CHAPTER VI

COST PERFORMANCE CRITERIA

In this study the cost performance is measured in cost/electricity unit (Baht/kWh) which is consist of three main costs that is Production Cost, Environment Cost and Social Cost.

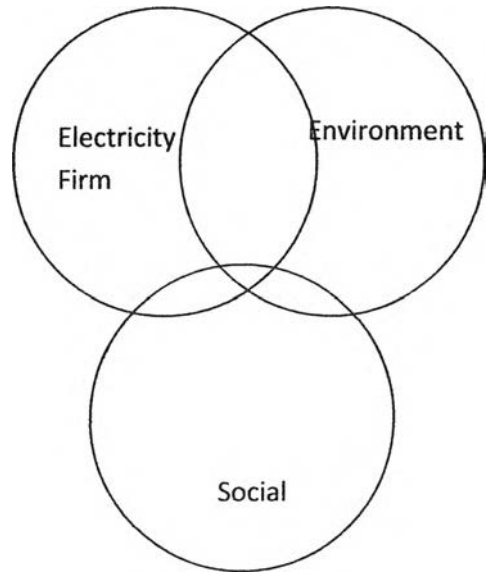

Figure 6-1 the responsible care integration of electricity firm

so total cost will be form in this award formula

$$\text{Total Cost} = \text{Production Cost} + \text{Environment Cost} + \text{Social Cost} \qquad (1)$$

From the formula (1) , the details of production cost , environmental cost and social cost will be describes as following

6.1 Production Cost

Production Cost of electricity include investment cost, fuel cost , Operation and Maintenance Cost (O&M) so production cost will form be in this formula (from feasibility study)

Production Cost =

Investment Cost + Fuel Cost + Operation and Maintenance Cost + Energy Fund + Insurance (2)

Each cost will be describes as follows

6.1.1 Investment Cost

A summary of capital cost estimate was developed for each power plant technology, based on a facility of a certain size (capacity). The total project is engineering, procurement and construction (EPC).

In the feasibility formula

Investment Cost = Plant Cost + Transmission Cost + Import Duty & Taxes + Escalation + Energy Fund + IDC + Front End-Fee + Commitment Fee (3)

6.1.1.1 Plant Cost

Plant Cost is the accumulate cost of equipments in the power plant such as gas turbine , steam turbine , HRSG , Cooling Tower ,etc as below

- Gas Turbines

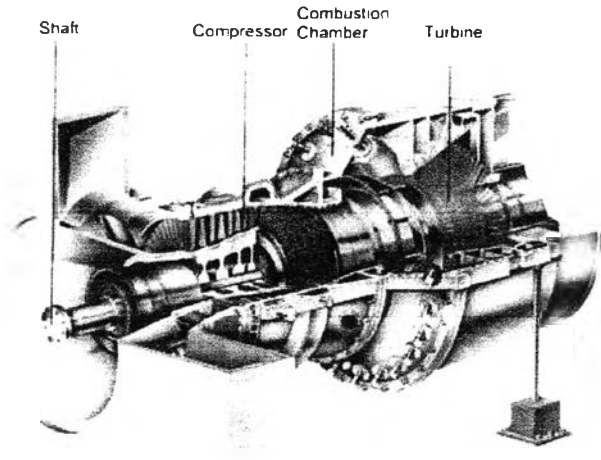

Figure 6-2 Gas Turbine or Combustion Turbine

- Steam Turbines

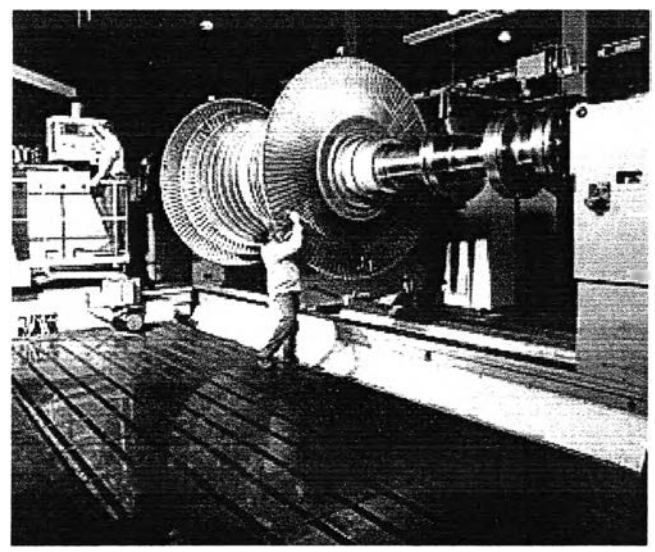

Figure 6-3 Steam Turbine

- Generator

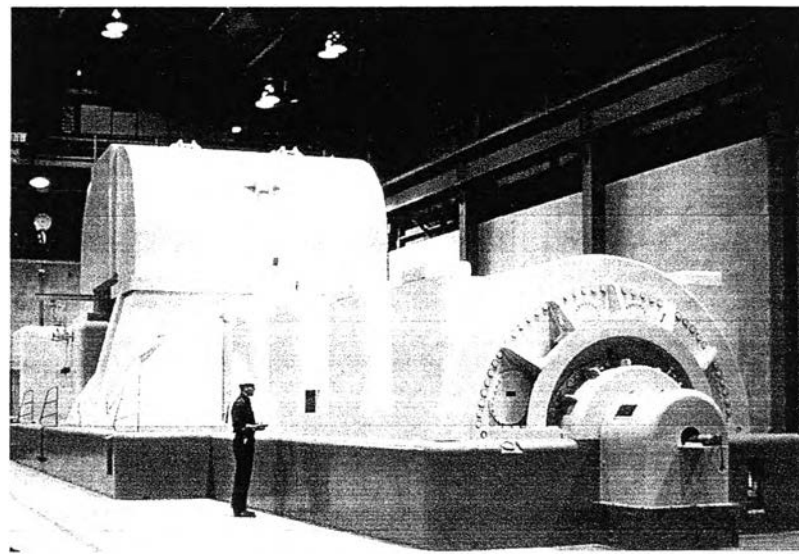

Figure 6-4 Electricity Generator

- Heat Recovery Steam Generators (HRSG)

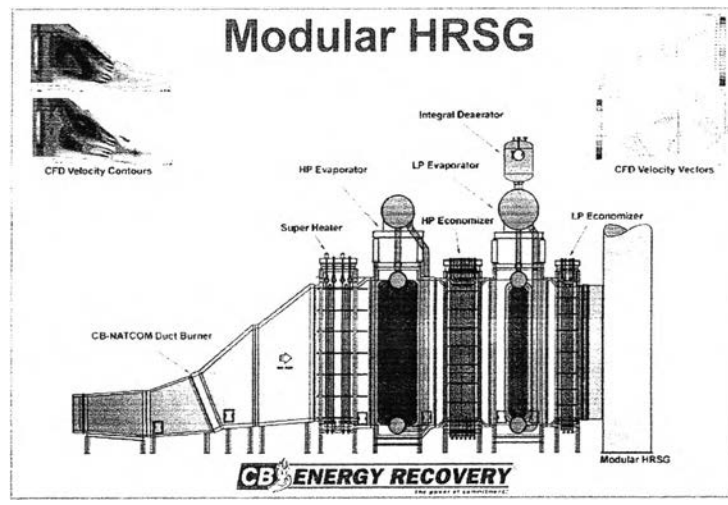

Figure 6-5 Heat Recovery Steam Generator (HRSG)

- Cooling Tower

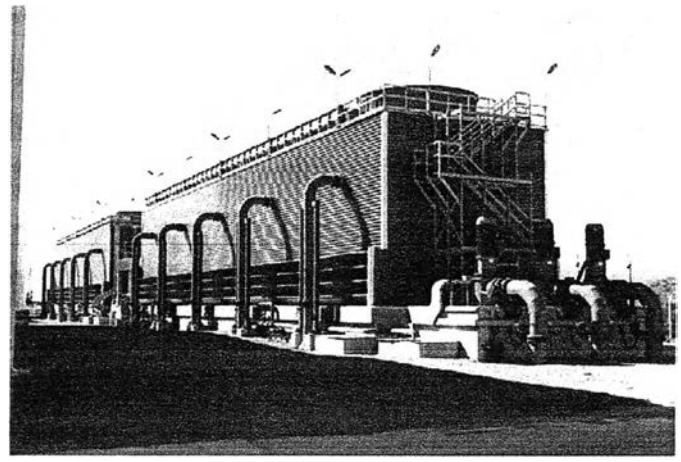

Figure 6-6 Cooling Tower

- Balance of Plant (BOP)

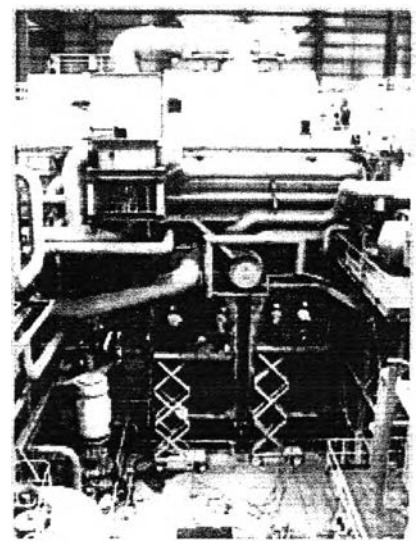

Figure 6-7 Balance of plant.

- Site Preparation & Civil Work

Site Preparation is the area preparation for construction and civil work.Civil Work is the process of construction in civil as piling , foundation preparation , excavation , concrete formwork reinforcement and structure work.

- Erection & Installation

Erection & Installation of all equipment from EPC Contract (Engineering ,Procurement and Construction) of the power plant.

6.1.2 Transmission Cost

Electricity transmission is the transferation of electrical energy from the source which generate power to local demand centers. This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as electric power distribution.

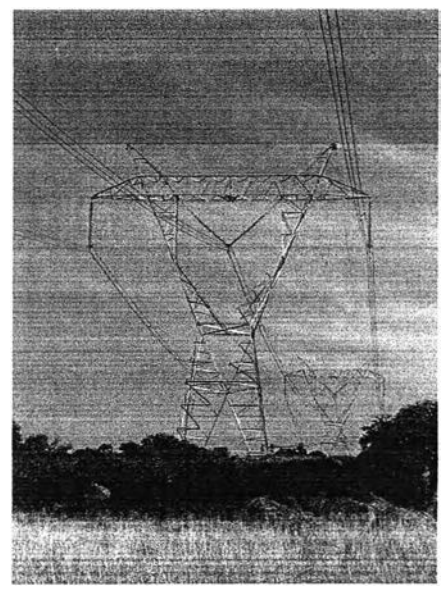

Figure 6-8 Transmission system.

6.1.3 Import Duty & Taxes

A tax collected on imports and some exports by the customs authorities of a country. This tax is used to raise state revenue. (http://www.investopedia.com/terms/i/import-duty.asp#ixzz25Spz8kPA)

6.1.4 Escalation

Cost escalation is defined as changes in the cost or price of specific goods or services in a given economy over a period. This is a similar to the concepts of inflation and deflation except that escalation is specific to an item or class of items.

6.1.5 Energy Fund

A fund shall be set up in the Office, under the name " Power Development Fund " with objectives to provide financial support for energy service extension to various localities. (Energy Regulatory Commission :Energy Industry Act 2007)

6.1.6 IDC (Interest During Construction)

The IDC is a cost for the project, though it is not always calculated as such. The IDC is calculated until the project begins to generate revenue.

6.1.7 Front End-Fee

Front End Fee is a commission or sales charge applied at the time of the initial purchase for an investment.

6.1.8 Commitment Fee

A fee charged by a lender to a borrower for an unused credit line or undisbursed loan.

It should be noted that an EPC (turnkey) or equipment supply and balance of plant, as applicable to a chosen technology. The investment cost will be included plant cost, transmission cost and working capital . In this study all of investment cost has a unit in Baht/kWh (Baht/unit).

Table 6-1 Investment cost of each power plant

Fuel types	Investment cost (Baht/kw)
Small Hydro	87,200
Gas (Combined cycle)	24,718
Gas (Combustion Turbine)	14,858
Coal	52,700
Nuclear	104,958
Solar	250,002
Wind	89,998
Biomass	70,006
Municipal Solid Waste	170,000

Reference : EGAT projects

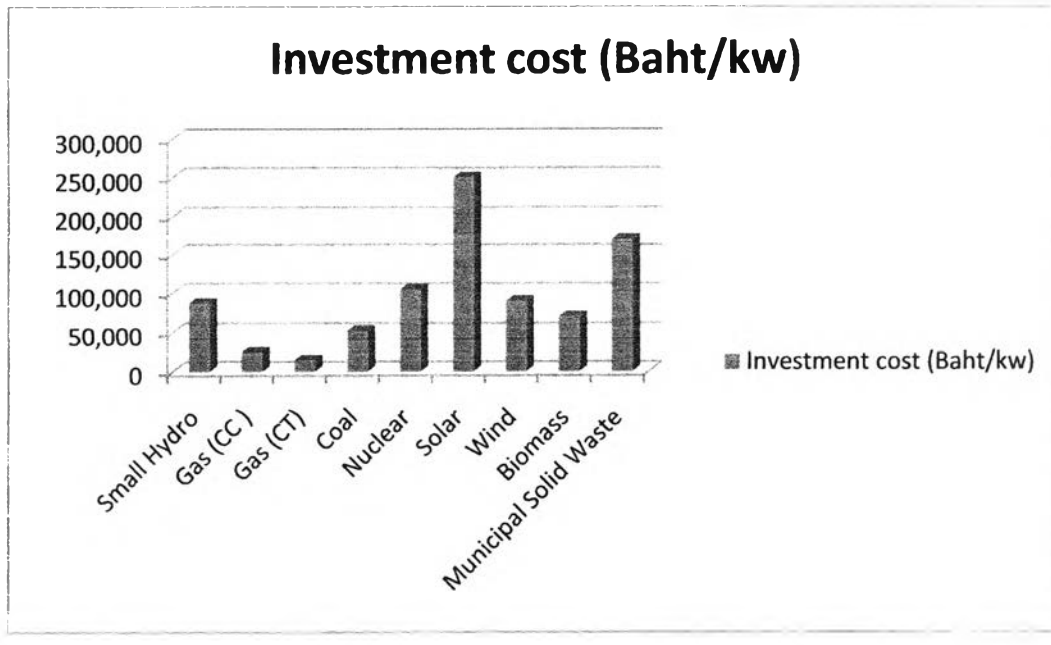

Figure 6-9 Investment cost of each power plant

6.2 Fuel Cost (Baht/kWh)

Fuel cost in a variable cost of source of energy such as coal, natural gas ,etc. Fuel cost is in term of cost / unit of each source of energy as shown in the Table

Table 6-2 shown fuel cost by each source of energy from 2012 to 2030

Year	Fuel Cost				
	Natural gas (baht/MMbtu)	Coal (Baht/ton)	Heavy Oil (Baht/Litre)	Diesel Oil (Baht/Litre)	Nuclear (baht/MMbtu)
2012	274.74	2,950.30	17.22	29.56	15.98
2013	280.24	3,154.12	17.81	30.42	15.98
2014	285.84	3,337.28	18.37	31.28	15.98
2015	291.56	3,440.52	19.18	32.21	16.46
2016	297.17	3,536.94	20.09	33.24	16.46
2017	304.52	3,639.43	21.09	34.36	16.46
2018	310.47	3,739.55	22.07	35.47	16.46
2019	316.06	3,862.48	23.32	36.86	16.46
2020	320.97	4,004.66	24.62	38.29	16.95
2021	328.31	4,062.62	25.10	38.90	16.95
2022	331.47	4,121.39	25.59	39.53	16.95
2023	334.62	4,181.32	26.09	40.16	16.95
2024	337.77	4,242.07	26.60	40.82	16.95
2025	340.92	4,319.31	26.86	41.22	17.46
2026	344.06	4,379.04	27.13	41.64	17.46
2027	347.22	4,439.97	27.40	42.05	17.46
2028	350.72	4,501.45	27.68	42.47	17.46
2029	353.83	4,564.16	27.95	42.90	17.46
2030	357.37	4,647.84	28.23	43.33	17.98

6.3 Operation and Maintenance Cost

Operation and Maintenance expenses consist of non-fuel O&M costs, owner's expenses, and fuel-related expenses. In evaluating the non-fuel O&M expenses. Production Related Non-Fuel O&M Expenses include the following categories:

- Fixed O&M ("FOM")
- Variable O&M ("VOM")

6.4 Environment Cost

In this study, we focus on the release of air pollutants and greenhouse gases from the combustion of fossil fuels—coal, oil, and natural gas—at large power plants.

The key primary pollutants of concern produced by fossil fuel power plants include CO2 ,SO2 and NOx . The releases of CO2 is an important pollutants called "greenhouse gas" (GHG).

6.4.1 Carbon Dioxide

CO_2 is the most abundant greenhouse gas (GHG) emitted from human activities. Greenhouse gases in the atmosphere absorb infrared light that would otherwise pass through the air on its way to outer space. By storing the light's energy in the atmosphere, greenhouse gases warm the planet significantly, making conditions more amenable to life. Rising concentrations of greenhouse gases beyond recent natural levels due to human activities increase the atmosphere's capacity to absorb energy from light, which in turn can raise the average global temperature. This change may affect global weather patterns, which can lead to rising sea levels, destruction of animal and plant habitat, increased frequency and severity of storms, glacial melting, and drought

6.4.2 Nitrogen Oxide

Emissions of NO_x contribute to smog formation (ground-level ozone), resulting in human respiratory problems and crop damage. Like SO_2, NO_x contributes to fine particulate formation (particularly during cold weather) and acid rain.

6.4.3 Sulfur Dioxide (SO_2)

Fine particles have been linked to a number of serious human health problems, particularly among children, the elderly, and individuals with pre-existing cardiovascular or lung diseases (e.g., asthma), which can result in harm to fish and other aquatic life, forests, crops, buildings, and monuments. Fine particles formed from SO_2 emissions also are significant contributors to poor visibility. Coal and oil both contain varying concentrations of sulfur, with the result that power plants create SO_2 when burning these fuels. Natural gas is a relatively minor source of SO_2 during combustion.

6.5 Emission Treatment System

Emission Treatment Cost is the cost to treatment of the emission such as CO_2 , NO_x and SO_x to have quantity below in standard. In this paper emission treatment cost will be a treatment equipment cost included in plant cost when construct the power plant.

6.5.1 Carbon Dioxide

The equipment to capture carbon dioxide is Carbon Capture and Sequestration (CCS). The concept of carbon sequestration is to put carbon dioxide somewhere other than into the atmosphere. There are two basic methods of sequestering carbon: geologic sequestration and terrestrial sequestration.

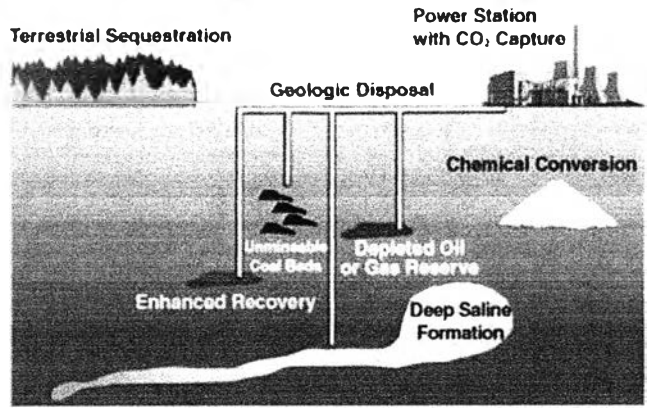

Figure 6-10 Carbon Capture and Sequestration

6.5.2 Nitrogen Oxide

Thermal NO_x Emission occur from 2 main causes that first is combustion temperature, second is long period in fuel combustion of air and fuel. The equipment to reduce NO_x emission is called " Dry Low NO_x (DLN) Burner " for control NOx emission in Flue Gas of combustion turbine engine by the principke of reduction of combustion temperature by modify combustion technique instead of directly water injection to the combustion zone.

The DLN Burner design principle is as follow

- Combustion design by more of air quantity than the air demanded in normal combustion to lower combustion temperature.
- DLN Burner will bring the air and fuel to mix together before intake to the combustion zone for more quick and complete combustion.

The 2 main design principle can reduce NOx emission below to 120 ppmvd .In present , the combustion turbine producer can design NOx emission control below to 70 ppmvd . For lessen impact from air quality , EGAT had set NOx emission control point at 70 ppmvd.

6.5.3 Sulfur Dioxide (SO_2)

Flue-gas desulfurization (FGD) is a set of technologies used to remove sulfur dioxide (SO_2) from exhaust flue gases of fossil-fuel power plants, and from the emissions of other sulfur oxide emitting processes.

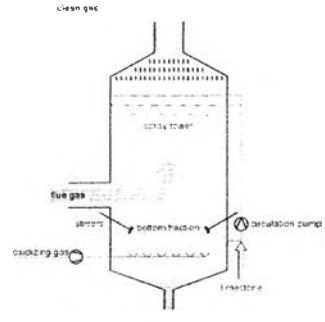

Figure 6-11 Flue-gas desulfurization (FGD)

6.5.4 Continuous Emission Monitoring Systems (CEMS)

Continuous Emission Monitoring Systems (CEMS) refers to a packaged system of gas analyzer, gas sampling system, gas temperature, flow and opacity monitors.

6.5.5 Noise pollution

Absorbing silencers are used for broad spectrum noise sources such as occur at the inlet and outlet of gas turbines and cooling towers.

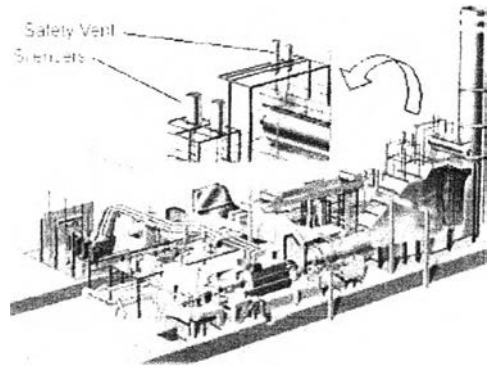

Figure 6-12 Silencer for power plant

6.5.6 Water treatment

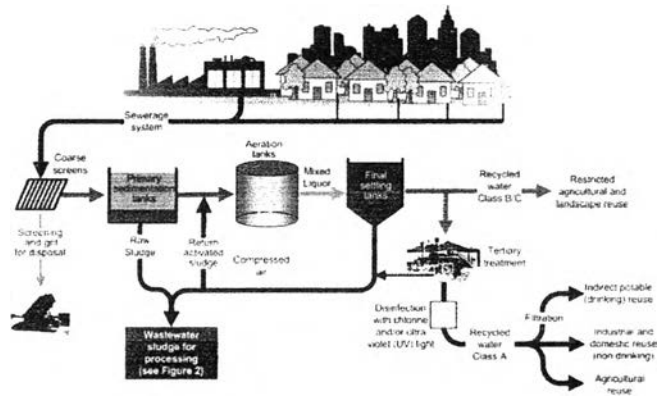

Figure 6-13 Processes in a typical wastewater (sewage) treatment plant

Water treatment is done for different purposes and there are water treatment plants serving different applications.

Table 6-3 Emission treatment system installation in each type of power plant in Thailand

Fuel types	CCS	Dry Low NOx Burner	FGD	CEMs	Water Treatment Plant	Silencer
Hydro						
Natural Gas		/		/	/	/
Heavy Oil				/	/	/
Diesel				/	/	/
Coal			/	/	/	/
Renewable Energy				/		
Nuclear				/	/	

So the environmental cost will be

Enniromental Cost = Air Treatment + Water Treatment + Noise Treatment (4)

Which

Air Treatment = CCS cost + DLN Burner cost + FGD cost + CEMs (5)

Table 6-4 Enviromental cost for each Emssion Treatment system

Emssion Treatment system	Emission system cost (Million Baht)
Carbon Capture and Sequestration (CCS)	558.00
Dry Low NO_x (DLN) Burner	510.00
Flue-gas desulfurization (FGD)	6,000.00
Continuous Emission Monitoring Systems (CEMS)	450.00
Water treatment plant	420.00
Silencers	280.00

6.6 Social Cost

Social cost is cost for social understanding to construct the power plant and cost for develop people life in area around the power plant . Social cost include the following categories:

- Social Information Announcement
- Social Connection with firm and social participation
- Education, sport , culture developing plan.
- Career encouragement
- Healthy development
- Recreation
- Social welfare