CHAPTER IV

POWER PLANT TECHNOLOGY

4.1 ADVANCED PULVERIZED COAL (APC)

4.1.1 MECHANICAL EQUIPMENT AND SYSTEMS

The following describes the Advanced Pulverized Coal Facility, which is a nominal 650 MW coal-fired supercritical steam-electric generating unit built in a Greenfield location. An analysis also provided for a nominally 1,300 MW coal-fired supercritical steam-electric generating unit built in a Greenfield location, which is essentially a dual-unit configuration.

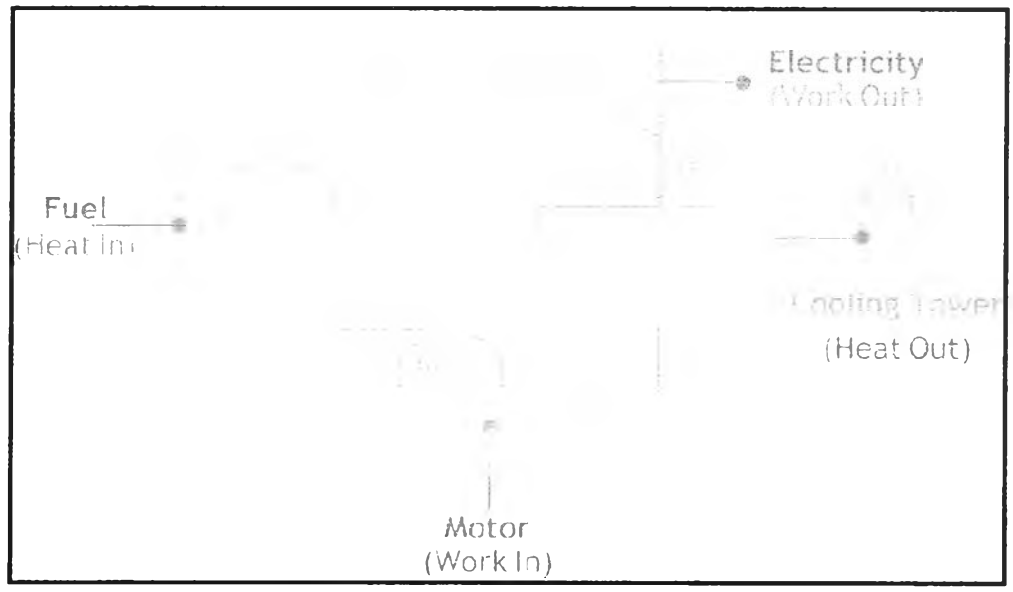

Figure 4-1 Advanced pulverized coal design configuration

4.1.2 ELECTRICAL AND CONTROL SYSTEMS

The Advanced Pulverized Coal Facility has one ST electric generator. The generator is a 60 Hertz ("Hz") machine rated at approximately 800 mega-volt-amperes ("MVA") with an output voltage of 24 kilovolts ("kV").

4.1.3 OFF-SITE REQUIREMENTS

Coal is delivered to the facility via rail, truck or barge. Water for all processes at the Advanced Pulverized Coal Facility can be obtained from one of a variety of sources.

4.1.4 O&M ESTIMATE

In addition to the general O&M,the APC Facility includes the major maintenance for boiler, ST, associated generator, BOP, and emissions reduction catalysts. These major maintenance expenses are included with the VOM expense for this technology and are given on an average basis across the megawatt-hours ("MWh") incurred. Typically,significant overhauls on an APC Facility occur no less frequently than six or seven years.Table 4-1 presents the FOM and VOM expenses for the APC Facility. Table 4-1 and Table 4-2 present the O&M expenses for the APC Facility.

Table 4-1 O&M Expenses for APC (650,000 KW)

Technology:	APC
Fixed O&M Expense	$35.97/kW-year
Variable O&M Expense	$4.25/MWh

Table 4-2 – O&M EXPENSES FOR APC (1,300,000 KW)

Technology:	APC
Fixed O&M Expense	$29.67/kW-year
Variable O&M Expense	$4.25/MWh

4.1.5 ENVIRONMENTAL COMPLIANCE INFORMATION

As mentioned in Section 1.1, the APC Facility is assumed to include low NOX combustion burners in the boiler, SCR, and a flue gas desulfurization ("FGD") to further control the emissions of NOX and SO2, respectively. Table 4-3 presents the environmental emissions for the APC Facility.

Table 4-3 – ENVIRONMENTAL EMISSIONS FOR APC

Technology:	APC
NO_X	0.06 lb/MMBtu
SO_2	0.1 lb/MMBtu
CO_2	206 lb/MMBtu

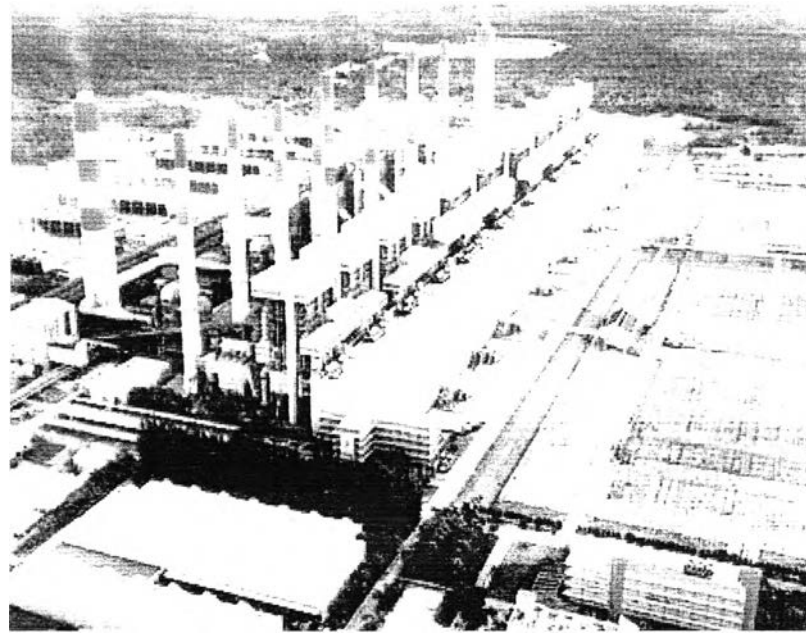

Figure 4-2 Coal Power Plant

4.2 CONVENTIONAL NATURAL GAS COMBINED CYCLE (NGCC)

4.2.1 MECHANICAL EQUIPMENT AND SYSTEMS

The Conventional NGCC produces 540 MW of net electricity. The facility utilizes two natural gas-fueled F-class CTs and associated electric generators, two supplemental-fired heat recovery steam generators ("HRSG"), and one condensing ST and associated electric generator operating in combined-cycle mode. Each CT is designed to produce nominally 172 MW and includes a dry-low NOX ("DLN") combustion system and a hydrogen-cooled electric generator. The two triple-pressure HRSGs include integrated deaerators, SCRs, oxidation catalyst for the control of carbon monoxide ("CO"), and supplemental duct firing with associated combustion management. The ST is a single-reheat condensing ST designed for variable pressure operation, designed to produce an additional 210 MW. The ST exhaust is cooled in a closed-loop condenser system with a mechanical draft cooling tower. The CTs are equipped with inlet evaporative coolers to reduce the temperature of the turbine inlet air to increase summer output. The Conventional NGCC plant also includes a raw water treatment system consisting of clarifiers and filters and a turbine hall, in which the CTs, ST, and HRSGs are enclosed to avoid freezing during periods of cold ambient temperatures. Figure 4-3 presents the Conventional NGCC process flow diagram.

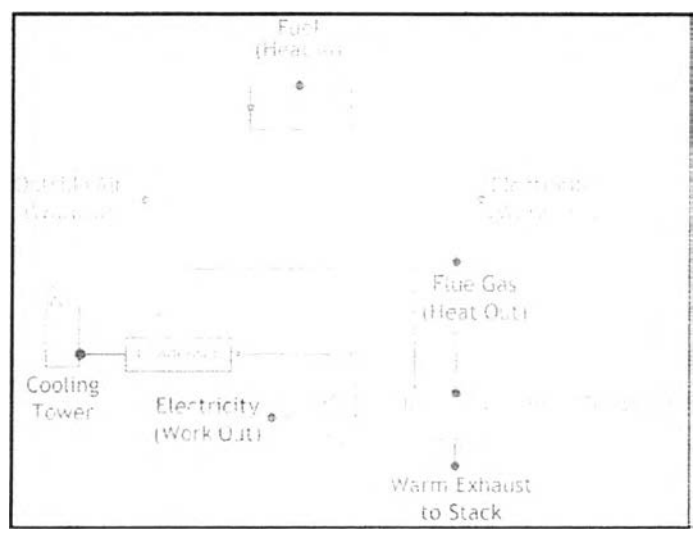

Figure 4-3 CONVENTIONAL NGCC DESIGN CONFIGURATION

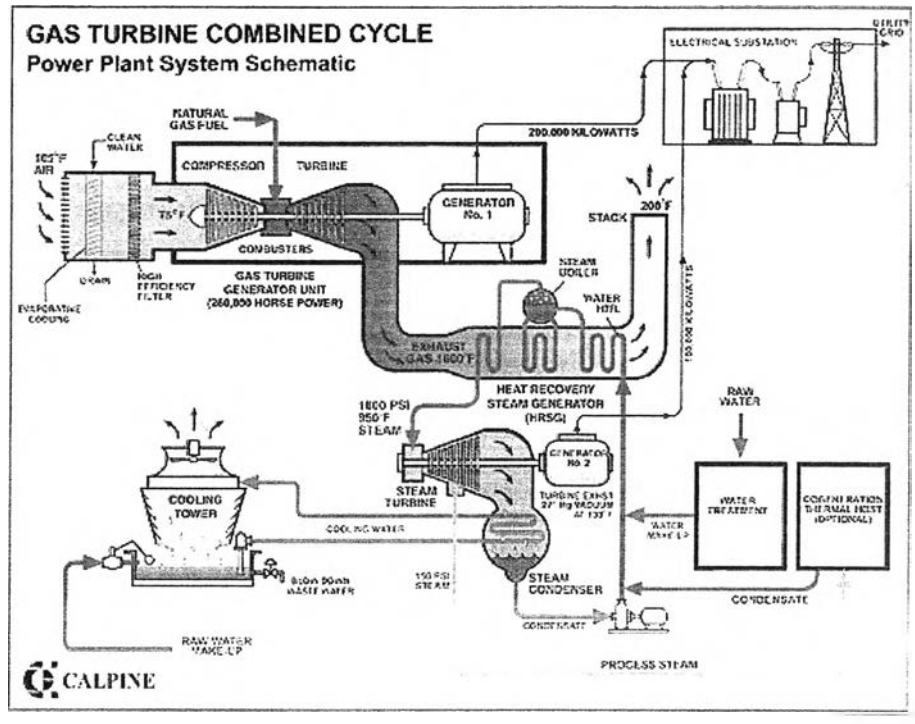

Figure 4-4 Gas Turbine Combined Cycle Power Plant System Schematic

4.2.2 ELECTRICAL AND CONTROL SYSTEMS

The Conventional NGCC has two CT electric generators and one ST electric generator. The generators for the CTs are 60 Hz and rated at approximately 215 MVA with an output voltage of 18 kV. The ST electric generator is 60 Hz and rated at approximately 310 MVA with an output voltage of 18 kV. Each CT and ST electric generator is connected to a high-voltage bus in the Conventional NGCC via a dedicated generator circuit breaker, generator GSU, and a disconnect switch. The GSUs increase the voltage from the electric generators from 18 kV to interconnected high voltage. The Conventional NGCC is controlled using a DCS. The DCS provides centralized control of the facility by integrating the control systems provided with each individual CT and associated electric generator, ST and associated electric generator, and the control of BOP systems and equipment.

4.2.3 OFF-SITE REQUIREMENTS

Natural gas is delivered to the facility through a lateral connected to the local natural gas trunk line. Water for all processes at the Conventional NGCC Facility is obtained from a one of several available water sources (e.g., municipal water supply). The Conventional NGCC Facility uses a water treatment system and a high-efficiency reverse osmosis system to reduce the

dissolved solids from the cooling water and to provide distilled water for HRSG makeup.Wastewater is sent to a municipal wastewater system. Further, the electrical interconnection from the Conventional NGCC on-site switchyard is effectuated by a connection to an adjacent utility substation.

4.2.4 O&M ESTIMATE

In addition to the general O&M , the Conventional NGCC Facility includes the major maintenance for the CTs, as well as the BOP, including the ST,associated electric generators, HRSGs, and emissions reduction catalysts. These major maintenance expenses are included with the VOM expense for this technology and are given on an average basis across the MWhs incurred. Typically, significant overhauls on a Conventional NGCC Facility occur no less frequently than 24,000 operating hour intervals. Table 4-4 presents the O&M expenses for the Conventional NGCC Facility.

Table 4-4 – O&M EXPENSES FOR CONVENTIONAL NGCC

Technology:	Conventional NGCC
Fixed O&M Expense	$14.39/kW-year
Variable O&M Expense	$3.43/MWh

4.2.5 ENVIRONMENTAL COMPLIANCE INFORMATION

The Conventional NGCC utilizes DLN combustion systems in the primary combustion zone of the CT and best available burner technology with respect to the duct burners in the HRSGs to manage the production of NOX and CO. Additional control of NOX and CO is accomplished through an SCR and an oxidization catalyst, respectively. Oxides of sulfur in the Conventional NGCC are managed through the natural gas fuel quality, which is generally very low in sulfur U.S. domestic pipeline quality natural gas, and consequently the low sulfur content translates into SO2 after combustion. The Conventional NGCC does not include any control devices for CO2, which is proportional the heat rate (inversely proportional to the efficiency) of the technology. Water, wastewater, and solid waste compliance are achieved through traditional onsite and off-site methods, and the costs for such compliance are included in the O&M estimate

for the Conventional NGCC Facility. Table 4-5 presents environmental emissions for the Conventional NGCC Facility.

Table 4-5 – ENVIRONMENTAL EMISSIONS FOR CONVENTIONAL NGCC

Technology:	Conventional NGCC
NO_X	0.0075 lb/MMBtu
SO_2	0.001 lb/MMBtu
CO_2	117 lb/MMBtu

4.3. ADVANCED GENERATION NATURAL GAS COMBINED CYCLE (AG-NGCC)

4.3.1 MECHANICAL EQUIPMENT AND SYSTEMS

The Advanced Generation ("AG")-NGCC design is the same as the Conventional NGCC, except an H-class CT is utilized in lieu of F-class, and there is only one CT/HRSG supporting the ST included. Since the H-class CT design employees steam cooling of both stationary and rotational hot parts, the HRSG systems and the ST are both considered "advanced" designs, as compared to the Conventional NGCC. The net output of the AG-NGCC is 400 MW. Figure 4-5 presents the AG-NGCC process flow diagram.

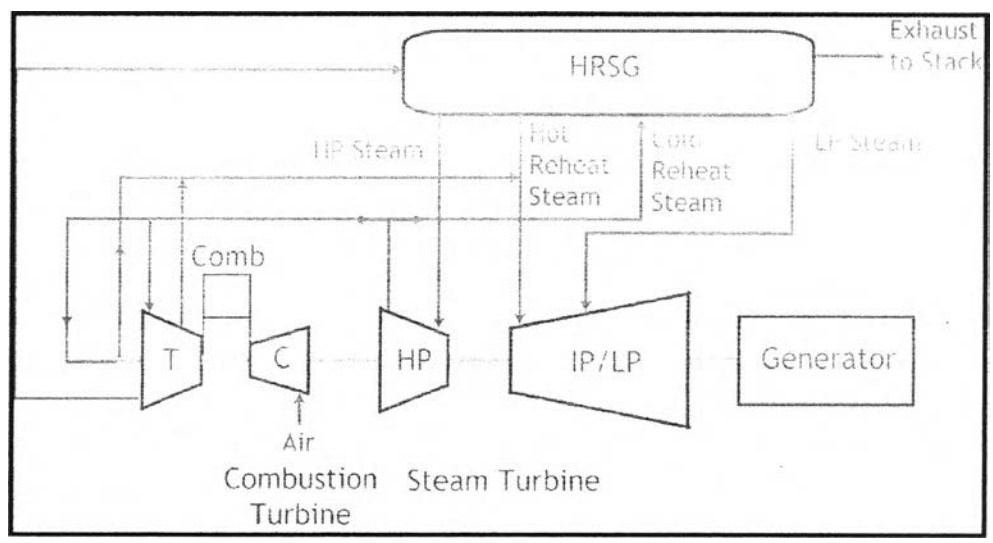

Figure 4-5 AG-NGCC DESIGN CONFIGURATION

4.3.2 ELECTRICAL AND CONTROL SYSTEMS

The AG-NGCC electrical and control systems are similar to the Conventional NGCC Facility, except that the sizing of the generators and transformers are larger to support the larger CT and ST equipment utilized in the AG-NGCC.

4.3.3 OFF-SITE REQUIREMENTS

The off-site requirements for the AG-NGCC Facility are the same as the Conventional NGC C for the description of the Conventional NGCC off-site requirements.

4.3.4 O&M ESTIMATE

The O&M items for the AG-NGCC Facility are the same as those described in NGCC for the Conventional NGCC Facility. Table 4-6 presents the O&M expenses for the AG-NGCC Facility.

Table 4-6 – O&M EXPENSES FOR AG-NGCC

Technology:	AG-NGCC
Fixed O&M Expense	$14.62/kW-year
Variable O&M Expense	$3.11/MWh

4.3.5 ENVIRONMENTAL COMPLIANCE INFORMATION

The environmental compliance strategy and equipment for the AG-NGCC Facility is the same as those described in the Conventional NGCC Facility. Table 4-7 presents environmental emissions for the AG-NGCC Facility.

Table 4-7 – ENVIRONMENTAL EMISSIONS FOR AG-NGCC

Technology:	AG-NGCC
NO_X	0.0075 lb/MMBtu
SO_2	0.001 lb/MMBtu
CO_2	117 lb/MMBtu

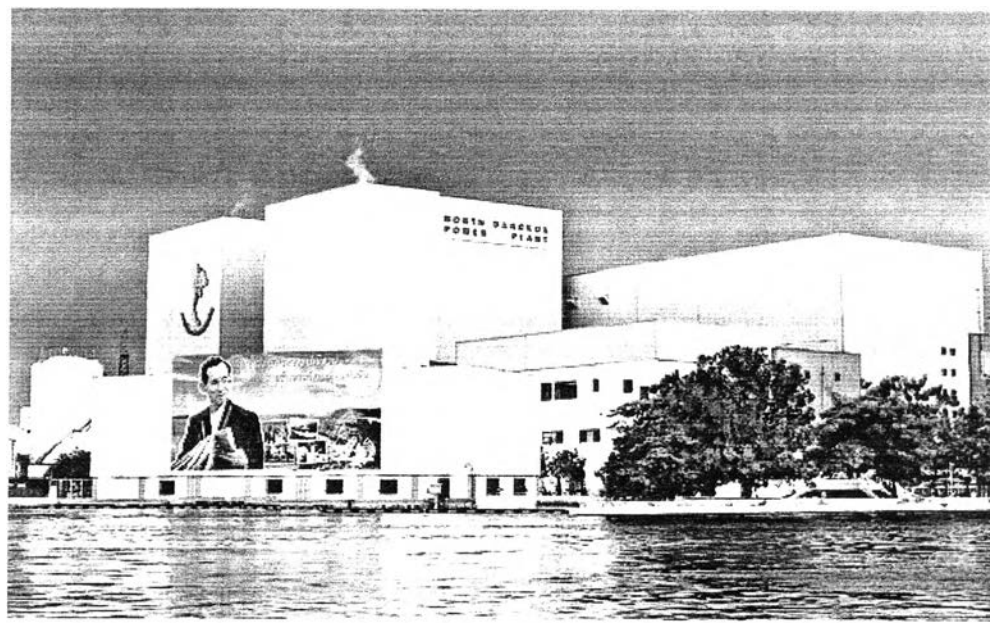

Figure 4-6 Natuaral Gas Combined Cycle Power Plant

4.4 CONVENTIONAL COMBUSTION TURBINE (CT)

4.4.1 MECHANICAL EQUIPMENT AND SYSTEMS

The Conventional CT Facility produces 85 MW of electricity using a single natural gas-fueled E-class CT and associated electric generator in simple-cycle mode. The CT is equipped with an inlet evaporative cooler to reduce the temperature of the turbine inlet air to increase summer output. Figure 4-7 presents the Conventional CT Facility process flow diagram.

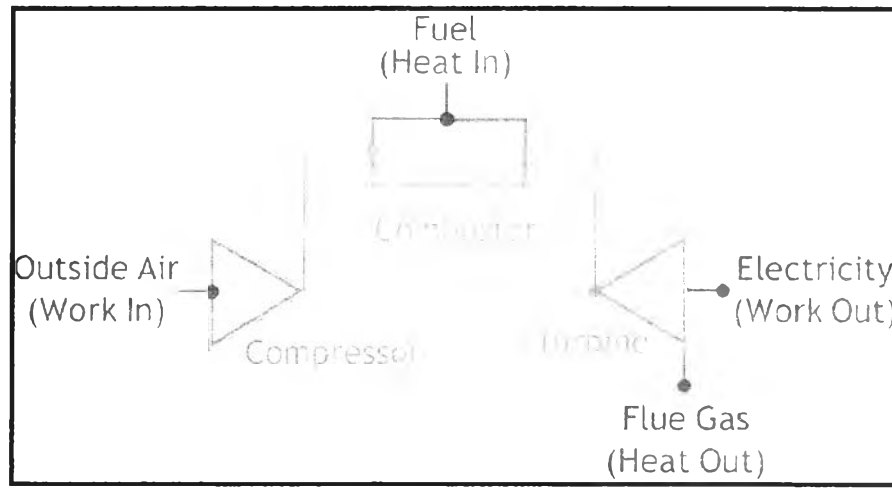

Figure 4-7 – CONVENTIONAL CT DESIGN CONFIGURATION

4.4.2 ELECTRICAL AND CONTROL SYSTEMS

The Conventional CT Facility has one CT electric generator. The generator is a 60 Hz machine rated at approximately 101 MVA with an output voltage of 13.8 kV. The CT electric generator is connected to a high-voltage bus in the Conventional CT Facility switchyard via a dedicated generator circuit breaker, GSU, and a disconnect switch.

4.4.3 OFF-SITE REQUIREMENTS

Natural gas is delivered to the facility through an approximately lateral connected to the local natural gas trunk line. Water for the limited processes that utilize water at the Conventional CT Facility is obtained from a one of several available water sources (e.g., municipal water supply).

The Conventional CT Facility uses a water treatment system and a high-efficiency reverse osmosis system to reduce the dissolved solids for compressor cleaning. Wastewater is sent to a municipal wastewater system. Further, the electrical interconnection from the Conventional CT on-site switchyard is effectuated by a connection to an adjacent utility substation.

4.4.4 O&M ESTIMATE

In addition to the general O&M , the Conventional CT Facility includes the major maintenance for the CT and associated electric generator. These major maintenance expenses are

included with the VOM expense for this technology, based upon an assumed 10 percent annual capacity factor and an operating profile of approximately 8 hours of operation per CT start. Typically, significant overhauls on a Conventional CT Facility occur no less frequently than 8,000 operating hour intervals; with more significant major maintenance outages occurring at 24,000 operating hour intervals; however, often times the major maintenance for a CT at a peaking facility is driven off of CT hours (depending on the equipment manufacturer and the operating hours per start incurred on the equipment). Table 4-8 presents the O&M expenses for the Conventional CT Facility.

Table 4-8 – O&M EXPENSES FOR CONVENTIONAL CT

Technology:	Conventional CT
Fixed O&M Expense	$6.98/kW-year
Variable O&M Expense	$14.70/MWh

4.4.5 ENVIRONMENTAL COMPLIANCE INFORMATION

Typically, a Conventional CT Facility would be equipped with only the DLN combustion hardware to mitigate emissions. There are some states in the U.S. that do require a "hot" SCR that can operate at the higher exhaust temperatures of a simple-cycle plant, though that equipment was not contemplated herein.

Table 4-9 – ENVIRONMENTAL EMISSIONS FOR CONVENTIONAL CT

Technology:	Conventional CT
NO_X	0.03 lb/MMBtu
SO_2	0.001 lb/MMBtu
CO_2	117 lb/MMBtu

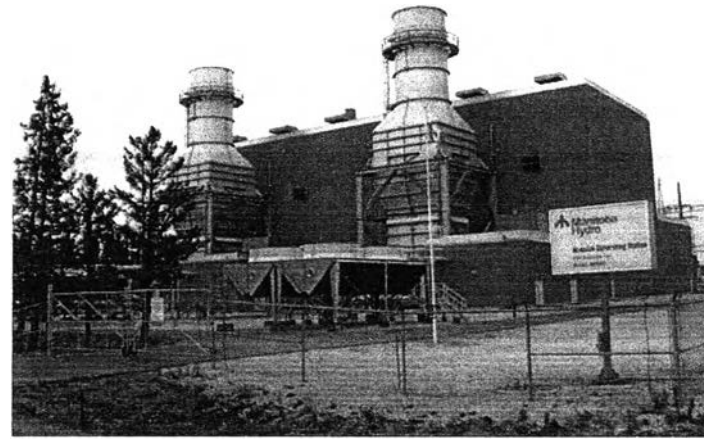

Figure 4-8 Combustion Turbine Plant