# Combined Cycle Power Plants

An Online Continuing Education Course for Engineers

**Course Number: M-4028**

**Credit: 4 Hours / 4 PDH / 4 CPD**

# Combined Cycle Power Plants

**Lee Layton, P.E.**

Huizhou Combined Cycle Power Plant

Photograph courtesy of Guangdong Yuedian Group

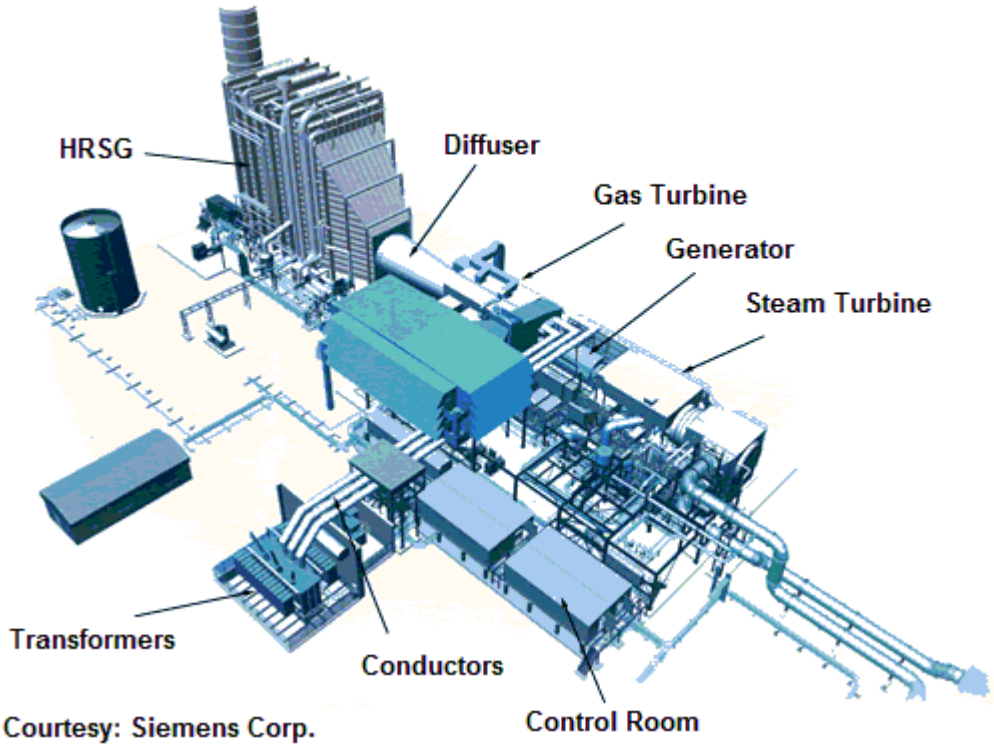
# Table of Contents

## Introduction

Fossil fuel-fired power plants use either steam or combustion turbines to provide the mechanical power to electrical generators. Pressurized high temperature steam or gas expands through various stages of a turbine, transferring energy to the rotating turbine blades. The turbine is mechanically coupled to a generator, which produces electricity.

The Combined Cycle power plant is a combination of a fuel-fired turbine with a Heat Recovery Steam Generator (HRSG) and a steam powered turbine. These plants are very large, typically rated in the hundreds of mega-watts. They combine the Rankine Cycle (steam turbine) and Brayton Cycle (gas turbine) thermodynamic cycles by using heat recovery boilers to capture the energy in the gas turbine exhaust gases for steam production to supply a steam turbine.

The image below (courtesy Siemens Corporation) is a pictorial view of a typical combined cycle power plant.



Natural gas is a major fuel source for electric generation through the use of gas turbines and steam turbines. Most grid peaking power plants and some off-grid engine-generators use natural gas. Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns more cleanly than other fossil fuels, such as oil and coal, and produces less carbon dioxide per unit energy released. For an equivalent amount of heat, burning natural gas produces about 30% less carbon dioxide than burning petroleum and about 45% less than burning coal. Combined cycle power generation using natural gas is thus the cleanest source of power available using fossil fuels, and this technology is widely used wherever gas can be obtained at a reasonable cost.

Combined-cycle power plants have high thermal efficiency, high reliability and economic power generation for application in base load utility service. The features contributing to their outstanding generation economics are:

• High thermal efficiency

• Low installed cost

• Fuel flexibility – wide range of gas and liquid fuels

• Low operation and maintenance cost

• Operating flexibility – base, mid-range, daily start

• High reliability

• High availability

• Short installation time

• High efficiency in small capacity increments

• Minimum environmental impact – low stack gas emissions and heat rejection

Combined-cycle power generation equipment is manufactured in two basic configurations, single-shaft and multi-shaft. The single-shaft combined cycle system consists of one gas turbine, one steam turbine, one generator and one heat recovery steam generator (HRSG), with the gas turbine and steam turbine coupled to a single generator in a tandem arrangement. Multi-shaft combined-cycle systems have one or more gas turbine generators and HRSGs that supply steam through a common header to a separate single steam turbine generator unit. Both configurations perform their specific functions, but the single shaft configuration excels in the base load and mid-range power generation applications.

The multi-shaft combined-cycle system configuration is most frequently applied in phased installations in which the gas turbines are installed and operated prior to the steam cycle installation and where it is desired to operate the gas turbines independent of the steam system. The multi-shaft configuration was applied most widely in the early history of heat recovery combined-cycles primarily because it was the least departure from the familiar conventional steam power plants. The single shaft combined-cycle system has emerged as the preferred configuration for single phase applications in which the gas turbine and steam turbine installation and commercial operation are concurrent.

Depending on the power re… …y operate only the fired tur… …ency. Large fossil fuel … …ants can exceed 60% …

The f… …numbers are expec… …out.

In this … …ere the current and ex… …ombined cycle power p… …a combined cycle po…