Electric Power Generation
EEE210

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Overview

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Electric energy can be transported easily at high efficiency and reasonable cost.

The first electric network in the U.S. was established by Thomas Edison in 1882 at the Pearl Street Station in New York city.

The station supplied DC power for lower Manhattan area.

With the invention of the transformer (William Stanley, 1885) and induction motor, replacing DC motors (Nikola Tesla, 1888), the advantage of AC system became apparent.

The first single-phase AC systems in U.S. was at Oregon City, where power was generated by two 300 hp waterwheel turbines and transmitted at 4kV to Portland.

Southern California Edison Company installed the first three-phase system at 2.3kV in 1893.

The DC system was phased out due to its disadvantages:

- Filtering is essential to eliminate harmonics.
- Large amount of reactive power compensation is required at both ends of the line.

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Generation of electricity in the U.S. is performed by four types of companies:

- Investor-owned utilities (IOUs) - 66%
- Publicly owned utilities - 10.7%
- Federally owned utilities - 8.2%
- Cooperatively owned utilities - 3.1%

The transmission system of electric utilities in the United States and Canada is interconnected into a large power grid known as the North American Power Systems Interconnection. The power grid has evolved into three major separated areas, which are:

- The Eastern Interconnection
- The Western Interconnection
- The Texas Interconnection

Each area consists of several neighboring utilities which operate jointly to schedule generation in a cost-effective manner.

The electric power industry in the U.S. has undergone fundamental changes in the last two decades.

The generation business is rapidly becoming market-driven.

This is a major chance from an industry where power generation was once dominated by large, vertically integrated monopolies.

The implementation of open transmission access has resulted in many new companies that produce and market wholesale and retail electric power.

The shift has not been smooth as it creates flaws for independent producers to manipulate prices.

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Sources to generate electricity are:

- fossil fuels,
- uranium,
- water,
- wind,
- solar,
- geothermal,
- biomass,
- fuel cell, and
- oil.

Each source has advantages and disadvantages, but majority pose environmental concerns.

Many alternatives employ energy sources from the sun and the earth for power generation, known as renewable energy sources.

Figure 1 shows the contribution of each energy source to the total generation in the U.S.

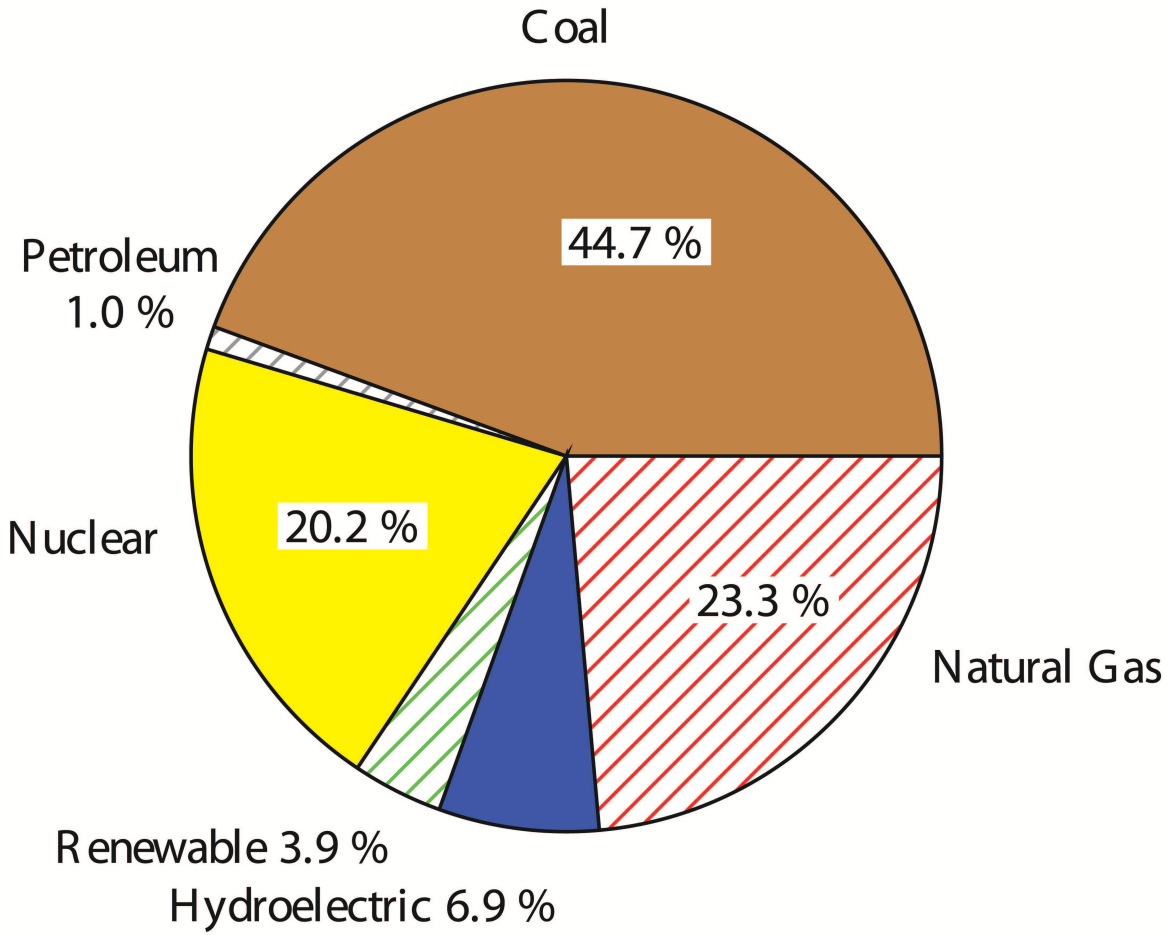

Figure 1: Net generation shares by energy source, year-to-date through December, 2009

The combustion of coal produces carbon dioxide, sulfur dioxide, nitrogen oxide, and fine particles which are released into the atmosphere.

This increases the green house effect and contributes to global climate change.

Sulfur dioxide and nitrogen oxides contribute to smog and acid rain.

Coal also contains toxic heavy elements such as mercury, arsenic, and radioactive material.

Multiple technologies for carbon dioxide capture are available; most of them can be classified into three main groups:

- Post-combustion: CO_2 capture from the flue gas after combustion of the fossil fuel.
- Pre-combustion: Removal of CO_2 from the fossil fuel prior to combustion.
- Oxy-fuel: Combustion of fossil fuel with pure oxygen rather than air.

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Most electricity today is generated by burning coal and producing steam, which is then used to drive a steam turbine that, in turn, drives an electrical generator.

Steam turbines operate relatively high speeds of 3600 or 1800 rpm, for 60Hz operation.

The generators to which they are coupled are cylindrical rotor, two-pole for 3600 rpm or four-pole for 1800 rpm.

Four types of fossil fuel power plants are:

1. Coal-fired power plants ($\eta = 43\% - 45\%$)
2. Gas turbine power plants ($\eta = 46\%$)
3. Combined-cycle power plants ($\eta = 60\%$)
4. Nuclear power plants ($\eta = 33\%$)

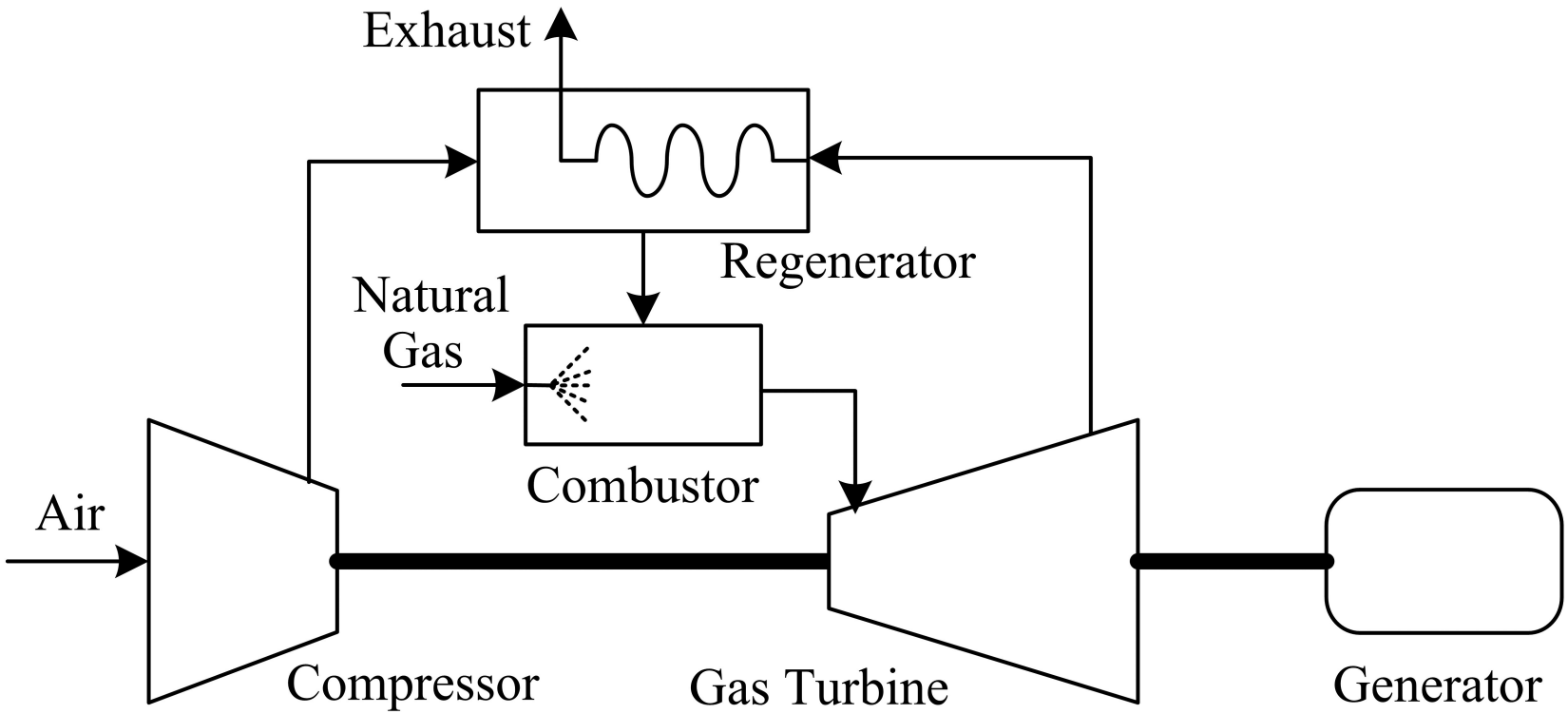

Figure 2: Schematic diagram of a simple gas turbine power plant

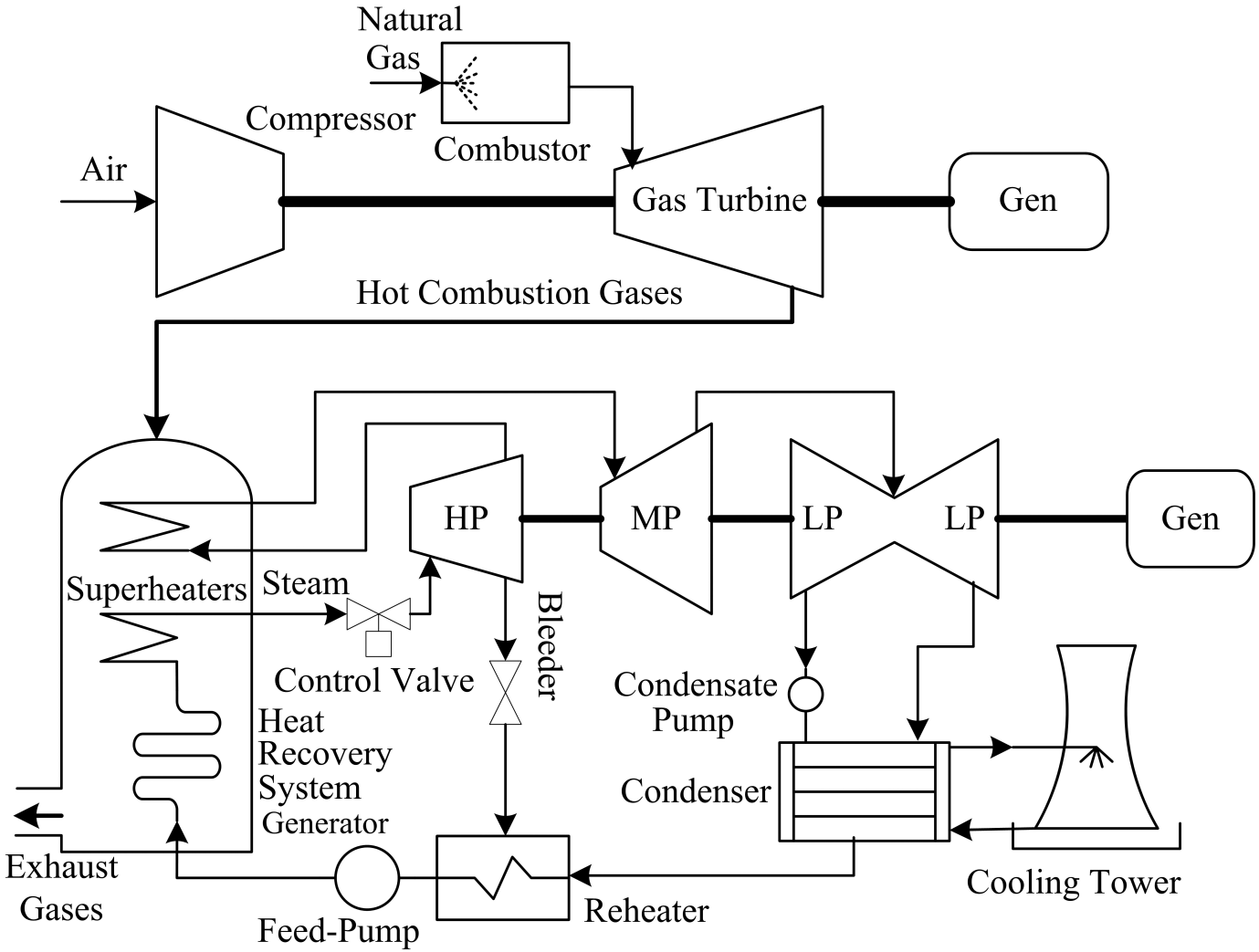

Figure 3: Schematic of combined-cycle power plant

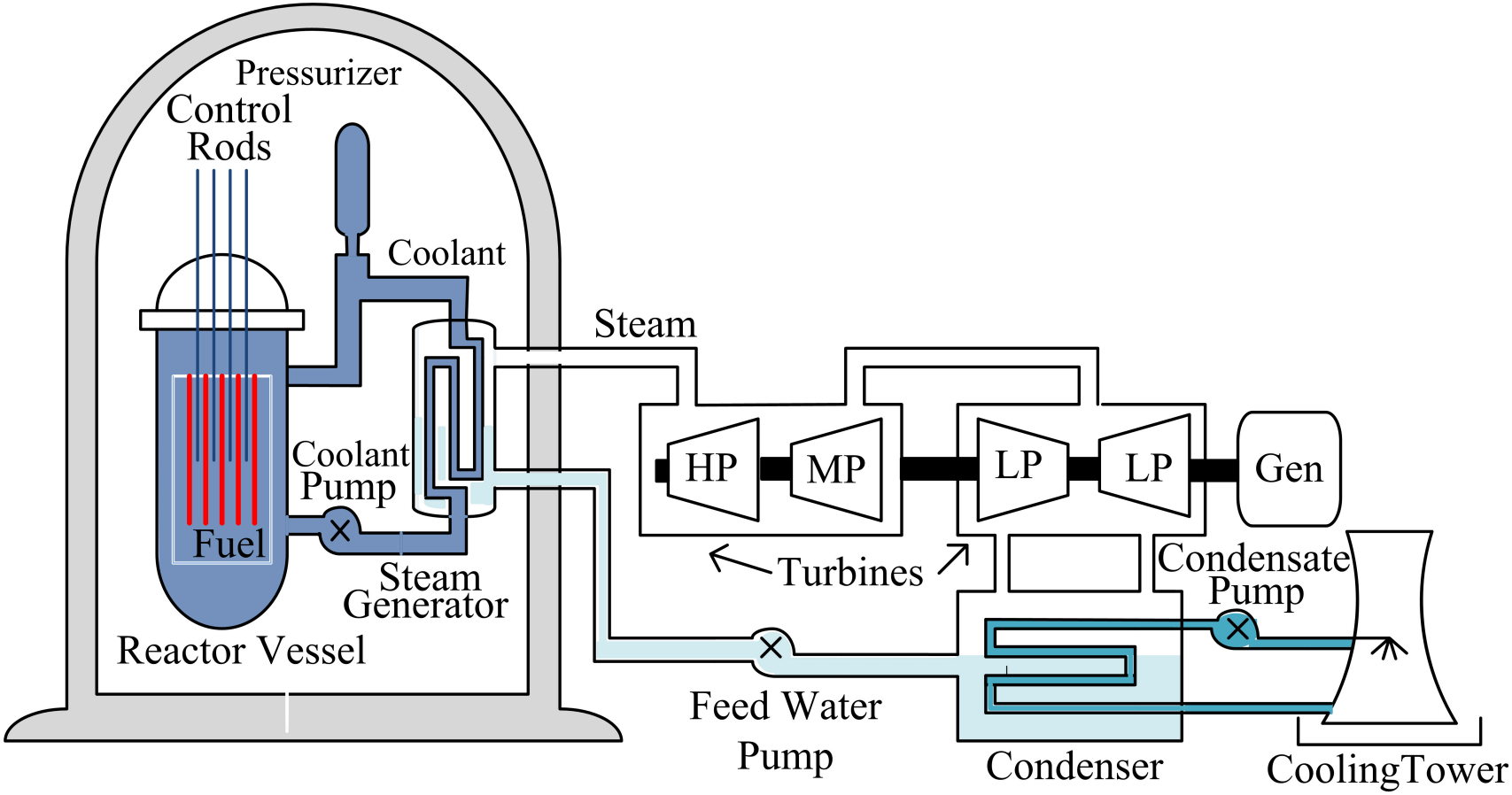

Figure 4: Schematic diagram of a pressurized water reactor

Group Discussion

- Describe the operation of gas turbine power plant based on Figure 2.

The End