

Combined Cooling, Heating and Power (CCHP) in Distributed Generation (DG)

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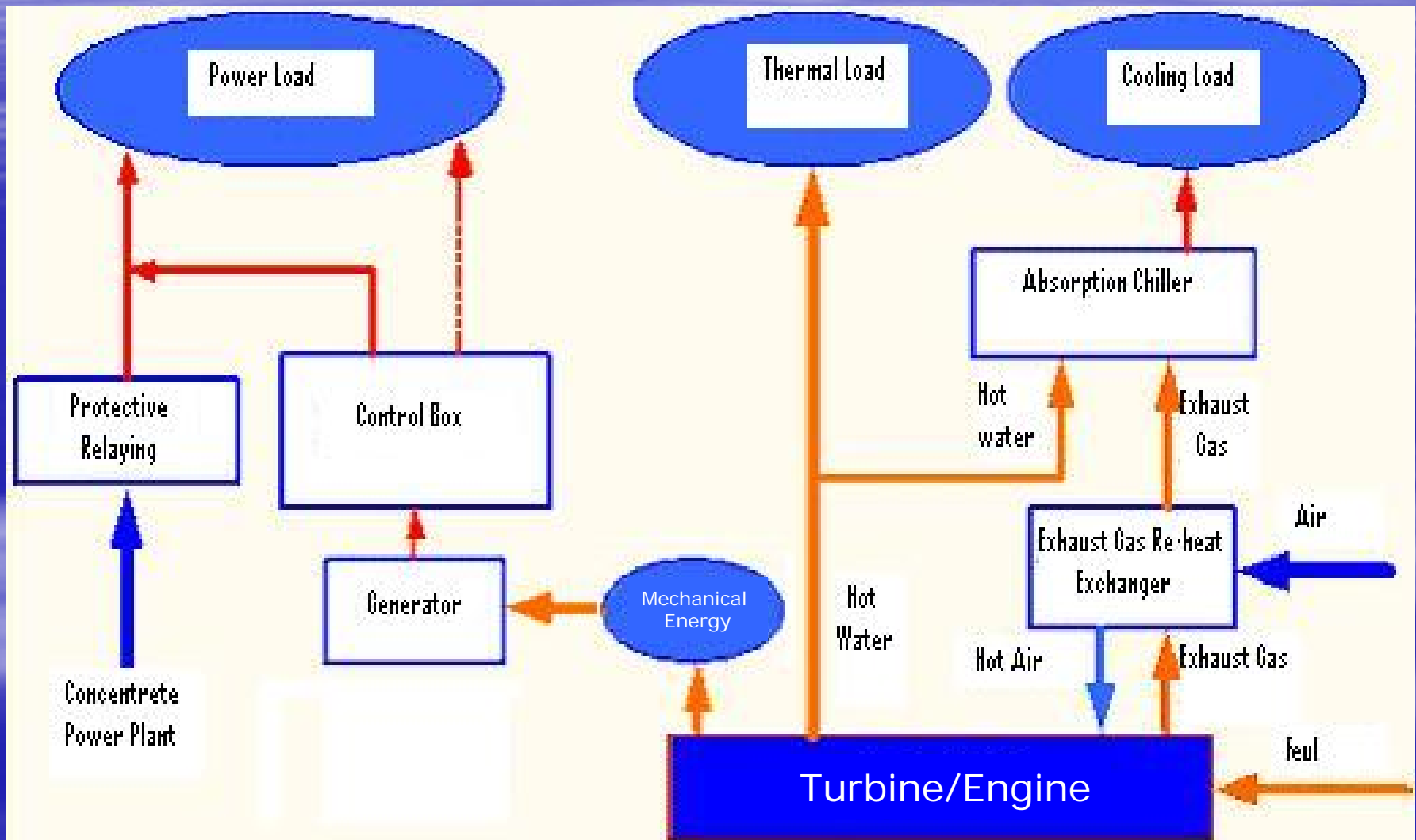
EE5250 Term Project

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Introduction

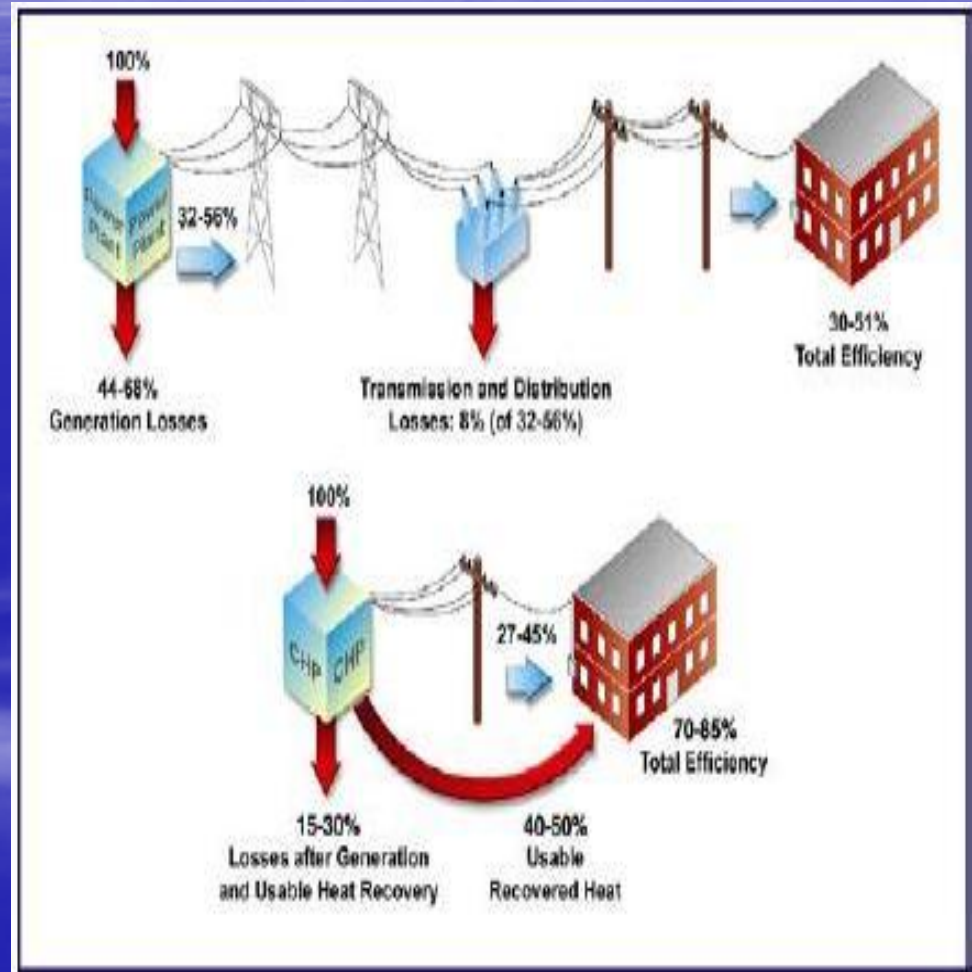
- What is the CCHP?
- The history of CCHP
- The application of CCHP in the world

Typical CCHP system



Why CCHP?

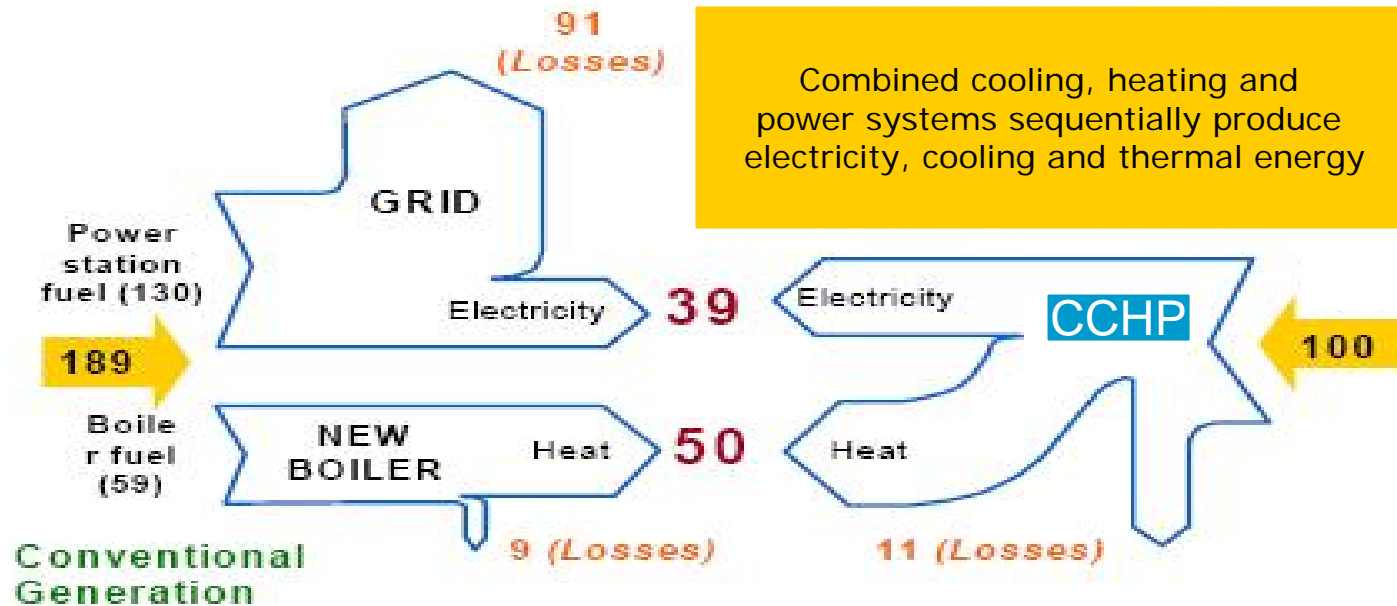
- Economic benefits
- Environmental benefits
- Technical benefits



The comparison of CCHP system and centralized power plant

CCHP comparison

Combined cooling, heating and power systems sequentially produce electricity, cooling and thermal energy



Future Cost and Efficiency Improvements in CCHP Technology

- A great deal of money will be saved
- The efficiency of devices will be improved

Size	Technology	Base (\$/kW)			Future (\$/kW)		
		Packaged Cost	Elec Eff	Installed Cost	Packaged Cost	Elec Eff	Installed Cost
150-300kW	Recip	510	33.5%	880	375	43.0%	640
	Microturbine	700	27.1%	1,075	475	40.0%	720
	Fuel Cell	4,500	39.6%	5,000	1,275	50.0%	1,555
300-600kW	Recip	490	35.0%	800	375	43.0%	605
	Microturbine	700	27.1%	1015	460	40.0%	675
	Fuel Cell	4,500	39.6%	4,800	1,275	50.0%	1,520
1-2.5MW	Recip	470	38.0%	700	370	45.0%	550
	Turbine	470	28.0%	700	360	40.0%	525
2.5-5MW	Recip	470	39.0%	620	350	45.0%	465
	Turbine	440	29.0%	590	330	40.0%	420

CCHP Power Generation Techniques

- ----Reciprocating Engines
- ----Turbines
- ----Fuel Cells

Emissions by power generation type (lbs/MWh)

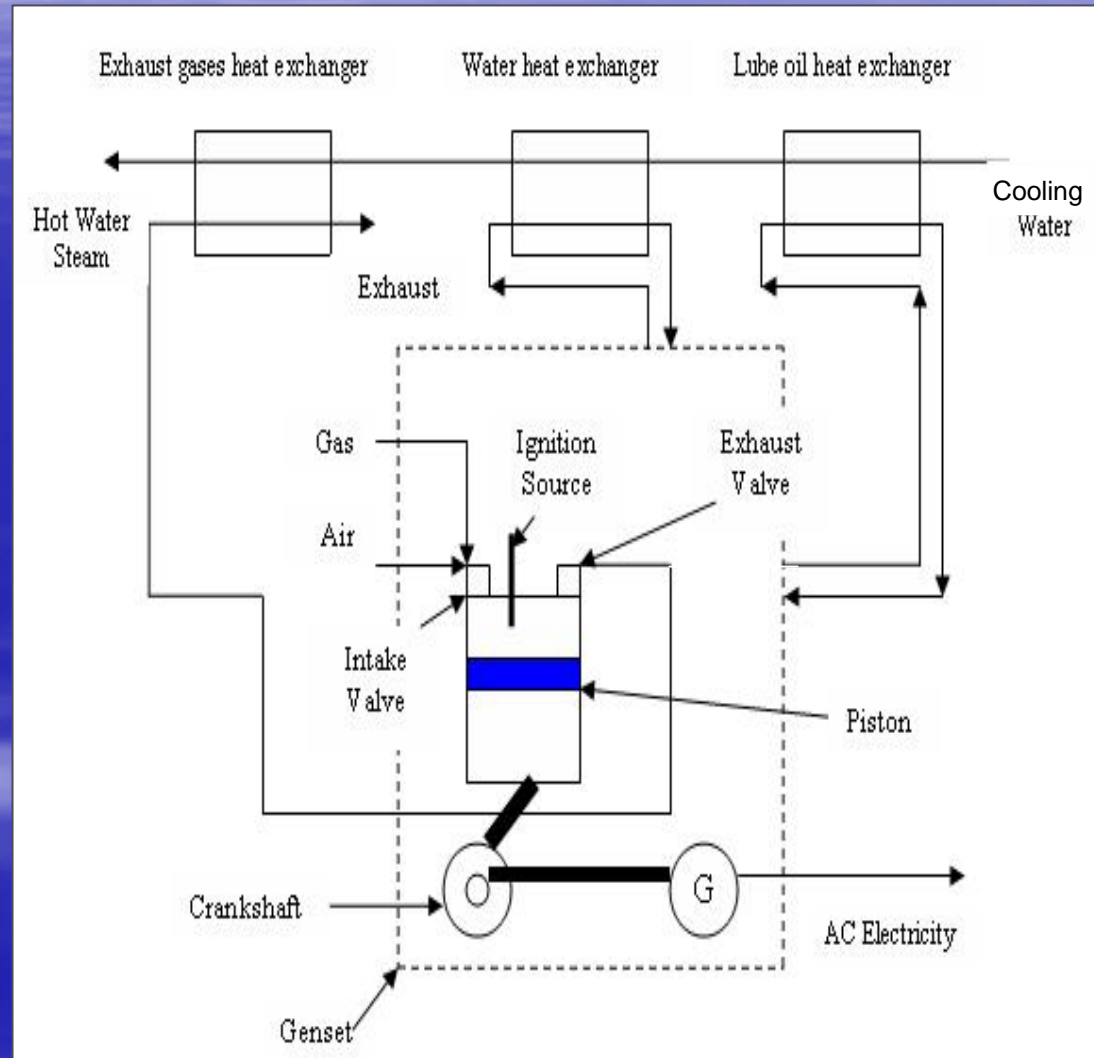
Power generation type	Emissions	NO_x	CO_x	SO_x
Natural gas reciprocating engines		0.09-3.8	770	~0
Oil (2.2% sulfur) fueled steam turbines		3.0-3.7	1,770	25.4
Oil (0.3% sulfur) fueled combustion turbines		3.7-6.8	2,190	4.4
Coal fueled steam turbines		6.1-9.4	1,960-2,310	46.6
Diesel reciprocating engines		17.0	1,700	5.0
Natural gas turbines		3.2-3.5	970	0.01
Fuel cells		~0	~0	~0

CCHP Heat Recovery Techniques

- ----Hot water heat exchanger
- ----Heat Recovery Steam Generator
- ----Absorption Chiller
- ----Desiccant Dehumidification Device

Reciprocating Engines

- Developed more than 100 years ago
- Most of reciprocating engines that used in power generation are four-stroke and operate in four cycles (intake, compression, combustion and exhaust).

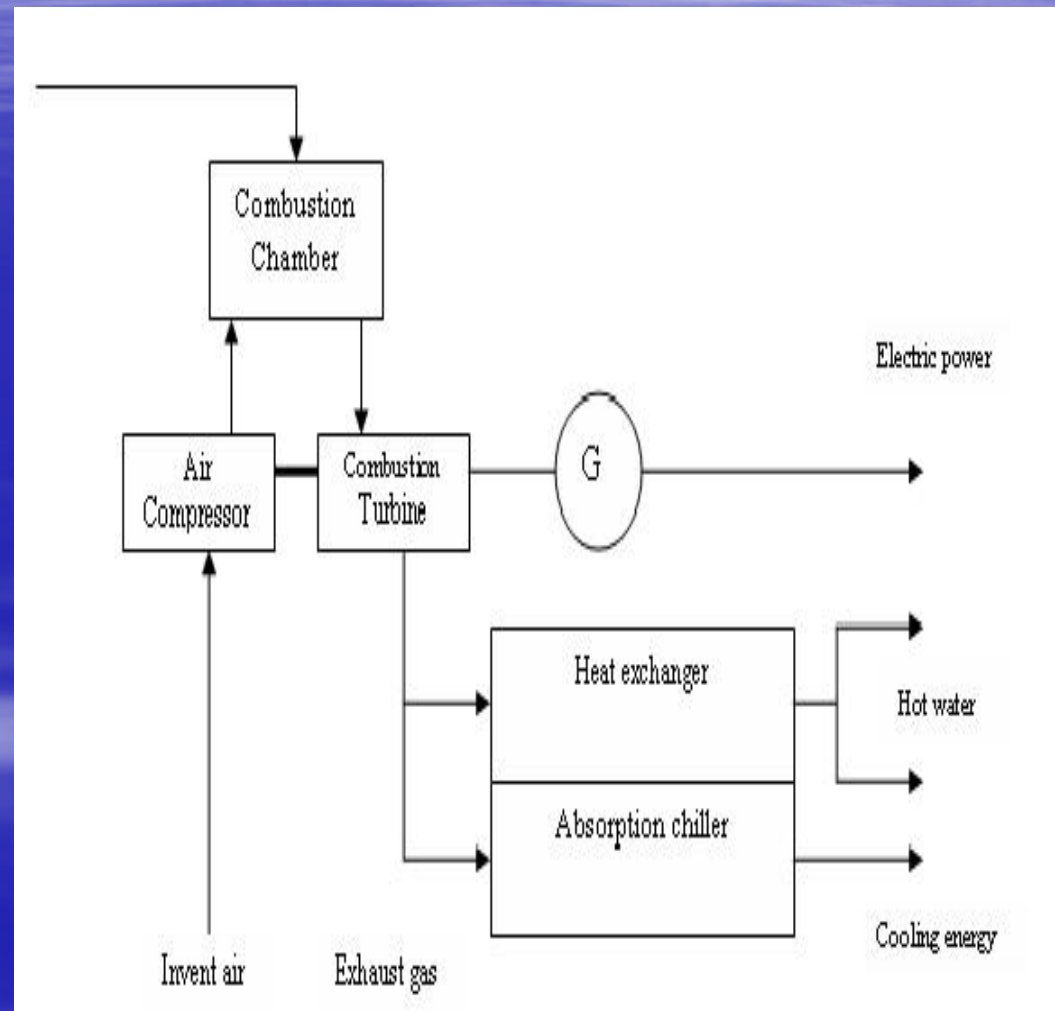


Turbines



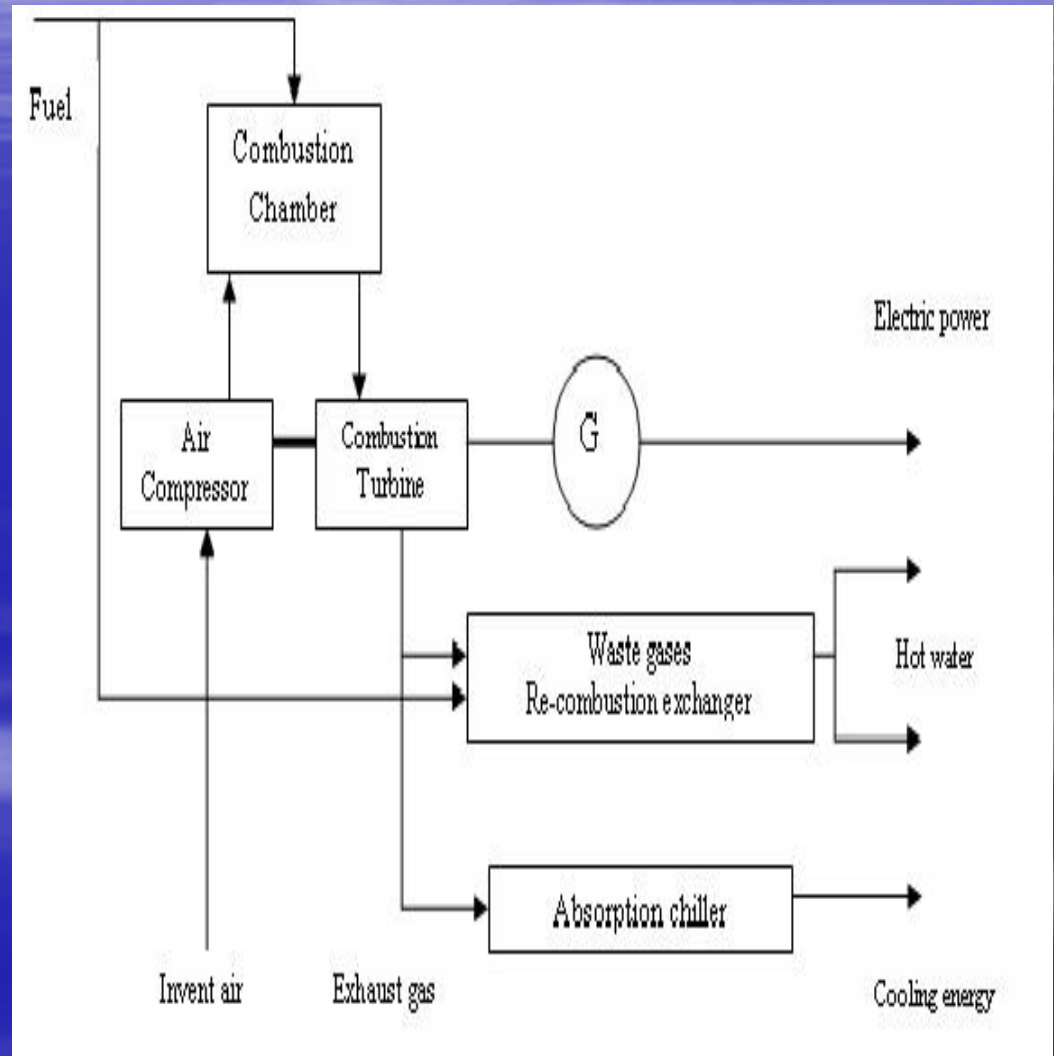
Turbines (1)

- Combined combustion turbine and parallel cooling, heat exchanger
- Simple structure and easy to be realized
- Relative lower efficiency



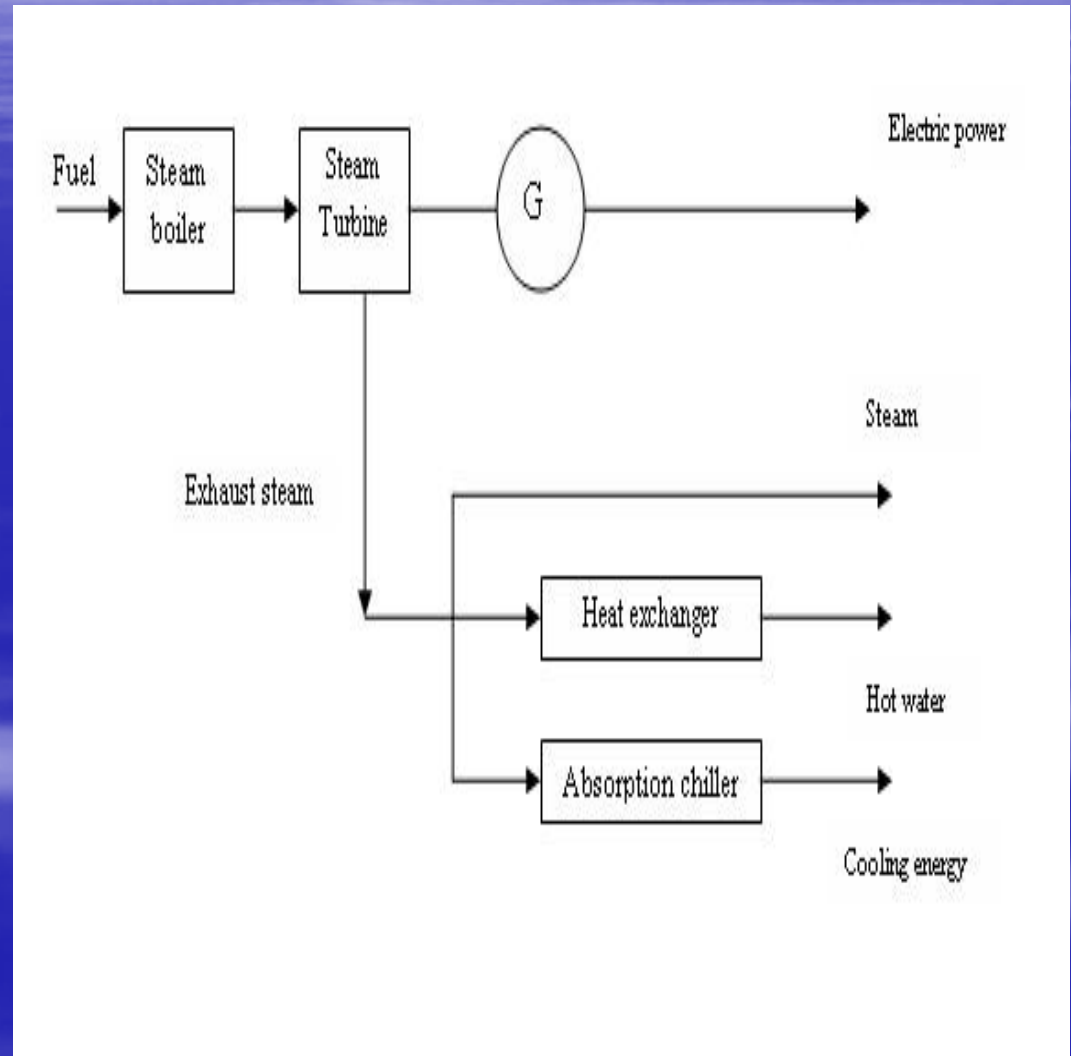
Turbines (2)

- Combined combustion turbine and heat re-combustion exchanger
- The efficiency of this structure is relative high that reaches 90%.



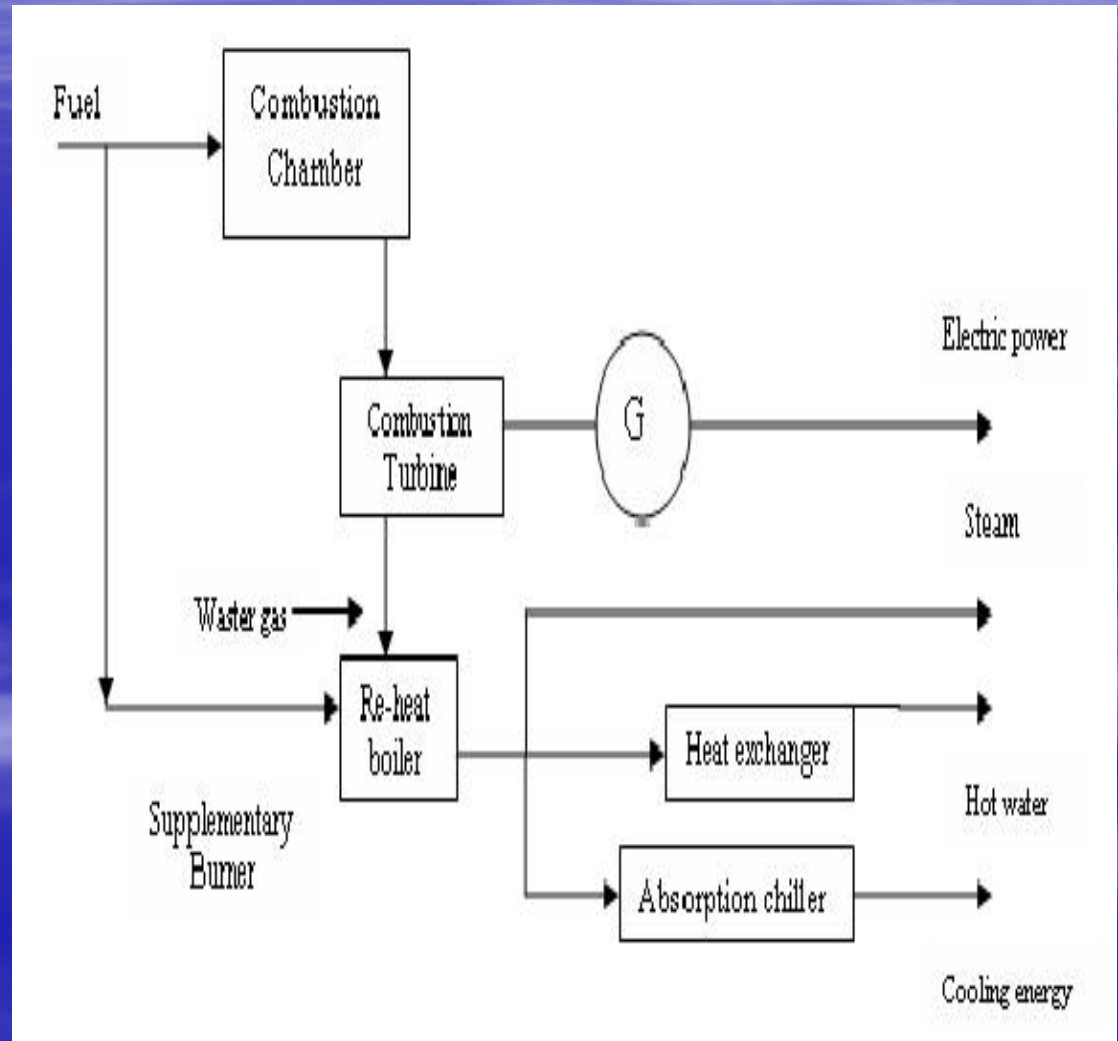
Turbines (3)

- Combined stream turbine and parallel cooling, heating exchanger
- Cheaper but low efficiency and high harmful gases emissions



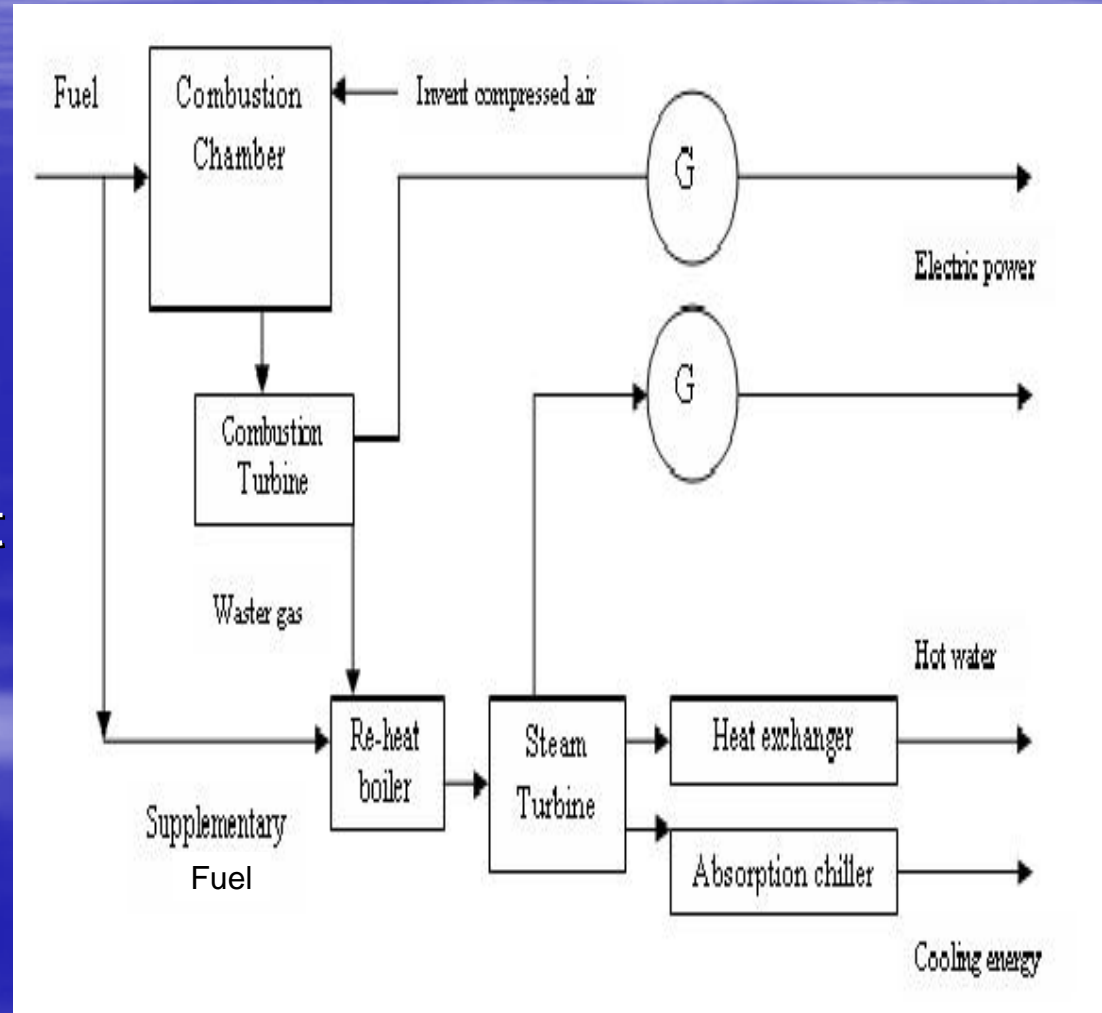
Turbines (4)

- Combined combustion turbine and re-heat boiler system
- Improve heat recycle efficiency through re-heat boiler

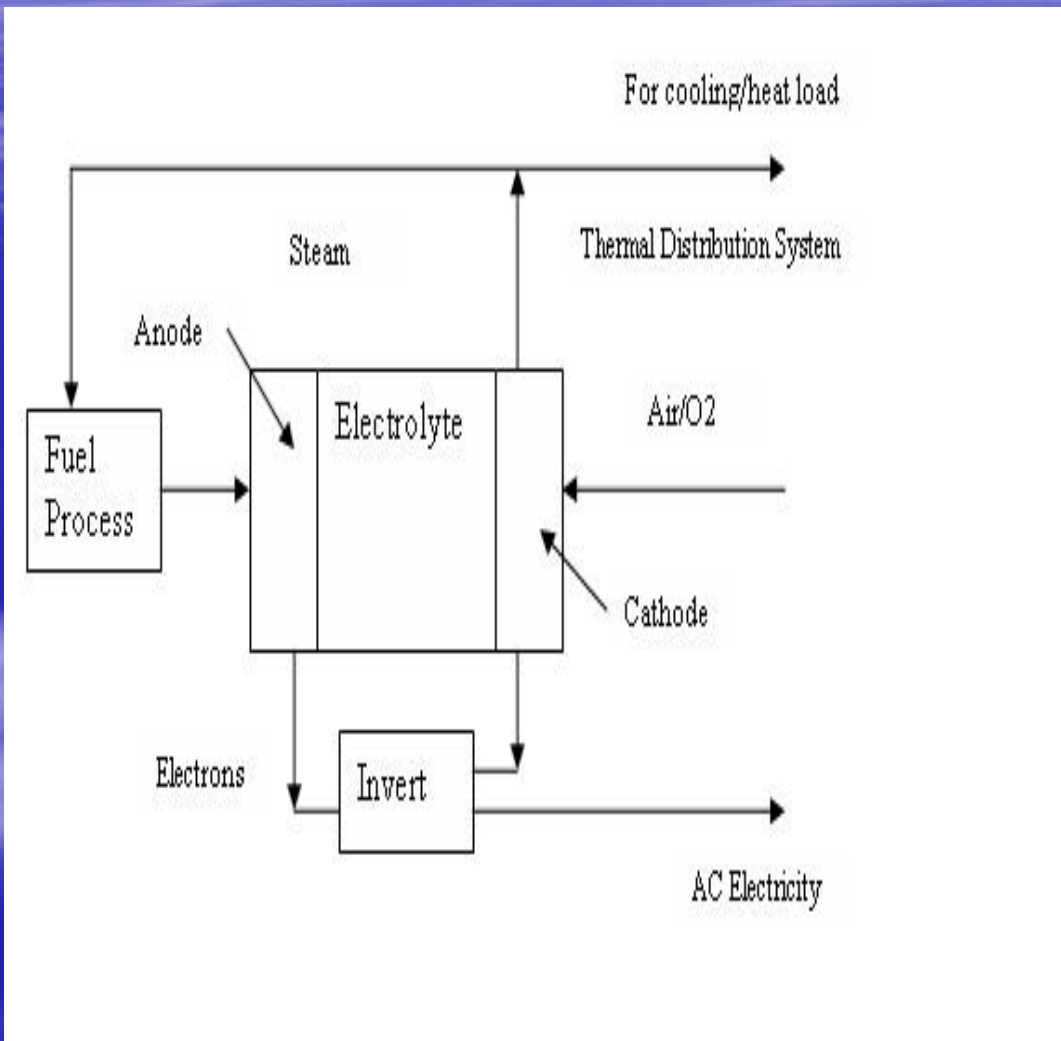


Turbines (5)

- Combined combustion turbine and steam turbine system
- High efficiency for heat recycle efficiency.
- More expensive than other structure



Fuel Cells



- High efficiency
- Very low harmful gases emissions
- Higher initial investment than other generation techniques

Chillers

Two kind of chillers are used in CCHP systems

- ----Absorption chiller
(usually use lithium bromide and ammonia)
- ----Engine drive chiller

Challenges and Barriers

- **Economical Barriers**

Higher initial investment; Long recovery period; Uncertainties about rates; Interconnection and other costs

- **Technological Barriers**

The lack of reliable information on performance and costs;
Large complex projects involve many actors; require special design

- **Political Barriers**

Exit fee; Need to install protective relaying and other security devices if interconnecting with power grid; Permitting, siting, local red-tape

Emerging and further techniques (Cont.)

- BCHP
(Building cooling, heating and power)
- Energy storage system
- power storage
- cooling storage
- thermal storage



Emerging and further techniques (Cont.)

- The evaluation system of CCHP

To evaluate CCHP systems according to a lot of factors such as economy, energy, environment and policy etc.

- Optimal configuration, control and operation in CCHP

To find the optimal operation and control strategy to realize best economical profits

Emerging and further technologies

- Fuel cells

It has an efficiency of more than 40% in electricity power proceeding and more than 80% in the whole CCHP systems. It has high potential in further CCHP systems.

- Dehumidifying system

To improve air quality in building.

- Renewable resource

Use wind and biomass to develop “green” CCHP

Conclusion

- A lot of advantages and benefits
- Need to develop heat recover techniques to maximize use of waste heat
- Focus on clean and efficient technique
- Focus on markets with highest potential for success CCHP techniques

Reference (Cont.)

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Reference

- [4] Natural Gas Cooling Equipment and Services Guide, American Gas Cooling Center, Arlington, VA, January 1998.
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Website

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<http://www.ornl.gov/femp/index.html>
- United States Combined Heat and Power Association <http://www.nemw.org/uschpa/>

Thank you!

Question?