1. PV Power Plant, Bang Pa-in, Ayutthaya

Overview:

- Plant Capacity- 38 MW
- PV Module - 157,200 panels
- Electricity Production – 63 M kWh/Year
- Number of Inverters- 61
- Area covered- 82 hectares

Objectives:

- To study about how to produce electricity from solar energy using PV system.
- To study the different pros and cons of using of solar PV technology.

Observations and details:

Sunny Bangchak is the largest solar plant in Southeast Asia and an important milestone in solar energy's development in the region. The commitment of Suntech and BCP's to usher for clean and sustainable energy future in Thailand is being demonstrated. The high aspiration of Thailand to meet 20% of its total demand with renewables by 2022 is expected to be well justified by this project. Its major goal is to annually reduce the need to import about 40,000 tons of coal and mitigate 32,000 tons of CO2 emissions.

It has done PPA to supply 30 MW to EGAT and 8 MW to PEA. The output from 20 panels are connected to a string box; 6-8 string box to a junction box and finally connected to inverter. Lastly, from inverter to MDB plant to RMU plant and to feeder. Generally the output of one string is estimated to be around 800-1000V. A software is used for monitoring the solar panels to detect outage of panels. The inverter used is 99% efficient.

Impressions and Conclusion:

This is renewable source of energy using solar radiation to produce energy. Extraction of solar energy is weather dependent and cannot be operated at night. 11AM to 2 PM is the only peak hour to generate electricity. Winter is the best season to produce electricity as there is no cloud and weather is not hot. If there is temperature rise then losses are high. The overall efficiency of the solar plant is quite low. Apart from its low capacity production and weather dependent, it is clean, quiet and is useful to rural household areas, especially for those areas which do not have electricity connected to the grid.

2. Geothermal Power Plant, Fang, Chiang Mai

Objectives:

- To study about the power generation from geothermal plant.

Observations and Details:

The Fang Geothermal Power Plant is located at Pong Num Ron in the Fang District of Chiang Mai province. During surveys 16 holes were drilled but only 3 of them were found to be sufficient for getting hot water continuously. The installation of this plant was completed in December 1989 as the first geothermal power plant in Thailand and the first binary cycle geothermal plant in South East Asia.

The energy source for the binary cycle system is hot water from wells reaching approximately 160 meters below ground surface into a shallow hot water reservoir (formed in the fractured rock). The natural pressure about 1 bar in such reservoir provides a maximum water flow rate of 22 liters per second at a temperature about 150^{o}C. The hot water also contains steam which is separated and left to the atmosphere. This hot water is passed through a heat exchanger which transfer heat to a low boiling point fluid (Iso-butane having low boiling point around 27.5^{o}C) there being sufficient heat to vaporize the working fluid to give a heat exchanger out let pressure of 3-4.5 bar at a temperature of about 85^{o}C. This pressurized working fluid then used to drive the turbine which is connected to the electrical generator. On discharge from the turbine, the working fluid is passed through a cooling condenser, the cooled working fluid then being returned to the vaporizer. The cooling water for the condenser is obtained from nearby stream which as a seasonal temperature variation of 15^{o}C to 30^{o}C and sufficient flow capacity to provide the maximum cooling water flow requirement of 94 liters per second. The output from the 300 kW generator at 400 V is stepped up and connected to the local distribution grid system of the PEA at 22 kV and provides 1.2 million kWh annually to the grid.

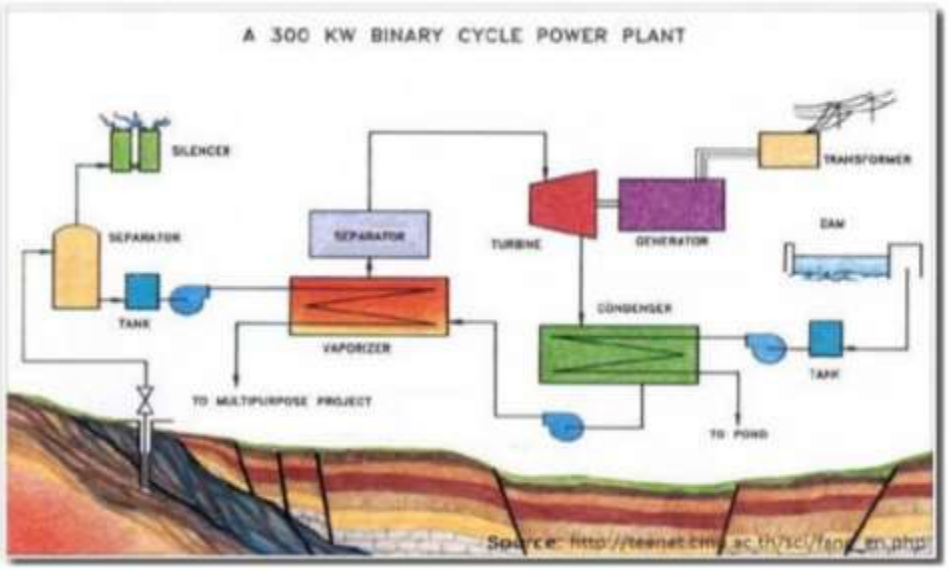
Impressions and Conclusion:

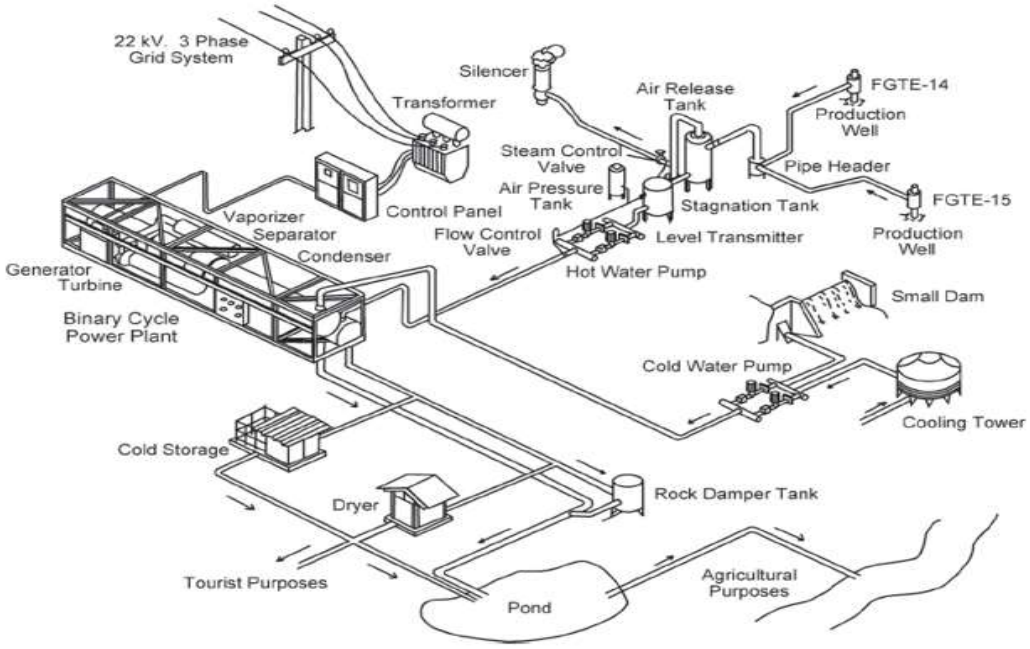
This is the first geothermal power plant in Thailand and the first binary cycle geothermal plant in South East Asia. The plant is a demonstration project but they are planning it to expand and feasibility study is going on. The energy source for the binary cycle system is hot water from wells reaching approximately 160 meters below ground surface into a shallow hot water reservoir (formed in the fractured rock). Thus, the geothermal power plant is renewable energy resource. Plant may have high investment to drill or excavate hot water spring but on long run the plant is sustainable. This can operate in isolated mode supplying power in small local area. Moreover, the hot water coming out from evaporator has temperature at 80^{o}C and the same flow rate as that in inlet which can be used on various sectors such as drying fruits, air conditioning system, spa for tourism etc. At very low cost, we can have optimum advantages.

Cost of generation = 6 baht/unit

Selling price = 2 baht/unit to PEA

No financial benefit expected and no government subsidy because EGAT is a state enterprise.





Fang Geothermal multi-purpose project (commissioned in 1989)

3. Micro Hydro Power Plant, Fang, Chiang Mai

Overview:

- Capacity = 110 kW
- ROR type of plant
- Area = 0.112 m^2
- Turbine: Horizontal shaft Francis, rated output = 875 kW, 750 RPM
- Generator: Synchronous Generator, rated output = 1040 kVA, 750 RPM, brushless excitation
- Power Transformer: Rated output = 1250 kVA, Voltage = 0.4/22 kV

Objectives:

- To study generation of electricity from hydro resource.

Observations and Details:

Mae jai Micro hydro power plant has the total capacity of 1×875 kVA with the generation of 110 kW having connection FAA03. The plant generates 1,992,790 kWhr. The total expense is around 3,317,167.49 THB whereas the profit made is about 5,246,260.83 THB. The plant gets benefit by selling electricity to customer, also being the renewable energy resource. Since, Thailand is working out for sustainable resource of energy to replace the fossil fuel consumption, hydropower plant such as Mai jai is having good weightage. Although hydropower fulfills very less electricity demand around the world, it has been proved to be the best alternative to non-renewables energy resource due to its low operating cost, low electricity cost, longer life.

Mae Jai micro hydro power plant is run off river type project having following features:

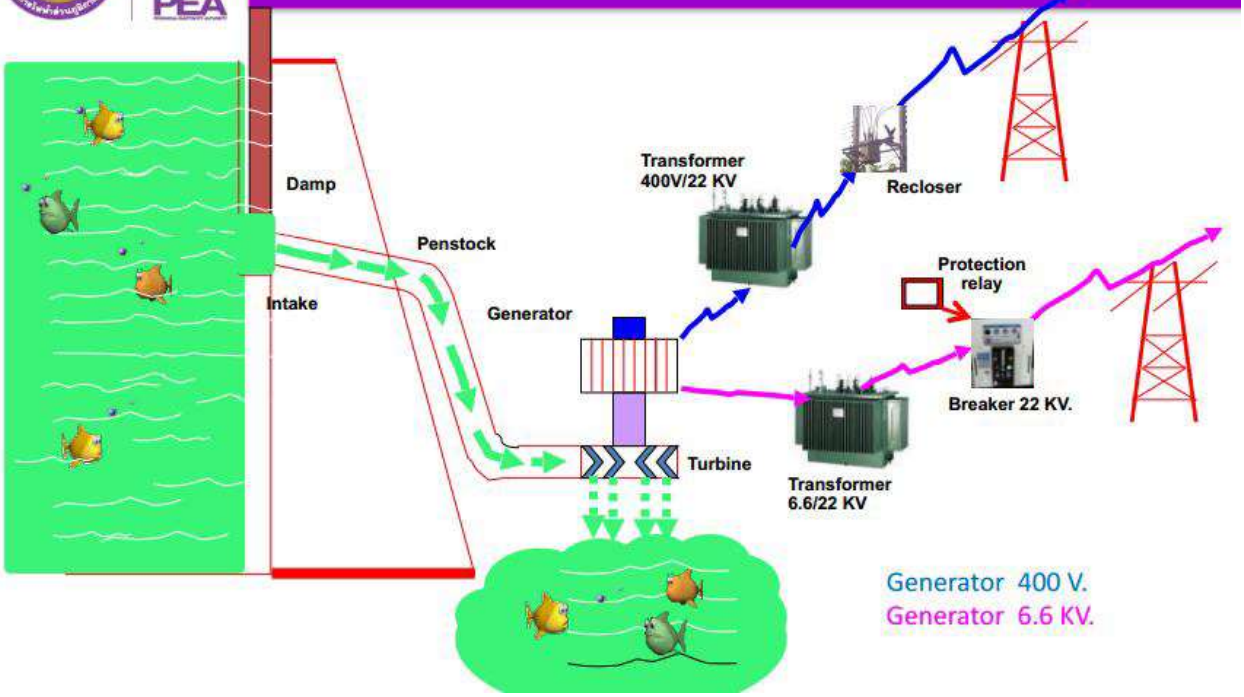
- Dam's width = 38m
- Height = 5m
- Steel inlet pipeline = dimension 1.2m, 9 mm thickness 880 m long
- Penstock pressure pipeline = dimension 1.2m, 9.5 cm thickness, 450 m long

The inlet valve is Shut-off; non-Return valve"Gurostor"NP1000/NP10 with hydraulic cylinder and counter weight (butterfly valve). Governor is UG8 type manufactured by Woodward Governor Comp. The breaker specification include: the rated voltage of 660V, rated current is 2000 A, 24V dc controlled voltage, 24 Vdc motor drive and manufacturer is Novmax G2.

Impression and Conclusion:

Since the plant was shut down for maintenance we could not visualize the operation but got the information via demonstration and presentation.

schemes


Damp
Intake
Penstock
Generator
Turbine
Transformer
400V/22 KV
Recloser
Protection
relay
Breaker 22 KV.
Transformer
6.6/22 KV
Generator 400 V.
Generator 6.6 KV.

4. Biogas Power Plant, Chiang Mai University

Overview:

- Demonstration project.
- Technique = Water scrubbing
- Capacity = 200 kg/day
- Utilization = Fuel for vehicle

Objectives:

- To understand the bio gas power technology in detail
- To study about the process of producing Compressed Biomethane Gas

Observation and Details:

This plant is first Clean Development Mechanism in Thailand and fifth in the world. This plant utilizes the bio gas produced from anaerobic process using waste from pig farm and various waste around the university. The biogas is a renewable energy which mainly contains methane. Two types of technology is used to generate the biogas which are described below:

CSTR Technology

Biogas is produced in Continuously Stirred Tank Reactor (CSTR). CSTR makes solution intensity equally in whole area in reactor without using air. This reactor had been developed from the conventional anaerobic digester which has low efficiency and takes so long time for digestion. The efficiency of CSTR is increased by installing the paddle or screw to increase more contact or touch between nutrient and microorganism. And this technology is suitable for producing biogas from wastewater containing high suspended solids or solid wastes.

Output of CSTR give the biogas, and biogas consists of Methane (CH_4), Carbon Dioxide (CO_2) Oxygen (O_2), Nitrogen (N_2), Hydrogen Sulfide ( ) and moisture. Hydrogen Sulfide and moisture is removed from biogas using following methods. Removal process uses many tanks that fully consist of steel wool and flow biogas into and out of tank in every tank or using bio filter that has very big size compared with tank. Condensation process is used for removing vapor or decreasing RH value in biogas or use gas dryer system. Finally, Biogas is used to produce electricity using induction generator.

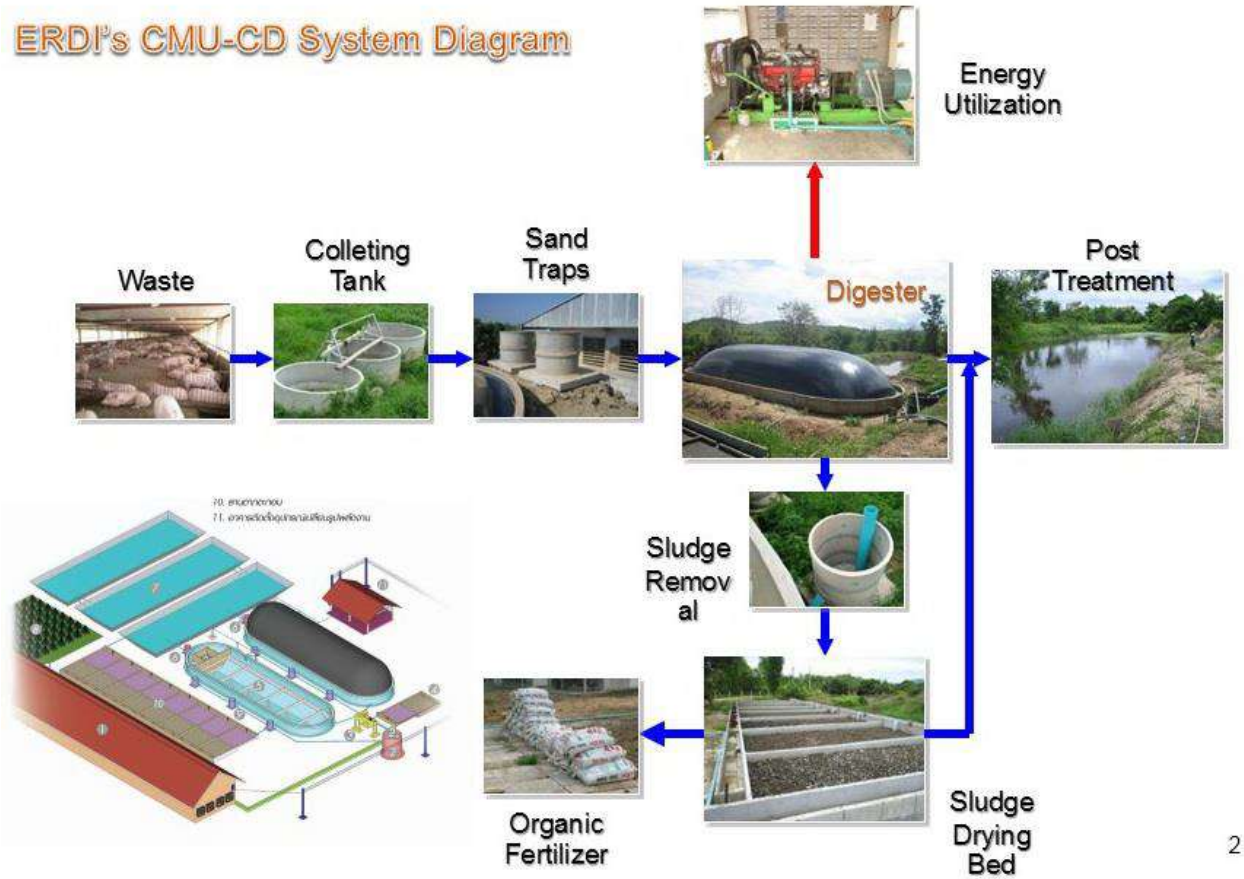
CBG Technology

Compressed Biomethane Gas (CBG) is biogas that undergoes quality upgrading process by removing carbon dioxide (CO_2), hydrogen sulfide, moisture and increasing its heating value to match the vehicle fuel specification. Therefore, it can be directly used as the replacement for compressed natural gas. This clean and green CBG, produced from waste, is the only form of renewable energy for natural gas fueled vehicles. The Water scrubbing technology is used to produce CBG which is quite complicated process. First, water is sprayed at the top of absorber, and raw gas is compressed to 3 bars at bottom of absorber by compressor and dissolves with sprayed water in absorber, and the amount of methane increases called biomethane gas. Then biomethane gas will be delivered to the storage. After that the compressor sucks bio methane gas from storage to NGV/CNG tank with higher pressure at 200 bar called Compressed Biomethane Gas (CBG). The water which has and dissolved will be sent to flash tank. Flash tank will separate some methane that dissolves, and send water with and to de-absorber. Water sprays to the top of desorber, and the ambient air is

bringing to the bottom for rushing these separated gas process. This plant produce 48 cubic meter CBG per day at pressure of 200 bar and among this 15 kg is stored in the tank and others are delivered to fuel the vehicle.

Impression and Conclusion:

The main purpose of the plant is waste water treatment and biogas is produced as a byproduct. Equalization tank is used to collect waste water from pig farm which is then pumped to digester and anaerobic digestion is done there. Since this plant is a demonstration plant so the bio fuel is used for transportation within the university. Storage tank made up of ceramic and fiber is used for storing CBG. 20 kg of CBG can be used to drive 200 km. The composition of CBG basically consists of methane (84%). CO_2 emission per day during full operation is 60 kg. Calorific value of gas (40.33-40.57) is maintained within the standard value of NGV.



5. Mae Moh Coal Mine, Lampang

Overview:

Type = Thermal power plant (Fuel = lignite)

Capacity = 10 units (150 * 4 + 300 * 6 =2400 MW)

Coal property:

Moisture = 30-32% (by weight)

Ash = 20-26 % (by weight)

Volatile matter = 22-32% (by weight)

Fixed carbon = 15-23% (by weight)

Heating value = LHV (2450 kcal/kg) and HHV (2750 kcal/kg)

Sulphur = 2.4-3.5% (by weight)

Objectives:

- To study about the process of electricity generation from coal mine power plant.
- To study about the way of reducing environmental hazards from this plant.

Observations and details:

Excavated lignite is passed into pulverizer to grind it for easy burning with high efficiency and is passed into the boiler furnace. After coal has been burnt, the waste ash is delivered downward and taken out of furnace. The heat from combustion of the coal boils water in the boiler to produce steam. The steam is then piped to a turbine. The high pressure steam impinges and expands across a number of sets of blades in the turbine. The high pressure steam impinges and expands across a number of sets of blades in the turbine. Rotation of the turbine rotates the generator rotor to produce electricity based of Faraday's Principle of electromagnetic induction.

During the coal combustion in furnace, raw flue gas go out and flow to ESP (Electrostatic

Precipitator) that has efficiency 99.5% which is supplied at voltage of 6.6 kV. ESP consists of collecting plate that hang in parallel in positive charge and emitting coil that hang between both plates, negative charge. Flue gas particle move to plate and collected downward into hopper and out of ESP.

Lime stone ($CaCO_3$) is used to catch sulfur dioxide with oxidation air and water, and this chemical reaction gives Gypsum ($CaSO_4.2H_2O$) and carbon dioxide. This chemical process calls Flue Gas Desulfurization (FGD) which consists of CO2 going out of stack to atmosphere and Calcium Sulfur Dehydrate (Gypsum) is taken for sell. Mae Moh power plant has 10 units, number 4-13. Using four pulverizer and one left for standby in each plant. Plant number 4-7 capacity is 150 MW in each plant and plant number 8-13 capacity is 300 MW in each plant and the overall capacity is 24,000 MW.

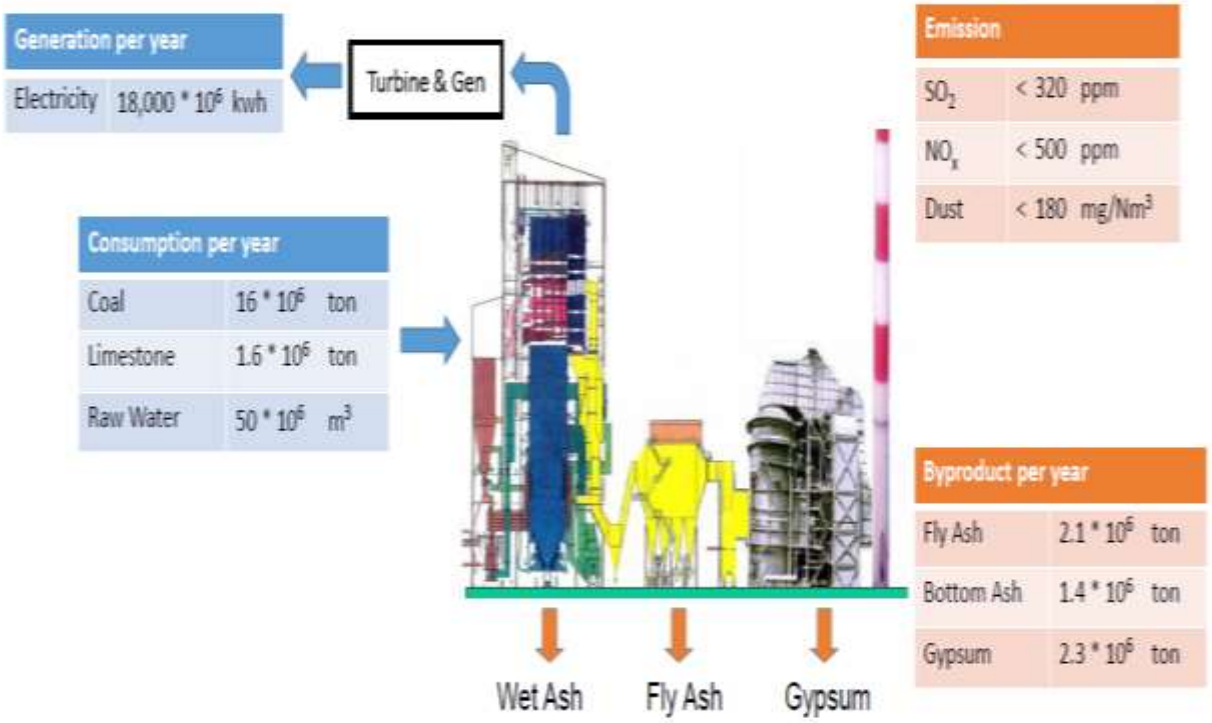
This plant has its own coal mine near to the plant and from that mine lignite is excavated and transported to the plant. Mae Moh power plant consumes lignite 45,000 tons per day or 16 million tons per year. Raw water consume every day about 133,000 in the steaming and cooling process, and lime stone to desulfurize for 3,600 tons in every day in flue gas desulfurization. The overall efficiency of the plant is 30-35 percent.

Ash produced is 3.6 mtons per year. Gypsum collecting out of process by flue gas desulfurization system is 2.1 mtons per year and sulfur dioxide is reduced by chemical process or desulfurization. Nitrogen oxide controlled by low-NOx burner.

There is also waste water treatment plant. There are 11 environment pollution measuring units around the plant area and 1 point at stack for each unit to measure CO2 and other gas emissions.

Impression and Conclusion:

Mae Moh power plant has maintained air pollution (SO_2, NO_x, TSP) under the regulation value by using different technologies such as FGD, ESP, etc. Sulfur dioxide emission is around 50-100 ppm, but the regulation standard is 320 ppm. Nitrogen oxide is 250-400 ppm but the regulation standard is 500 ppm. Dust particles out of stack are about 20 mg/m3, while standard is 180 mg/m3. In addition to this it has also adopted ash management system. Fly ash (about 60%) is used as construction materials whereas dry ash (about 40%) is transported to ash dump pit. In conclusion, EGAT is also very conscious about the environment around the plant rather than only generating the electricity.



6. Transmission substation (230/115 kV), Phitsanulok 2

Objectives:

- To study different component of a substation.

Observations and Details:

230/115 kV Transmission sub-station is located at Northern Region Operation Area, Electricity Generation Authority of Thailand (EGAT), Phrom Phiram district, Phitsanulok. The Northern region of Thailand consumes approximately 2,000 MW. It receives power from 4 power plants (Mae Moh, HongSa, Bhumibol Hydro, Sirikit Hydro), distributes to 44 substations and 17 provinces. The total length = up to which this substation supplies power is about 8444 km. The substation has 3 tie transformers each of 200 MVA 230/115kV and 2 Load transformers with rating 25MVA, 230/22kV.

The substation uses Gas Insulated Circuit Breakers, Lighting Arrestors, Earthing system and instrument transformers etc. for protection. The substation has 115kV fixed capacitor bank of 26.4MVAr to control reactive power in the transmission lines. 230/115kV has now Main and Transfer bus bar scheme and is going to be soon upgraded to Double Main & Transfer bus bar scheme. And, 115kV SWYD has Breaker and Half configuration. The station uses SCADA system for monitoring the active and reactive power by maintaining almost constant voltage and frequency in the system.

Impression and Conclusion:

Electricity Generation Authority of Thailand (EGAT) is the main body that manages and monitors Thailand's energy system. It does so through different Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA). EGAT has control over the Generation, Transmission and Distribution System. Phitsanulok substation is a part of EGAT. It also owns different substations. It serves for Power system control, Transmission line maintenance, Substation equipment maintenance and Communication system maintenance.

EGAT transmits electrical power through this substation to two groups of customer: Direct customer (Industries) and Provincial Electricity Authority (PEA). The transmission line is of different voltage level i.e.500 kV, 230 kV and 115 kV.

7. Sirikit Oilfield, Lankrabue, Kampaengphet

Objectives:

- To understand the process of oil exploration, production and refining

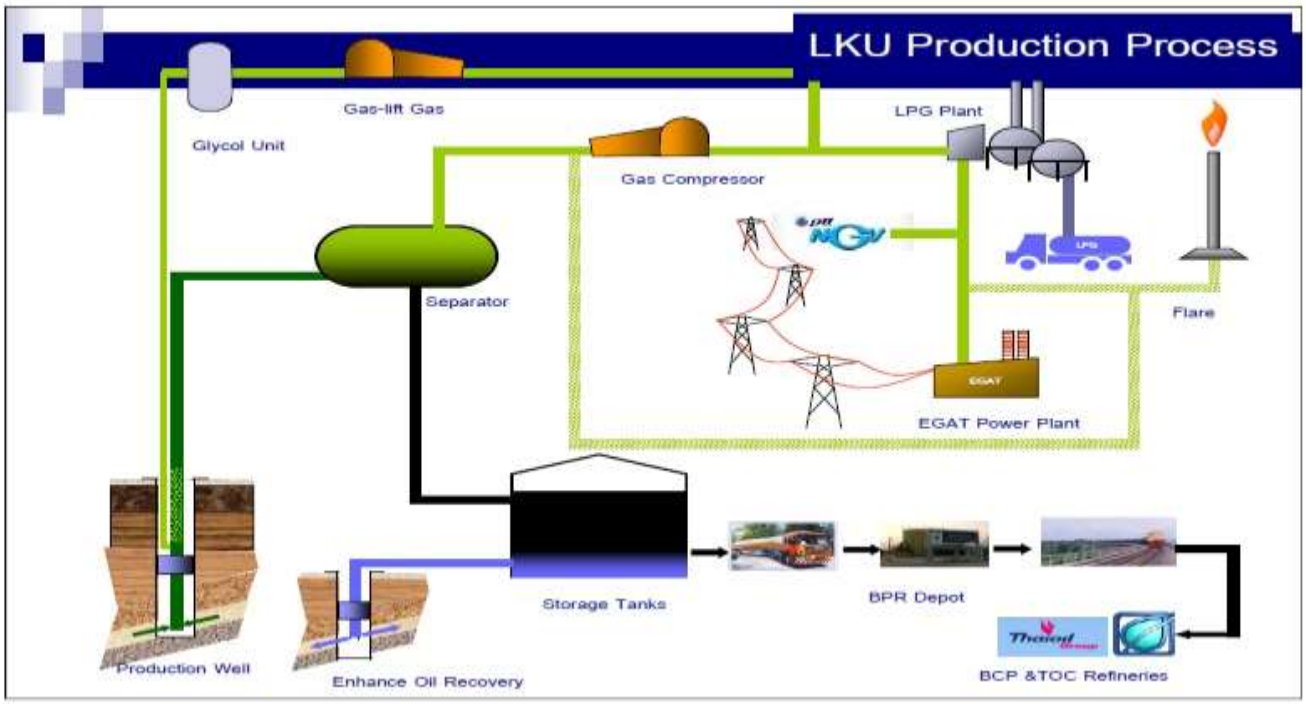
Observations and Details:

Seismic survey is used to map a 3D model of what lies below the surface area. If survey shows the presence of oil in significant amount which is economical to produce, then the hole is drilled. After drilling is done geologist will take samples and analyse the properties. The first 10% will flow out due to the pressure.

Pump is used to pump up the oil after the pressure dropped. The electric motor moves a lever up and down; the rod is attached to a sucker rod. The motion create a suction drawing oil up from well. The new drilling is setting up, the setup takes 7 days and the drilling takes another 7 days. The pumping runs 24 hours, every day. There are 60 wells now producing crude oil. The refinery is on site, however upon visit, the refinery site was closed on schedule for maintenance. The refinery consists of two burner one atmospheric burner and second one is vacuum burner. The crude oil is heated upto 335^{o}C in the first burner and remove the moisture content of the oil and reduced crude oil is passed through the second burner and heated up to 385^{o}C. The three products after refining are high speed diesel, kerosene and gasoline. Most of the oil produced from this plant is supplied to fulfill the need of Thai military.

Impression and Conclusion:

Fang Oil field is the oldest oil field in Thailand and is still producing oil. The first oil seepage was found on the ground surface in the dense jungle over a hundred years ago by local inhabitants. The oilfield has been investigated by pioneer explorers from different government sectors involved in oil exploration and production. When the Defense Energy Department (DED) took responsibility for the site in 1956, a new era of modern technologies of geological survey, 3-D seismic survey, and directional drilling wells have been seriously applied.


LKU Production Process
Gas-lift Gas
Glycol Unit
LPG Plant
Gas Compressor
Separator
Flare
EGAT Power Plant
Storage Tanks
BPR Depot
Production Well
Enhance Oil Recovery
BCP &TOC Refineries

8. Rice Husk Power Plant, Phichit

Objectives:

- To study the overall biomass power plant process by using rice husk as fuel.
- To know how each equipment in each part of process doing.

Observations and Details:

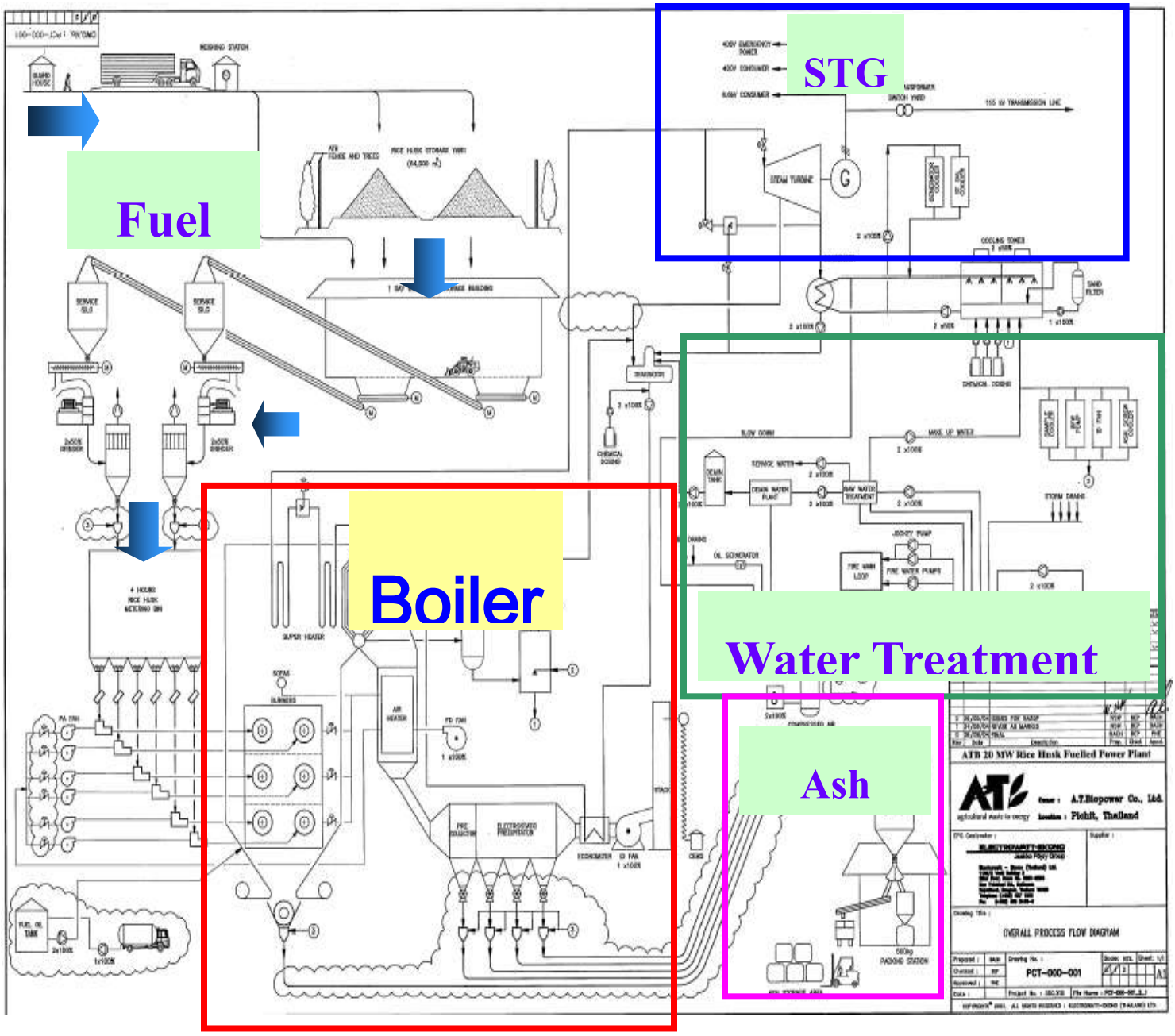
The production process starts with the continuous conveying of rice husks in a sequential order as follows: from the storage yard to the indoor storage, to the grinder, to the service silo and finally to the furnace chamber of a boiler. Rice husks will be burned at a temperature of 800- 900^{o}C. The resulting thermal energy will be used to boil water to generate steam of 485^{o}C at pressure of 65 bars. This steam will be used to move the turbines of a generator to generate electricity. Steam which has passed the electricity generation process will be cooled down by a condenser. This will then be transported as drops of water to a boiler to be recycled as steam. Meanwhile, the cooling water used for condensing steam, which now become hotter will be cooled in a cooling tower for reuse. This system is thus a closed-circuit type cooling system. Rice husk power plant consume rice husk around 450 tons per day or 14,000 tons per month to produce electricity. The capacity of the plant is 22.5 MW and Power export to EGAT grid is 20MW and has contract agreement of 25 years with EGAT. During the process, the bi product ash has been taken to sell by amount of 80 tons per day. This plant sucks water from the river named Nan River with amount of 1,500 per day, and zero waste water discharge.

The specific rice husk consumption is 1.04 kg/kWh and produces 91 tons of steam per hour. It generates electricity at 6.6 kV and step up to 115 kV before connecting to EGAT grid. The plant has aim to operate not less than 4600 hour per year. The stored rice husk is sufficient only to operate plant for one month. The plant has hot start time of about 2 hours, warm start time of 5 hour and cold start time of 10 hours approximately.

AT bio power buy rice husk in price of 1,400 baht per kg and sell electricity to EGAT with a price of 400 bhat/kW per month plus 3.5 baht per kWh.

Impressions and Conclusion:

This plant using a new technology of furnace, separate a rich husk at the top and hard husk at the bottom. Old technology is convey rice husk on the conveyor into furnace and then burn directly. Using a very high efficiency of ESP, the efficiency is up to 99%. There is no waste water discharge. Biomass power plant use the bioplant such as rice husk or sugarcane as a fuel and produce much electricity to selling to grid in the MV line of EGAT. Biomass power plant takes long time for establish, install and completion for around 2 years, then plant can be started up.


STG
Fuel
Boiler
Water Treatment
Ash
ATB 20 MW Rice Husk Fuelled Power Plant
A.T.Biopower Co., Ltd.
Pichit, Thailand
OVERALL PROCESS FLOW DIAGRAM
PCT-000-001

9. Wind-turbine (EGAT), Lamtakhong, Nakhon Ratchasima

Objectives:

- To learn how wind turbine works
- To know the advantages and disadvantages of wind turbine

Observations and Details:

The total capacity of the plant is (2×1.25) MW. The wind speed obtainable is around 5-6 m/sec. The plant has wind turbine height of 68 m with the blade's diameter of 64 m. The wind strikes on the 3 blades which are held high. 3 blades of wind turbine is perfect about balance that has not have wobble problem, but has a slightly less efficiency in comparison to single or double blade wind turbine plant. The cut-in wind speed is 2.8 m/sec and cut-out wind speed is 23 m/sec. The rated wind speed is 12.5m/sec. The rotor part of the 3-phase generator (DFIG) is coupled with the rotating motion of the blades thereby generating maximum power 1250 kW, revolution speed at 1100 rpm.

Impression and Conclusion:

Wind turbine has no pollution to environment, except noise when the blade against wind but it is not too loud. Properly design of wind turbine is 3 blade, it looks very suitable with column and beautiful. Producing a clean electricity by using clean source or renewable source. The wind turbine power plant can produce very much of electricity unit per each turbine by using the free energy or renewable energy and can distribute electricity to household in province area or selling back to EGAT.