or room control.

4.6.6. Gas, Water & Fuel Supplier

For do the production process PT. Bekasi Power need several raw material to produce power until 130 MW. Those material are liquid natural gas, water, and fuel that supplied from;

Liquid Natural Gas : - Perusahaan Gas Negara

- PT. Bayu Buana Gemilang

(Subordinate of PT. Pertamina)

Liquid natural gas is transferred through underground pipe way.

Water : - PT. Jababeka Water Treatment

The water that PT. Jababeka Water Treatment send through underground pipe way.

Fuel : - PT. Pertamina, Tbk

Fuel that company received is through truck transfer way.

4.7. Organization Structure

Organization in PT. Bekasi Power is shown below;

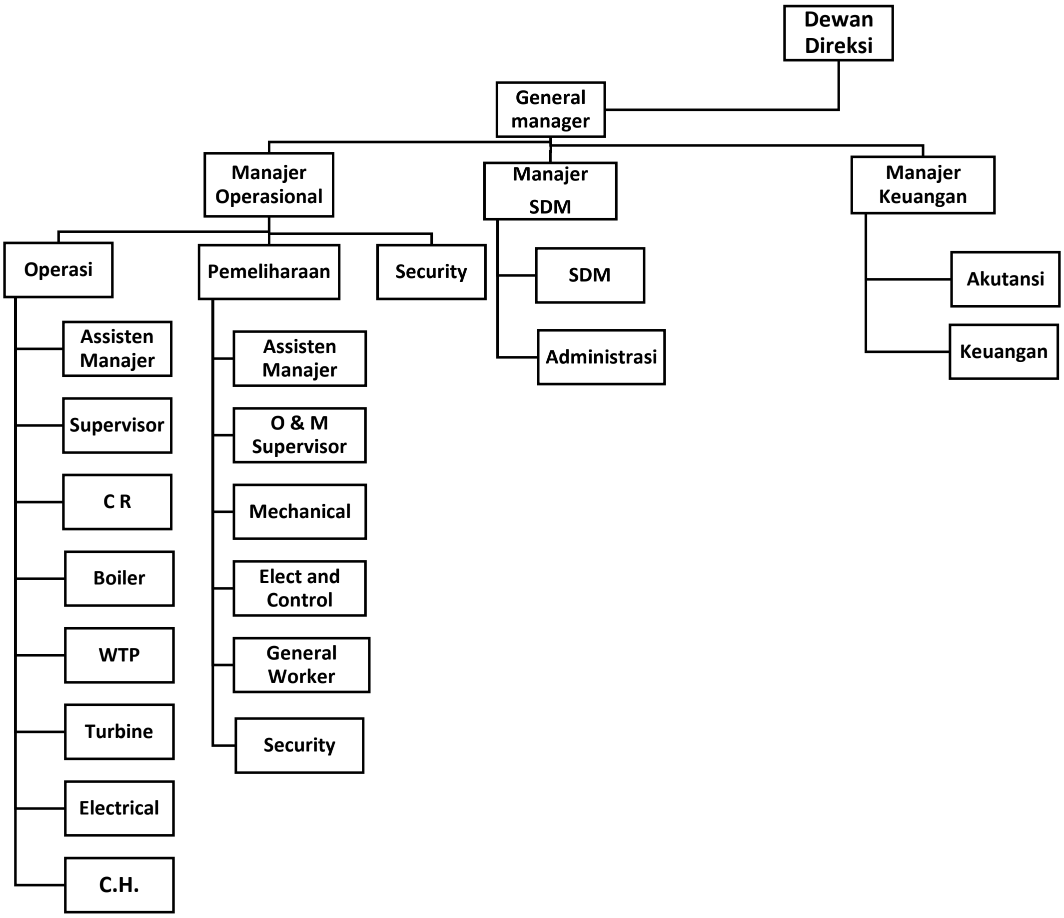


Figure 4.2 Organization Structure in PT. Bekasi Power

4.7.1. Organization Description

Each department in PT. Bekasi Power has different responsibility to support the production process and their business. Each function of department are;

- *Main function of General Manager:* Responsible for the overall system of power generation in terms of administrative and technical Manager Operational
- *Main Function of Operational Manager:* Technically responsible for the smooth running of the plant operation and is responsible to the General Manager.

- *Main Function of SDM Manager:* Responsible for personnel and administration.
- *Main function of financial manager:* Responsible for all matters related to financial in the plant or company.
- *Main function of Assistant Manager of operational*: Fully responsible for the smooth operation of existing power plants.
- *Main function of assistant manager of maintenance:* Fully responsible for the smooth running of the maintenance of power plants.
- *Main function of head of safety environment:* Directly responsible to the Operations manager in terms of security and safety throughout the plant area.

CHAPTER V

DATA COLLECTION & CALLCULATION

5.1. Data Collection

In this chapter all of data that needed to solve the research is collected. Those data that needed are;

5.1.1. Gas Line

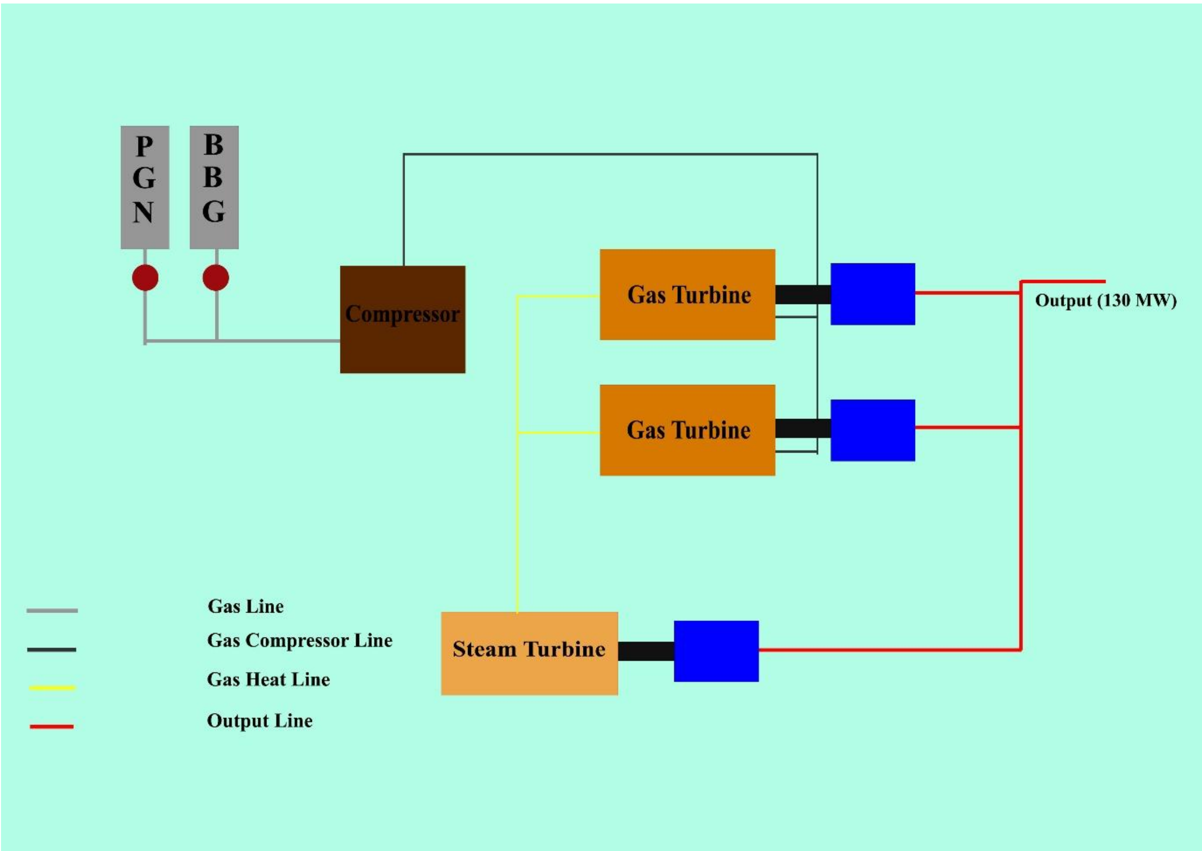


Figure 5.1 Gas Line in PT. Bekasi Power

Figure 5.1 above shown the data about gas gate valve system and gas flow in PT.Bekasi Power. Since this company starting their operation on 2007 until now, the (open-close) gas gate valve system is based on the gas that have big pressure will be used maximally in term of BTU/SCF. And the gas with small gas pressure will be used minimum. Where the gas is from two supplier which are Perusahaan Gas Negara and PT. Bayu Buana Gemilang.

Gas flow is starting from the gate valve, goes to compressor. In the compressor liquid natural gas will be processed to make the gas have the pressure. Liquid natural gas with good GHV, or with GHV ≥ 1000 BTU/SCF, can produce the residue of gas heating with temperature more than 589.31^0 C. Liquid natural gas from Compressor goes to Gas turbine 1 and gas turbine 2. At the end residue of gas heating from both gas turbine will goes to steam turbine through HRSG.

Since 2007 the gate valve system is depend on the gas pressure report that Perusahaan Gas Negara send to PT. Bekasi Power daily. This report as the guidance for the gate valve system, because PT. Bayu Buana Gemilang only can send the report weekly, and it will be received by PT. Bekasi Power at the end of week.

The system is like if in certain period as example during 8 April – 14 April. In the 9^{th} April the gas pressure in liquid natural gas from PGN is around 1008 BTU/SCF, the gas gate valve will be opened minimal. And the gate valve of liquid natural gas from BBG is not opened maximal but the gate valve will be opened more than gate valve of PGN. It because PT. Bekasi Power is not get the gas pressure report yet in this period. The BBG will give the report in 14 April. So there is a hit-or-miss with this system. Why? Because when the company do the system like that and the real gas pressure from BBG is less than 1008 BTU/SCF so the company will lose.

5.1.2. LNG Contract during Period September 2014 – August 2015

Table 5.1 LNG Contract for a Year

LNG Agreement with Supplier	PGN (SCF)/day	BBG (SCF)/day
Minimum Contract	250.145,00	250.145,00
Maximum Contract	300.174,00	300.174,00
Maximum Gas Additional	360.000,00	360.000,00
Maximum Gas Excess	396.000,00	396.000,00

Those data is explain about the contract of gas use for the production electricity process. The contract will be different in each period, it is depend on the agreement with supplier and the other power plant in the RAE big meeting in each year, before the producing process in a year is done.

5.1.3. Actual Gross Heating Value during Period April-June

Data below shown the actual gross heating value from PT. Bayu Buana Gemilang and Perusahaan Gas Negara that already received and used for the production during 28 April – 22 June by PT. Bekasi Power. And those data will be collected as the data that needed to solve the problem in this research.

a. PT. Bayu Buana Gemilang

1. 28 April – 04 May 2015 1034.85 BTU/SCF

PT PERTAMINA GAS
WESTERN JAVA AREA

JL. RAYA INDUSTRI CIKARANG TEGALGEDE - BEKASI 17550
TELEPON : (021) 89833861 FAX : (021) 89833904

PERTAMINA GAS

B-006/PG1313/2013-S0/F-001

HASIL ANALISA GAS
&
PERHITUNGAN SPECIFIC GRAVITY DAN NILAI KALOR

PENGAMBILAN SAMPLE

File : 017 / LAB.SKG.T-TGD / IV / 2015 — No. Sampel : 017
Tanggal / Jam : **27-04-2015** / 06:00 WIB
Lokasi : SKG. TEGALGEDE
Pemakai : PT. BAYU BUANA GEMILANG (LINE - II)
Pressure Sample : 303.15 PSIG
Temperature Sample : 87.35 °F
Periode : 28 APRIL 2015 s.d 04 MEI 2015

KOMPONEN ----(1)----	SUMMATION FACTOR b_i ----(2)----	SPECIFIC GRAVITY GAS IDEAL G_i^{id} ----(3)----	NILAI KALOR KOTOR GAS IDEAL H_{vi}^{id} ----(4)----	KOMPOSISI (FRAKSI) X_i ----(5)----	KOMPRESIBILITAS (FRAKSI) $X_i b_i$ --(6)=(2)x(5)--	SPECIFIC GRAVITY (FRAKSI) $X_i G_i^{id}$ --(7)=(3)x(5)--	NILAI KALOR (FRAKSI) $X_i H_i^{id}$ --(8)=(4)x(5)--
N_2	0.00442	0.96720	0.0000	0.0428	0.00019	0.0414	0.0000
CO_2	0.01950	1.51950	0.0000	0.0677	0.00132	0.1029	0.0000
C_1H_4	0.01160	0.55390	1,010.0000	0.7996	0.00928	0.4429	807.5960
C_2H_6	0.02380	1.03820	1,769.7000	0.0382	0.00091	0.0397	67.6025
C_3H_8	0.03470	1.52250	2,516.1000	0.0311	0.00108	0.0473	78.2507
n-C_4H_{10}	0.04700	2.00680	3,262.3000	0.0073	0.00034	0.0146	23.8148
i-C_4H_{10}	0.04410	2.00680	3,251.9000	0.0061	0.00027	0.0122	19.8366
n-C_5H_{12}	0.06060	2.49110	4,008.7000	0.0016	0.00010	0.0040	6.4139
i-C_5H_{12}	0.05760	2.49110	4,000.9000	0.0024	0.00014	0.0060	9.6022
C_6H_{14}+	0.08637	3.21755	5,129.2200	0.0032	0.00028	0.0103	16.4135
TOTAL				1.0000	0.01390	0.7213	1,029.5302

1. Faktor Kompresibilitas Gas Campuran, Zb $= 1-(\Sigma X_i b_i)^2 Pb$ 0.9972
2. Specific Gravity Nyata Gas Campuran, G $= (\Sigma X_i G_i^{id})(Za/Zb)(Pb/Pa)$ 0.7248
3. Gross HV Gas Campuran, BTU/SCF $= (\Sigma X_i H_i^{id})(Pb/14.696)/zb$ 1,034.8559
4. Pb = 14.73 PSIA (Perjanjian)

REFERENSI :
GPA Standard 2261-00
Analysis for Natural Gas and Similar Gaseous Mixtures by Chromatograph.
GPA Standard 2172-09
Calculation of Gross Heating Value, Relative Density, Compressibility and Theoritical Hydrocarbon Liquid Content for Natural Gas Mixtures for Custody Transfer.

Tegalgede, April 28, 2015

Disetujui Oleh :
Head of Operation Control
(Marcel Wijaya)

Disiapkan Oleh :
Analyst Laboratory
(Jatu Wanda Irnawaty)

Figure 5.2 Example Average of Actual GHV Report from BBG for a Week

2. 05 May - 11 May 2015 1041.48 BTU/ SCF

LAPORAN HASIL PENGUJIAN

PENGAMBILAN SAMPLE

No.	: 018 / LAB.SKG.T-TGD / V / 2015	No. Sampel	: 018
Tgl / jam ambil contoh	: **04-05-2015** / 06:00 WIB	Diterima dari	: Petugas BBG
Lokasi contoh	: SKG. TEGALGEDE		
Pemakai	: **PT. BAYU BUANA GEMILANG (LINE - II)**		
Tekanan contoh	: 254.17 PSIG		
Temperatur contoh	: 91.64 °F		
Periode	: 05 MEI 2015 s.d 11 MEI 2015		

No.	PARAMETER UJI ----(1)----	SUMMATION FACTOR b_i ----(2)----	SPECIFIC GRAVITY GAS IDEAL G_i^{id} ----(3)----	NILAI KALOR KOTOR GAS IDEAL H_{vi}^{id} ----(4)----	KOMPOSISI (FRAKSI) X_i ----(5)----	KOMPRESSIBILITAS (FRAKSI) $X_i b_i$ --(6)=(2)x(5)--	SPECIFIC GRAVITY (FRAKSI) $X_i G_i^{id}$ --(7)=(3)x(5)--	NILAI KALOR (FRAKSI) $X_i H_i^{id}$ --(8)=(4)x(5)--
1.	N_2	0.00442	0.96720	0.0000	0.0401	0.00018	0.0388	0.0000
2.	CO_2	0.01950	1.51950	0.0000	0.0723	0.00141	0.1099	0.0000
3.	C_1H_4	0.01160	0.55390	1,010.0000	0.7984	0.00926	0.4422	806.3840
4.	C_2H_6	0.02380	1.03820	1,769.7000	0.0397	0.00094	0.0412	70.2571
5.	C_3H_8	0.03470	1.52250	2,516.1000	0.0295	0.00102	0.0449	74.2249
6.	n-C_4H_{10}	0.04700	2.00680	3,262.3000	0.0067	0.00031	0.0134	21.8574
7.	i-C_4H_{10}	0.04410	2.00680	3,251.9000	0.0056	0.00025	0.0112	18.2106
8.	n-C_5H_{12}	0.06060	2.49110	4,008.7000	0.0016	0.00010	0.0040	6.4139
9.	i-C_5H_{12}	0.05760	2.49110	4,000.9000	0.0022	0.00013	0.0055	8.8020
10.	C_6H_{14}+	0.08637	3.21755	5,129.2200	0.0039	0.00034	0.0125	20.0040
TOTAL					1.0000	0.01394	0.7237	1,026.1539

1 Faktor Kompresibilitas Gas Campuran, Zb $= 1-(\Sigma X_i b_i)^2 Pb$ 0.9971

2. Specific Gravity Nyata Gas Campuran, G $= (\Sigma X_i G_i^{id})(Za/Zb)(Pb/Pa)$ 0.7272

3. Gross HV Gas Campuran, BTU/SCF $= (\Sigma X_i H_i^{id})(Pb/14.696)/zb$ 1,031.4803

4. Pb = 14.73 PSIA (Perjanjian)

3. 12 May - 18 May 2015 1017.31 BTU/SCF

LAPORAN HASIL PENGUJIAN

PENGAMBILAN SAMPLE

No. : 019 / LAB.SKG.T-TGD / V / 2015 No. Sampel : 019

Tgl / jam ambil contoh : **11-05-2015** / 06:00 WIB Diterima dari : Petugas BBG

Lokasi contoh : SKG. TEGALGEDE

Pemakai : **PT. BAYU BUANA GEMILANG (LINE - II)**

Tekanan contoh : 284.45 PSIG

Temperatur contoh : 88.22 °F

Periode : 12 MEI 2015 s.d 18 MEI 2015

No.	PARAMETER UJI ----(1)----	SUMMATION FACTOR b_i ----(2)----	SPECIFIC GRAVITY GAS IDEAL G_i^{id} ----(3)----	NILAI KALOR KOTOR GAS IDEAL H_{vi}^{id} ----(4)----	KOMPOSISI (FRAKSI) X_i ----(5)----	KOMPRESSIBILITAS (FRAKSI) X_ib_i --(6)=(2)x(5)--	SPECIFIC GRAVITY (FRAKSI) $X_iG_i^{id}$ --(7)=(3)x(5)--	NILAI KALOR (FRAKSI) $X_iH_i^{id}$ --(8)=(4)x(5)--
1.	N_2	0.00442	0.96720	0.0000	0.0396	0.00018	0.0383	0.0000
2.	CO_2	0.01950	1.51950	0.0000	0.0803	0.00157	0.1220	0.0000
3.	C_1H_4	0.01160	0.55390	1,010.0000	0.7947	0.00922	0.4402	802.6470
4.	C_2H_6	0.02380	1.03820	1,769.7000	0.0380	0.00090	0.0395	67.2486
5.	C_3H_8	0.03470	1.52250	2,516.1000	0.0287	0.00100	0.0437	72.2121
6.	n-C_4H_{10}	0.04700	2.00680	3,262.3000	0.0063	0.00030	0.0126	20.5525
7.	i-C_4H_{10}	0.04410	2.00680	3,251.9000	0.0054	0.00024	0.0108	17.5603
8.	n-C_5H_{12}	0.06060	2.49110	4,008.7000	0.0015	0.00009	0.0037	6.0131
9.	i-C_5H_{12}	0.05760	2.49110	4,000.9000	0.0021	0.00012	0.0052	8.4019
10.	C_6H_{14}+	0.08637	3.21755	5,129.2200	0.0034	0.00029	0.0109	17.4393
	TOTAL				1.0000	0.01390	0.7270	1,012.0747

1. Faktor Kompresibilitas Gas Campuran, Zb = $1-(\Sigma X_i\, b_i)^2 Pb$ 0.9972
2. Specific Gravity Nyata Gas Campuran, G = $(\Sigma X_i\, G_i^{id})(Za/Zb)(Pb/Pa)$ 0.7305
3. Gross HV Gas Campuran, BTU/SCF = $(\Sigma X_i\, H_i^{id})(Pb/14.696)/zb$ 1,017.3112
4. Pb = 14.73 PSIA (Perjanjian)

4. 19 May - 25 May 2015 1016.96 BTU/SCF

LAPORAN HASIL PENGUJIAN

PENGAMBILAN SAMPLE

No. : 020 / LAB.SKG.T-TGD / V / 2015 No. Sampel : 020

Tgl / jam ambil contoh : **18-05-2015** / 06:00 WIB Diterima dari : Petugas BBG

Lokasi contoh : SKG. TEGALGEDE

Pemakai : **PT. BAYU BUANA GEMILANG (LINE - II)**

Tekanan contoh : 271.23 PSIG

Temperatur contoh : 89.72 °F

Periode : 19 MEI 2015 s.d 25 MEI 2015

No.	PARAMETER UJI ----(1)----	SUMMATION FACTOR b_i ----(2)----	SPECIFIC GRAVITY GAS IDEAL G_i^{id} ----(3)----	NILAI KALOR KOTOR GAS IDEAL H_{vi}^{id} ----(4)----	KOMPOSISI (FRAKSI) X_i ----(5)----	KOMPRESSIBILITAS (FRAKSI) X_ib_i --(6)=(2)x(5)--	SPECIFIC GRAVITY (FRAKSI) $X_iG_i^{id}$ --(7)=(3)x(5)--	NILAI KALOR (FRAKSI) $X_iH_i^{id}$ --(8)=(4)x(5)--
1.	N_2	0.00442	0.96720	0.0000	0.0414	0.00018	0.0400	0.0000
2.	CO_2	0.01950	1.51950	0.0000	0.0849	0.00166	0.1290	0.0000
3.	C_1H_4	0.01160	0.55390	1,010.0000	0.7866	0.00912	0.4357	794.4660
4.	C_2H_6	0.02380	1.03820	1,769.7000	0.0379	0.00090	0.0393	67.0716
5.	C_3H_8	0.03470	1.52250	2,516.1000	0.0288	0.00100	0.0438	72.4637
6.	n-C_4H_{10}	0.04700	2.00680	3,262.3000	0.0065	0.00031	0.0130	21.2050
7.	i-C_4H_{10}	0.04410	2.00680	3,251.9000	0.0055	0.00024	0.0110	17.8855
8.	n-C_5H_{12}	0.06060	2.49110	4,008.7000	0.0017	0.00010	0.0042	6.8148
9.	i-C_5H_{12}	0.05760	2.49110	4,000.9000	0.0023	0.00013	0.0057	9.2021
10.	C_6H_{14}+	0.08637	3.21755	5,129.2200	0.0044	0.00038	0.0142	22.5686
	TOTAL				1.0000	0.01403	0.7361	1,011.6771

1. Faktor Kompresibilitas Gas Campuran, Zb = $1-(\Sigma X_i\, b_i)^2 Pb$ 0.9971
2. Specific Gravity Nyata Gas Campuran, G = $(\Sigma X_i\, G_i^{id})(Za/Zb)(Pb/Pa)$ 0.7397
3. Gross HV Gas Campuran, BTU/SCF = $(\Sigma X_i\, H_i^{id})(Pb/14.696)/zb$ 1,016.9655
4. Pb = 14.73 PSIA (Perjanjian)

5. 26 May - 01 June 2015 1055.34 BTU/SCF

LAPORAN HASIL PENGUJIAN

PENGAMBILAN SAMPLE

No. : 021 / LAB SKG.T-TGD / V / 2015

Tgl / jam ambil contoh : **25-05-2015** / 06:00 WIB

Lokasi contoh : SKG. TEGALGEDE

Pemakai : PT. BAYU BUANA GEMILANG (LINE - II)

Tekanan contoh : 306.01 PSIG

Temperatur contoh : 88.70 °F

Periode : 26 MEI 2015 s.d 01 JUNI 2015

No. Sampel : 021

Diterima dari : Petugas BBG

No.	PARAMETER UJI ----(1)----	SUMMATION FACTOR b_i ----(2)----	SPECIFIC GRAVITY GAS IDEAL G_i^{id} ----(3)----	NILAI KALOR KOTOR GAS IDEAL H_{vi}^{id} ----(4)----	KOMPOSISI (FRAKSI) X_i ----(5)----	KOMPRESSIBILITAS (FRAKSI) $X_i b_i$ --(6)=(2)x(5)--	SPECIFIC GRAVITY (FRAKSI) $X_i G_i^{id}$ --(7)=(3)x(5)--	NILAI KALOR (FRAKSI) $X_i H_i^{id}$ --(8)=(4)x(5)--
1.	N_2	0.00442	0.96720	0.0000	0.0354	0.00016	0.0342	0.0000
2.	CO_2	0.01950	1.51950	0.0000	0.0661	0.00129	0.1004	0.0000
3.	C_1H_4	0.01160	0.55390	1,010.0000	0.8023	0.00931	0.4444	810.3230
4.	C_2H_6	0.02380	1.03820	1,769.7000	0.0401	0.00095	0.0416	70.9650
5.	C_3H_8	0.03470	1.52250	2,516.1000	0.0333	0.00116	0.0507	83.7861
6.	n-C_4H_{10}	0.04700	2.00680	3,262.3000	0.0079	0.00037	0.0159	25.7722
7.	i-C_4H_{10}	0.04410	2.00680	3,251.9000	0.0066	0.00029	0.0132	21.4625
8.	n-C_5H_{12}	0.06060	2.49110	4,008.7000	0.0019	0.00012	0.0047	7.6165
9.	i-C_5H_{12}	0.05760	2.49110	4,000.9000	0.0026	0.00015	0.0065	10.4023
10.	$C_6H_{14}^+$	0.08637	3.21755	5,129.2200	0.0038	0.00033	0.0122	19.4910
TOTAL					1.0000	0.01412	0.7239	1,049.8187

1. Faktor Kompresibilitas Gas Campuran, Zb $= 1-(\Sigma X_i b_i)^2 Pb$ 0.9971
2. Specific Gravity Nyata Gas Campuran, G $= (\Sigma X_i G_i^{id})(Za/Zb)(Pb/Pa)$ 0.7275
3. Gross HV Gas Campuran, BTU/SCF $= (\Sigma X_i H_i^{id})(Pb/14.696)/zb$ 1,055.3457
4. Pb = 14.73 PSIA (Perjanjian)

Tegalgede, May 26, 2015

6. 02 June - 08 June 2015 1044.90 BTU/SCF
7. 09 June - 15 June 2015 1049.73 BTU/SCF
8. 16 June - 22 June 2015 1067.20 BTU/SCF

Data above is the data about gross heating value of liquid natural gas that company get weekly at the end of week in certain period from BBG (PT. Bayu Buana Gemilang). These data are during from 28 April to 22 June 2015. The supplier give gross heating value in term of average during one week, because they can’t give the GHV report daily and the actual daily gross heating value that Bekasi Power received is a constant number each day. For example during 28 April – 04 May 2015, GHV value in liquid natural gas from PT. Bayu Buana Gemilang have average number around 1034.85 BTU/SCF, but the actual GHV on 26 April, 27,28 to 04 May is not have same value. The average here is from (total all GHV each day) divided by seven days.

So from data above, can be assumed in each day the number of GHV is same according to the actual GHV weekly;

Table 5.2 Daily Actual GHV Assumption

Period	Actual GHV Weekly BTU/SCF	Gross Heating Value BTU/SCF
28-Apr	1034.85	1034.85
29-Apr		1034.85
30-Apr		1034.85
1-May		1034.85
2-May		1034.85
3-May		1034.85
4-May		1034.85
5-May	1041.48	1041.48
6-May		1041.48
7-May		1041.48
8-May		1041.48
9-May		1041.48
10-May		1041.48
11-May		1041.48
12-May	1017.31	1017.31
13-May		1017.31
14-May		1017.31
15-May		1017.31
16-May		1017.31
17-May		1017.31
18-May		1017.31
19-May	1016.96	1016.96
20-May		1016.96
21-May		1016.96
22-May		1016.96
23-May		1016.96
24-May		1016.96
25-May		1016.96
26-May	1055.34	1055.34
27-May		1055.34
28-May		1055.34
29-May		1055.34
30-May		1055.34
31-May		1055.34
1-Jun		1055.34
2-Jun	1044.9	1044.9

3-Jun		1044.9
4-Jun		1044.9
5-Jun		1044.9
6-Jun		1044.9
7-Jun		1044.9
8-Jun		1044.9
9-Jun	1049.73	1049.73
10-Jun		1049.73
11-Jun		1049.73
12-Jun		1049.73
13-Jun		1049.73
14-Jun		1049.73
15-Jun		1049.73
16-Jun	1067.2	1067.2
17-Jun		1067.2
18-Jun		1067.2
19-Jun		1067.2
20-Jun		1067.2
21-Jun		1067.2
22-Jun		1067.2

Data above is the actual gross heating value of liquid natural gas that BBG (PT. Bayu Buana Gemilang) send to the PT. Bekasi Power during 28 April – 22 June 2015. The data that BBG send to the PT. Bekasi Power is the average value of GHV during a week at the end of week, and there is no actual GHV daily. For example in period 28 April – 4 May, PT. Bekasi Power will receive the report of GHV from BBG in the 5 May. Based on the assumption, so in this research, the GHV in a week is assumed same from day to day.

b. Perusahaan Gas Negara

Table 5.3 Daily Actual GHV from PGN

Period	**Daily GHV Contract BTU/SCF**	**Gross Heating Value BTU/SCF**
28-Apr	1055	1079.58
29-Apr	1055	1061.55
30-Apr	1055	1064.43
1-May	1055	1063.56
2-May	1055	1057.34

3-May	1055	1072.34
4-May	1055	1083.44
5-May	1055	1042.48
6-May	1055	1051.57
7-May	1055	1053.54
8-May	1055	1076.21
9-May	1055	1071.88
10-May	1055	1078.78
11-May	1055	1054.23
12-May	1055	1065.43
13-May	1055	1068.65
14-May	1055	1047.78
15-May	1055	1058.33
16-May	1055	1056.42
17-May	1055	1066.22
18-May	1055	1071.17
19-May	1055	1058.89
20-May	1055	1068.43
21-May	1055	1060.55
22-May	1055	1055.43
23-May	1055	1057.55
24-May	1055	1057.43
25-May	1055	1066.22
26-May	1055	1071.17
27-May	1055	1055.34
28-May	1055	1059.21
29-May	1055	1055.34
30-May	1055	1056.34
31-May	1055	1057.34
1-Jun	1055	1055.34
2-Jun	1055	1044.9
3-Jun	1055	1035.85
4-Jun	1055	1044.72
5-Jun	1055	1072.34
6-Jun	1055	1083.44
7-Jun	1055	1043.73
8-Jun	1055	1067.35
9-Jun	1055	1078.12
10-Jun	1055	1065.31
11-Jun	1055	1064.12

12-Jun	1055	1072.34
13-Jun	1055	1083.44
14-Jun	1055	1065.33
15-Jun	1055	1048.36
16-Jun	1055	1067.2
17-Jun	1055	1034.85
18-Jun	1055	1044.72
19-Jun	1055	1072.34
20-Jun	1055	1083.44
21-Jun	1055	1041.48
22-Jun	1055	1046.65

Data above is the actual gross heating value of liquid natural gas that Perusahaan Gas Negara (PGN) send to the PT. Bekasi Power during 28 April – 22 June 2015. PGN was make an agreement with PT. Bekasi Power about minimum daily GHV contract is around 1055 BTU/SCF, but the opportunity GHV is below the contract is still exist. Where the smallest GHV is 1034.85 in 17-June and the highest one is 1083.44 BTU/SCF that was happen in several period.

5.1.4. The Actual Gross Heating Value to Proof the Analysis

Here the data of actual gross heating value period 23-29 June 2015 from PT. Bayu Buana Gemilang is collected as the guidance to proof the forecasting result.

Table 5.4 Actual GHV Period 23-29 June 2015

Period	PGN GHV	BBG GHV
23-Jun	1057.2	1073.2
24-Jun	1024.85	1073.2
25-Jun	1034.72	1073.2
26-Jun	1062.34	1073.2
27-Jun	1073.44	1073.2
28-Jun	1031.48	1073.2
29-Jun	1036.65	1073.2

5.1.5. Price of Liquid Natural Gas

Data about LNG price from both supplier is needed to fill the aggregate planning calculation method.

Table 5.5 LNG Price

GAS PRICE	Perusahaan Gas Negara	Rp. 750.00/SCF
	PT. Bayu Buana Gemilang	Rp. 750.00/SCF

SCF = Unit of Gas in mm^3

All of data above is the data that needed for the analysis using three method, which are aggregate planning, double moving average with MA 5, and double moving average with MA 7. Then the result with smallest standard error (divided with the actual data in the next seventh period) will be as the best method to solve the problem and can achieve the objective of this research.

5.2. Calculation and Analysis

5.2.1. Aggregate Planning

Table 5.6 Actual GHV from PGN and BBG With the Price

Period	PGN GHV	BBG GHV
28-Apr	1079.58	1034.85
29-Apr	1061.55	1034.85
30-Apr	1064.43	1034.85
1-May	1063.56	1034.85
2-May	1057.34	1034.85
3-May	1072.34	1034.85
4-May	1083.44	1034.85
5-May	1042.48	1041.48
6-May	1051.57	1041.48
7-May	1053.54	1041.48
8-May	1076.21	1041.48
9-May	1071.88	1041.48
10-May	1078.78	1041.48
11-May	1054.23	1041.48
12-May	1065.43	1017.31
13-May	1068.65	1017.31
14-May	1047.78	1017.31
15-May	1058.33	1017.31
16-May	1056.42	1017.31
17-May	1066.22	1017.31
18-May	1071.17	1017.31
19-May	1058.89	1016.96
20-May	1068.43	1016.96
21-May	1060.55	1016.96
22-May	1055.43	1016.96
23-May	1057.55	1016.96
24-May	1057.43	1016.96
25-May	1066.22	1016.96
26-May	1071.17	1055.34
27-May	1055.34	1055.34
28-May	1059.21	1055.34
29-May	1055.34	1055.34
30-May	1056.34	1055.34
31-May	1057.34	1055.34

1-Jun	1055.34	1055.34
2-Jun	1044.9	1044.9
3-Jun	1035.85	1044.9
4-Jun	1044.72	1044.9
5-Jun	1072.34	1044.9
6-Jun	1083.44	1044.9
7-Jun	1043.73	1044.9
8-Jun	1067.35	1044.9
9-Jun	1078.12	1049.73
10-Jun	1065.31	1049.73
11-Jun	1064.12	1049.73
12-Jun	1072.34	1049.73
13-Jun	1083.44	1049.73
14-Jun	1065.33	1049.73
15-Jun	1048.36	1049.73
16-Jun	1067.2	1067.2
17-Jun	1034.85	1067.2
18-Jun	1044.72	1067.2
19-Jun	1072.34	1067.2
20-Jun	1083.44	1067.2
21-Jun	1041.48	1067.2
22-Jun	1046.65	1067.2
LNG Price	**Rp.750/SCF**	**Rp.750/SCF**

Table 5.7 Aggregate Planning

Period	PGN GHV x Gas Price	BBG GHV x Gas Price	Family X
28-Apr	809685	776137.5	1585822.5
29-Apr	796162.5	776137.5	1572300
30-Apr	798322.5	776137.5	1574460
1-May	797670	776137.5	1573807.5
2-May	793005	776137.5	1569142.5
3-May	804255	776137.5	1580392.5
4-May	812580	776137.5	1588717.5
5-May	781860	781110	1562970
6-May	788677.5	781110	1569787.5
7-May	790155	781110	1571265
8-May	807157.5	781110	1588267.5
9-May	803910	781110	1585020

10-May	809085	781110	1590195
11-May	790672.5	781110	1571782.5
12-May	799072.5	762982.5	1562055
13-May	801487.5	762982.5	1564470
14-May	785835	762982.5	1548817.5
15-May	793747.5	762982.5	1556730
16-May	792315	762982.5	1555297.5
17-May	799665	762982.5	1562647.5
18-May	803377.5	762982.5	1566360
19-May	794167.5	762720	1556887.5
20-May	801322.5	762720	1564042.5
21-May	795412.5	762720	1558132.5
22-May	791572.5	762720	1554292.5
23-May	793162.5	762720	1555882.5
24-May	793072.5	762720	1555792.5
25-May	799665	762720	1562385
26-May	803377.5	791505	1594882.5
27-May	791505	791505	1583010
28-May	794407.5	791505	1585912.5
29-May	791505	791505	1583010
30-May	792255	791505	1583760
31-May	793005	791505	1584510
1-Jun	791505	791505	1583010
2-Jun	783675	783675	1567350
3-Jun	776887.5	783675	1560562.5
4-Jun	783540	783675	1567215
5-Jun	804255	783675	1587930
6-Jun	812580	783675	1596255
7-Jun	782797.5	783675	1566472.5
8-Jun	800512.5	783675	1584187.5
9-Jun	808590	787297.5	1595887.5
10-Jun	798982.5	787297.5	1586280
11-Jun	798090	787297.5	1585387.5
12-Jun	804255	787297.5	1591552.5
13-Jun	812580	787297.5	1599877.5
14-Jun	798997.5	787297.5	1586295
15-Jun	786270	787297.5	1573567.5
16-Jun	800400	800400	1600800
17-Jun	776137.5	800400	1576537.5
18-Jun	783540	800400	1583940
19-Jun	804255	800400	1604655

20-Jun	812580	800400	1612980
21-Jun	781110	800400	1581510
22-Jun	784987.5	800400	1585387.5
Total	**44579655**	**43720792.5**	**88300447.5**
Percentage	**50.49%**	**49.51%**	**100%**

Forecasting

Table 5.8 Forecasting of Aggregate Planning

Forecasting			
t	**A_t**	**tA_t**	**t x t**
1	1585822.5	1585822.5	1
2	1572300	3144600	4
3	1574460	4723380	9
4	1573807.5	6295230	16
5	1569142.5	7845712.5	25
6	1580392.5	9482355	36
7	1588717.5	11121022.5	49
8	1562970	12503760	64
9	1569787.5	14128087.5	81
10	1571265	15712650	100
11	1588267.5	17470942.5	121
12	1585020	19020240	144
13	1590195	20672535	169
14	1571782.5	22004955	196
15	1562055	23430825	225
16	1564470	25031520	256
17	1548817.5	26329897.5	289
18	1556730	28021140	324
19	1555297.5	29550652.5	361
20	1562647.5	31252950	400
21	1566360	32893560	441
22	1556887.5	34251525	484
23	1564042.5	35972977.5	529
24	1558132.5	37395180	576
25	1554292.5	38857312.5	625
26	1555882.5	40452945	676
27	1555792.5	42006397.5	729
28	1562385	43746780	784
29	1594882.5	46251592.5	841
30	1583010	47490300	900
31	1585912.5	49163287.5	961

32	1583010	50656320	1024
33	1583760	52264080	1089
34	1584510	53873340	1156
35	1583010	55405350	1225
36	1567350	56424600	1296
37	1560562.5	57740812.5	1369
38	1567215	59554170	1444
39	1587930	61929270	1521
40	1596255	63850200	1600
41	1566472.5	64225372.5	1681
42	1584187.5	66535875	1764
43	1595887.5	68623162.5	1849
44	1586280	69796320	1936
45	1585387.5	71342437.5	2025
46	1591552.5	73211415	2116
47	1599877.5	75194242.5	2209
48	1586295	76142160	2304
49	1573567.5	77104807.5	2401
50	1600800	80040000	2500
51	1576537.5	80403412.5	2601
52	1583940	82364880	2704
53	1604655	85046715	2809
54	1612980	87100920	2916
55	1581510	86983050	3025
56	1585387.5	88781700	3136
TOTAL			
1596	**88300447.5**	**2522404748**	**60116**

$$a = \frac{\sum_{t=1}^{n} A_t - b\sum_{t=1}^{n} t}{n}$$

$$b = \frac{n\sum_{t=1}^{n} tA_t - \sum_{t=1}^{n} A_t \sum_{t=1}^{n} t}{n\sum_{t=1}^{n} t^2 - (\sum_{t=1}^{n} t)^2}$$

Figure 5.3 a and b Formula

- First is finding the value of b. Because to find the value of “a” the value of “b” is needed. So the value of “**b**” is;

$$\frac{56(2522404748) - 88300447.5(1596)}{56(60116) - (1596 \times 1596)}$$

$$\frac{1.41254665888 - 1.40927514210}{3366496 - 2547216}$$

$$\frac{327151650}{819280} = \mathbf{399.3160458}$$

From the calculation, the value of b is **399.3160458**

- Then after get the value of “b”, the next step is find the value of “**a**”, which is;

$$\frac{88300447.5 - 637308.4091}{56}$$

$$\frac{87663139.09}{56} = \mathbf{1565413.198}$$

Then from the calculation, the value of a is equal **1565413.198**

- Next is plot the value of “a” and “b” in the formula;

$$\mathbf{F_t = a + bt}$$

$$\mathbf{F_t = 1565413.198 + 399.3160458\ t}$$

- Aggregate planning for the next seven period

Ft = 1565413.198 + 399.3160458 t

F_{57}	1588174.213
F_{58}	1588573.529
F_{59}	1588972.845
F_{60}	1589372.161
F_{61}	1589771.477
F_{62}	1590170.793
F_{63}	1590570.109

- Percentage for the PGN 50.49 % and for the BBG 49.51 %

F_{57}

PGN	50.49%	x	1588174.213	=	801869.1599
BBG	49.51%	x	1588174.213	=	786305.0527

F_{58}

PGN	50.49%	x	1588573.529	=	802070.7746
BBG	49.51%	x	1588573.529	=	786502.754

F_{59}

PGN	50.49%	x	1588972.845	=	802272.3893
BBG	49.51%	x	1588972.845	=	786700.4554

F_{60}

PGN	50.49%	x	1589372.161	=	802474.004
BBG	49.51%	x	1589372.161	=	786898.1568

F_{61}

PGN	50.49%	x	1589771.477	=	802675.6186
BBG	49.51%	x	1589771.477	=	787095.8582

F_{62}

PGN	50.49%	x	1590170.793	=	802877.2333
BBG	49.51%	x	1590170.793	=	787293.5595

F_{63}

PGN	50.49%	X	1590570.109	=	803078.848
BBG	49.51%	X	1590570.109	=	787491.2609

- Master Product Scheduling

	Value	Price	GHV
F57			
PGN	800377.42	750	1067.169893
BBG	781396.13	750	1041.861507
F58			
PGN	800522.93	750	1067.363907
BBG	781538.19	750	1042.05092
F59			
PGN	800668.43	750	1067.557907
BBG	781680.25	750	1042.240333
F60			
PGN	800813.94	750	1067.75192
BBG	781822.31	750	1042.429747
F61			
PGN	800959.45	750	1067.945933
BBG	781964.36	750	1042.619147
F62			
PGN	801104.96	750	1068.139947
BBG	782106.42	750	1042.80856
F63			
PGN	801250.46	750	1068.333947
BBG	782248.48	750	1042.997973

From the data analysis above, the next average of gross heating value in the next seventh days after days 56th is around **1042.429741** BTU/SCF.

5.2.2. Double Moving Average

5.2.2.1 Moving Average Value 7

Table 5.9 Double Moving Average (MA 7)

Period	Demand d_t	MA (7) S_t'	MA (7x7) S_t''	a_t Value	b_t Value	Forecasting (d_t') $F_{t+m} = a_t + b_t(m)$
1	1034.85					
2	1034.85					
3	1034.85					
4	1034.85					
5	1034.85					
6	1034.85					
7	1034.85	1034.85				
8	1041.48	1035.797143				
9	1041.48	1036.744286				
10	1041.48	1037.691429				
11	1041.48	1038.638571				
12	1041.48	1039.585714				
13	1041.48	1040.532857	1037.691429	1043.374286	0.947142857	
14	1041.48	1041.48	1038.638571	1044.321429	0.947142857	1044.321429
15	1017.31	1038.027143	1038.957143	1037.097143	-0.31	1045.268571
16	1017.31	1034.574286	1038.647143	1030.501429	-1.357619048	1029.14381
17	1017.31	1031.121429	1037.708571	1024.534286	-2.195714286	1029.14381
18	1017.31	1027.668571	1036.141429	1019.195714	-2.824285714	1022.338571
19	1017.31	1024.215714	1033.945714	1014.485714	-3.243333333	1016.371429
20	1017.31	1020.762857	1031.121429	1010.404286	-3.452857143	1011.242381
21	1017.31	1017.31	1027.668571	1006.951429	-3.452857143	1006.951429
22	1016.96	1017.26	1024.701837	1009.818163	-2.480612245	1003.498571
23	1016.96	1017.21	1022.221224	1012.198776	-1.670408163	1007.337551
24	1016.96	1017.16	1020.226735	1014.093265	-1.022244898	1010.528367
25	1016.96	1017.11	1018.718367	1015.501633	-0.536122449	1013.07102
26	1016.96	1017.06	1017.696122	1016.423878	-0.212040816	1014.96551
27	1016.96	1017.01	1017.16	1016.86	-0.05	1016.211837
28	1016.96	1016.96	1017.11	1016.81	-0.05	1016.81
29	1055.34	1022.442857	1017.850408	1027.035306	1.530816327	1016.76
30	1055.34	1027.925714	1019.381224	1036.470204	2.848163265	1028.566122
31	1055.34	1033.408571	1021.702449	1045.114694	3.902040816	1039.318367
32	1055.34	1038.891429	1024.814082	1052.968776	4.69244898	1049.016735
33	1055.34	1044.374286	1028.716122	1060.032449	5.219387755	1057.661224

34	1055.34	1049.857143	1033.408571	1066.305714	5.482857143	1065.251837
35	1055.34	1055.34	1038.891429	1071.788571	5.482857143	1071.788571
36	1044.9	1053.848571	1043.377959	1064.319184	3.490204082	1077.271429
37	1044.9	1052.357143	1046.868163	1057.846122	1.829659864	1067.809388
38	1044.9	1050.865714	1049.362041	1052.369388	0.50122449	1059.675782
39	1044.9	1049.374286	1050.859592	1047.88898	-0.495102041	1052.870612
40	1044.9	1047.882857	1051.360816	1044.404898	-1.159319728	1047.393878
41	1044.9	1046.391429	1050.865714	1041.917143	-1.491428571	1043.245578
42	1044.9	1044.9	1049.374286	1040.425714	-1.491428571	1040.425714
43	1049.73	1045.59	1048.19449	1042.98551	-0.868163265	1038.934286
44	1049.73	1046.28	1047.326327	1045.233673	-0.34877551	1042.117347
45	1049.73	1046.97	1046.769796	1047.170204	0.066734694	1044.884898
46	1049.73	1047.66	1046.524898	1048.795102	0.378367347	1047.236939
47	1049.73	1048.35	1046.591633	1050.108367	0.586122449	1049.173469
48	1049.73	1049.04	1046.97	1051.11	0.69	1050.69449
49	1049.73	1049.73	1047.66	1051.8	0.69	1051.8
50	1067.2	1052.225714	1048.607959	1055.843469	1.205918367	1052.49
51	1067.2	1054.721429	1049.813878	1059.62898	1.63585034	1057.049388
52	1067.2	1057.217143	1051.277755	1063.156531	1.979795918	1061.26483
53	1067.2	1059.712857	1052.999592	1066.426122	2.237755102	1065.136327
54	1067.2	1062.208571	1054.979388	1069.437755	2.409727891	1068.663878
55	1067.2	1064.704286	1057.217143	1072.191429	2.495714286	1071.847483
56	1067.2	1067.2	1059.712857	1074.687143	2.495714286	1074.687143
57						1077.182857
58						1079.678571
59						1082.174286
60						1084.67
61						1087.165714
62						1089.661429
63						1092.157143

From the data analysis above, the next average of gross heating value in the next seventh days after days 56th (23 June – 29 June) is around **1084.67** BTU/SCF.

5.2.2.2 Moving Average 5

Table 5.10 Double Moving Average (MA 5)

Period	Demand dt	MA (5) St'	MA (5x5) St"	at Value	bt Value	Forecast (dt') Ft+m = at + bt(m)
1	1034.85					
2	1034.85					

3	1034.85					
4	1034.85					
5	1034.85	1034.85				
6	1034.85	1034.85				
7	1034.85	1034.85				
8	1041.48	1036.176				
9	1041.48	1037.502	1035.6456	1039.3584	0.9282	
10	1041.48	1038.828	1036.4412	1041.2148	1.1934	1040.2866
11	1041.48	1040.154	1037.502	1042.806	1.326	1042.4082
12	1041.48	1041.48	1038.828	1044.132	1.326	1044.132
13	1041.48	1041.48	1039.8888	1043.0712	0.7956	1045.458
14	1041.48	1041.48	1040.6844	1042.2756	0.3978	1043.8668
15	1017.31	1036.646	1040.248	1033.044	-1.801	1042.6734
16	1017.31	1031.812	1038.5796	1025.0444	-3.3838	1031.243
17	1017.31	1026.978	1035.6792	1018.2768	-4.3506	1021.6606
18	1017.31	1022.144	1031.812	1012.476	-4.834	1013.9262
19	1017.31	1017.31	1026.978	1007.642	-4.834	1007.642
20	1017.31	1017.31	1023.1108	1011.5092	-2.9004	1002.808
21	1017.31	1017.31	1020.2104	1014.4096	-1.4502	1008.6088
22	1016.96	1017.24	1018.2628	1016.2172	-0.5114	1012.9594
23	1016.96	1017.17	1017.268	1017.072	-0.049	1015.7058
24	1016.96	1017.1	1017.226	1016.974	-0.063	1017.023
25	1016.96	1017.03	1017.17	1016.89	-0.07	1016.911
26	1016.96	1016.96	1017.1	1016.82	-0.07	1016.82
27	1016.96	1016.96	1017.044	1016.876	-0.042	1016.75
28	1016.96	1016.96	1017.002	1016.918	-0.021	1016.834
29	1055.34	1024.636	1018.5092	1030.7628	3.0634	1016.897
30	1055.34	1032.312	1021.5656	1043.0584	5.3732	1033.8262
31	1055.34	1039.988	1026.1712	1053.8048	6.9084	1048.4316
32	1055.34	1047.664	1032.312	1063.016	7.676	1060.7132
33	1055.34	1055.34	1039.988	1070.692	7.676	1070.692
34	1055.34	1055.34	1046.1288	1064.5512	4.6056	1078.368
35	1055.34	1055.34	1050.7344	1059.9456	2.3028	1069.1568
36	1044.9	1053.252	1053.3872	1053.1168	-0.0676	1062.2484
37	1044.9	1051.164	1054.0872	1048.2408	-1.4616	1053.0492
38	1044.9	1049.076	1052.8344	1045.3176	-1.8792	1046.7792
39	1044.9	1046.988	1051.164	1042.812	-2.088	1043.4384
40	1044.9	1044.9	1049.076	1040.724	-2.088	1040.724
41	1044.9	1044.9	1047.4056	1042.3944	-1.2528	1038.636
42	1044.9	1044.9	1046.1528	1043.6472	-0.6264	1041.1416
43	1049.73	1045.866	1045.5108	1046.2212	0.1776	1043.0208

44	1049.73	1046.832	1045.4796	1048.1844	0.6762	1046.3988
45	1049.73	1047.798	1046.0592	1049.5368	0.8694	1048.8606
46	1049.73	1048.764	1046.832	1050.696	0.966	1050.4062
47	1049.73	1049.73	1047.798	1051.662	0.966	1051.662
48	1049.73	1049.73	1048.5708	1050.8892	0.5796	1052.628
49	1049.73	1049.73	1049.1504	1050.3096	0.2898	1051.4688
50	1067.2	1053.224	1050.2356	1056.2124	1.4942	1050.5994
51	1067.2	1056.718	1051.8264	1061.6096	2.4458	1057.7066
52	1067.2	1060.212	1053.9228	1066.5012	3.1446	1064.0554
53	1067.2	1063.706	1056.718	1070.694	3.494	1069.6458
54	1067.2	1067.2	1060.212	1074.188	3.494	1074.188
55	1067.2	1067.2	1063.0072	1071.3928	2.0964	1077.682
56	1067.2	1067.2	1065.1036	1069.2964	1.0482	1073.4892
57						1070.3446
58						1071.3928
59						1072.441
60						1073.4892
61						1074.5374
62						1075.5856
63						1076.6338

From the data analysis above, the next average of gross heating value in the next seventh days after days 56th (23 June – 22 June) is around **1073.489** BTU/SCF.

5.2.3. Standard Error from Each Method

1. Aggregate Planning: 1042.429741 BTU/SCF

   Compare with the real GHV value in the next seventh period, the standard error is around: **(1073.2/1042.429741) x 100% = 102.9%**

   Standard error = 100% - 102.9% =

   -2.9%

2. Double Moving Average with MA:7

   1084.67 BTU/SCF

   Compare with the real GHV vale in the next seventh period, the standard error is around: **(1073.2/1084.67) x 100% = 98.94%**

   Standard error = 100% - 98.94% =

1.06%

3. Double Moving Average with MA:5
   1073.489 BTU/SCF
   Compare with the real GHV vale in the next seventh period, the standard error is around: **(1073.2/1073.489) x 100% = 99.97%**
   Standard error = 100% - 99.97% =
   0.03%

By look at the standard error from those three method, so the conclusion the forecasting method must be used to forecasting the GHV value from liquid natural gas, by using *Double Moving Average* method, and using maximal MA value, it is 5, the standard error will be 0.03%.

5.2.4. Before Improvement

Before do the forecasting for the GHV value of BBG, the gas gate valve system in PT. Bekasi Power for BBG gate, the opening gate is based on the gas pressure in one SCF from PGN that they send daily to the Bekasi Power. According to the agreement with PGN, PT. Bekasi Power will get 1055 BTU/SCF per day. But the opportunity the gas pressure bellow the agreement can be occur. For example in certain period, the gas pressure from PGN is around 1040 BTU/SCF, it is not appropriate with the contract, so if this situation happen the gate valve system from BBG will opened 50%:50% with PGN gate.

By do the system like this, the opportunity of loss is big. For example, when the PGN send the gas, with gas pressure around 1040 BTU/SCF, and then in the same time, the gas pressure from BBG is 1030 BTU/SCF, by look the situation like this PT. Bekasi Power will be loss. This system is like *gambling*. The company can knows they loss or not at the end of period weekly.

5.2.5. Improvement

By look the system of gas gate valve system in PT. Bekasi Power above, this research can help the company to minimize the value of loss. By do the forecasting, and get the forecasting method with smaller standard error, company can forecast the gas pressure from BBG for the next seven periods, and not do the gambling again with actual GHV value of gas that has big percentage of loss opportunity occur. With forecasting method, company now has references of open-close gas gate valve from both suppliers.

5.2.6. Data Analysis After Research

Table 5.11 Data Analysis After Research

Period	PGN GHV	BBG GHV
23-Jun	1057.2	1073.2
24-Jun	1024.85	1073.2
25-Jun	1034.72	1073.2
26-Jun	1062.34	1073.2
27-Jun	1073.44	1073.2
28-Jun	1031.48	1073.2
29-Jun	1036.65	1073.2

Forecasting for GHV from BBG;

23-Jun	1070.3446
24-Jun	1071.3928
25-Jun	1072.441
26-Jun	1073.4892
27-Jun	1074.5374
28-Jun	1075.5856
29-Jun	1076.6338

After do the research, data above shown, company is better open gas gate valve of BBG maximally, and smaller the gate of PGN. Except in the period 27 June, better both of the gas gate valve is opened normally, because between the PGN actual gross heating value with the actual gross heating value from BBG, the different of value is close from PGN 1073.44 BTU/SCF and from BBG is around 1074.5374 where the actual GHV from BBG have error until 0.03%.

CHAPTER VI
CONCLUSION & RECOMMENDATION

In the conclusion, to solve the system of open-close gas gate valve in the company that still like a gambling now, PT. Bekasi Power can use the double moving average forecasting method with number of moving average five, to predict the next seven period actual gross heating value of liquid natural gas that company will receive. Then the result of forecasting can be as the guidance for the open-close the gas gate valve from supplier, where the result is followed by the forecasting of actual gross heating value daily from BBG.

And for the recommendation, PT. Bekasi Power can add department or job desk in the plant to do the forecasting of actual gross heating value for the next seven period. By exploit the double moving average method with moving average 5, PT. Bekasi Power can get the actual gross heating value from BBG daily, and can predict the average value of GHV for the next seven period, then it can be as the guidance of open-close gas gate valve system. So the opportunity of losses because the gas additional can be reduced and the percentage of gambling fault can be reduce also.

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BIWEEKLY REPORT

Here the document of daily activity during internship period in PT. Bekasi Power from 28 April – 7 July 2015.