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

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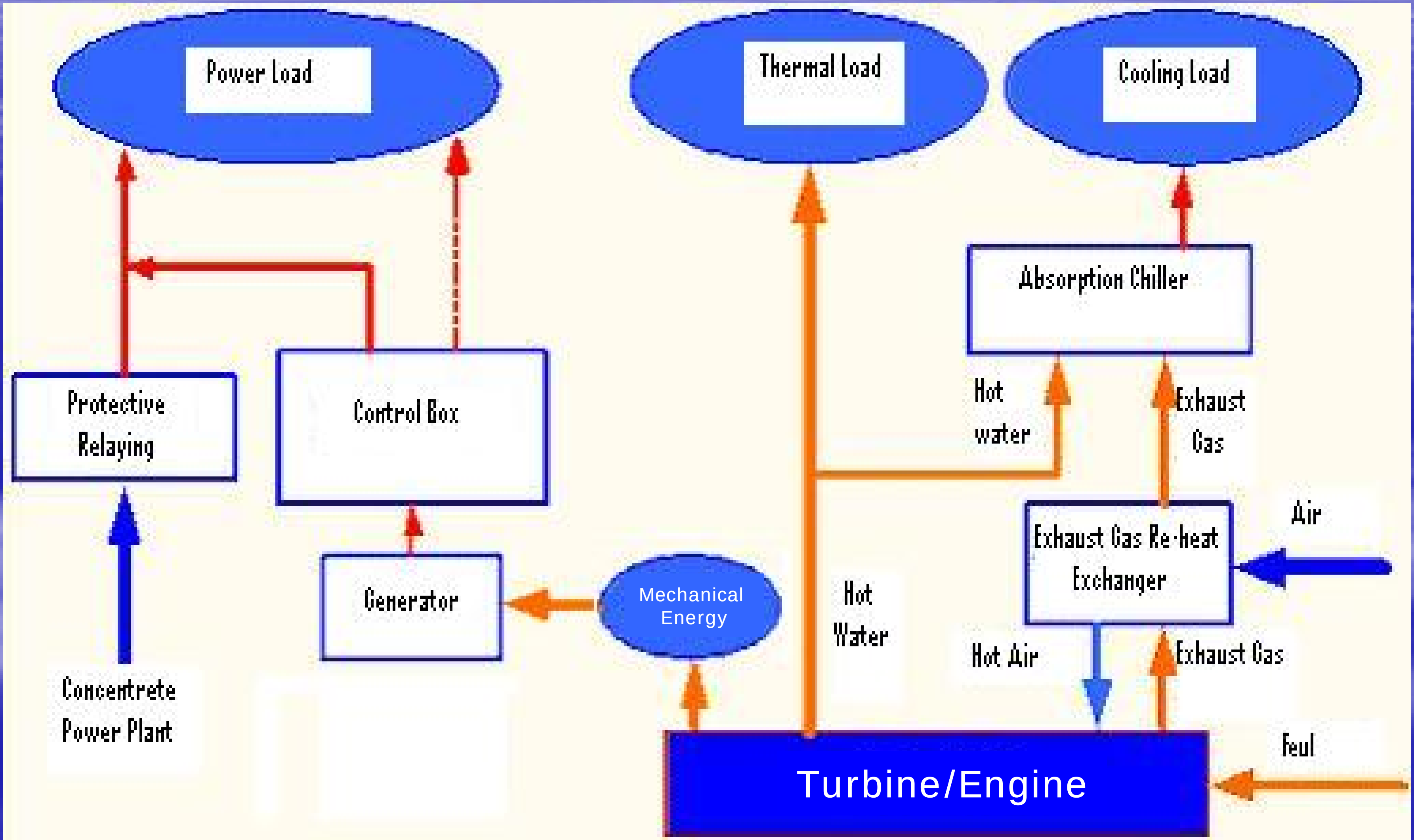
Introduction

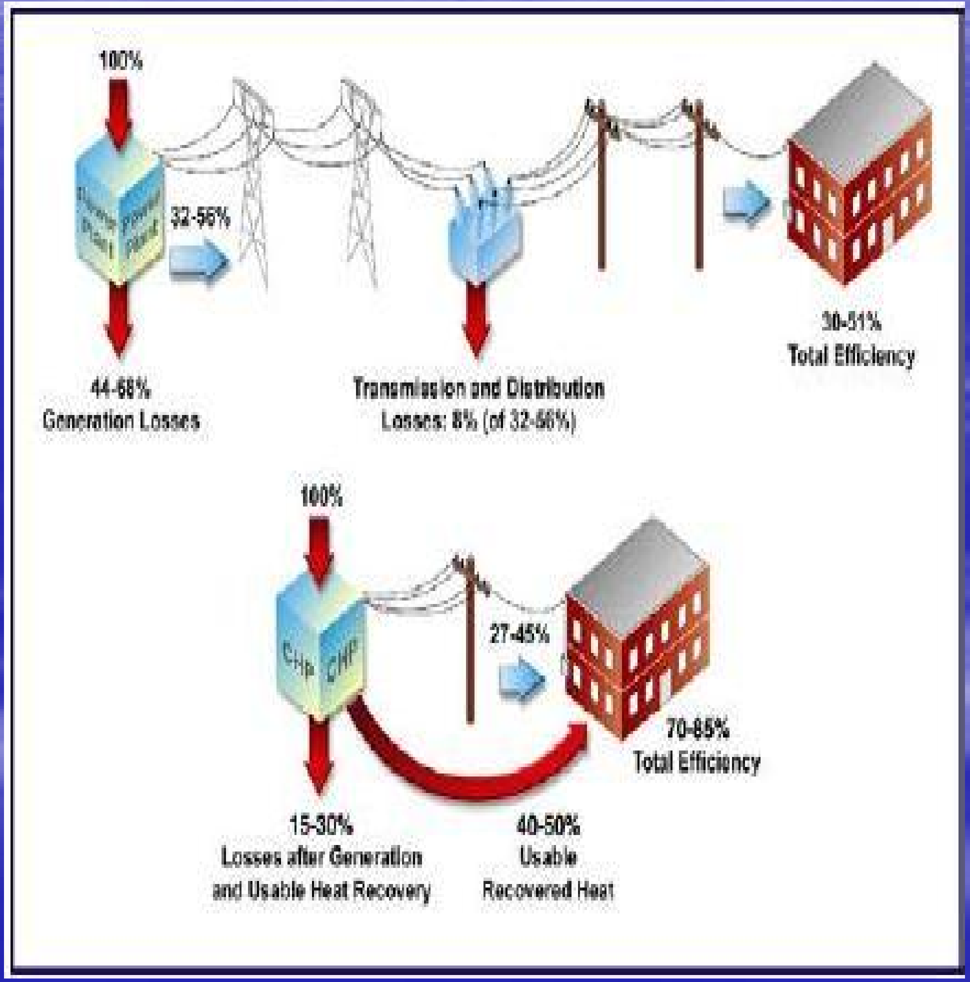
- What is the CCHP?
- The history of CCHP
- The application of CCHP in the world

Typical CCHP system

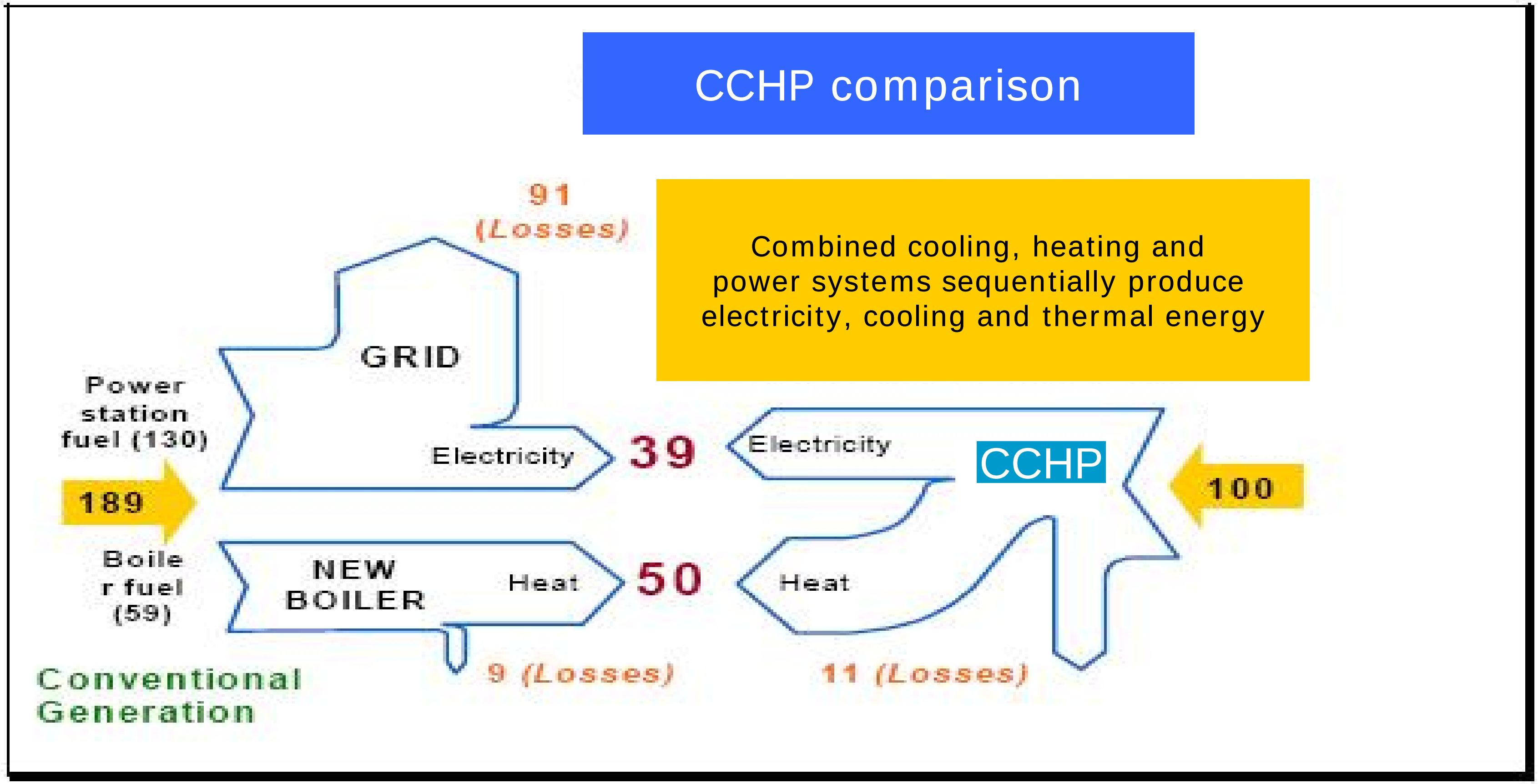


Why CCHP?

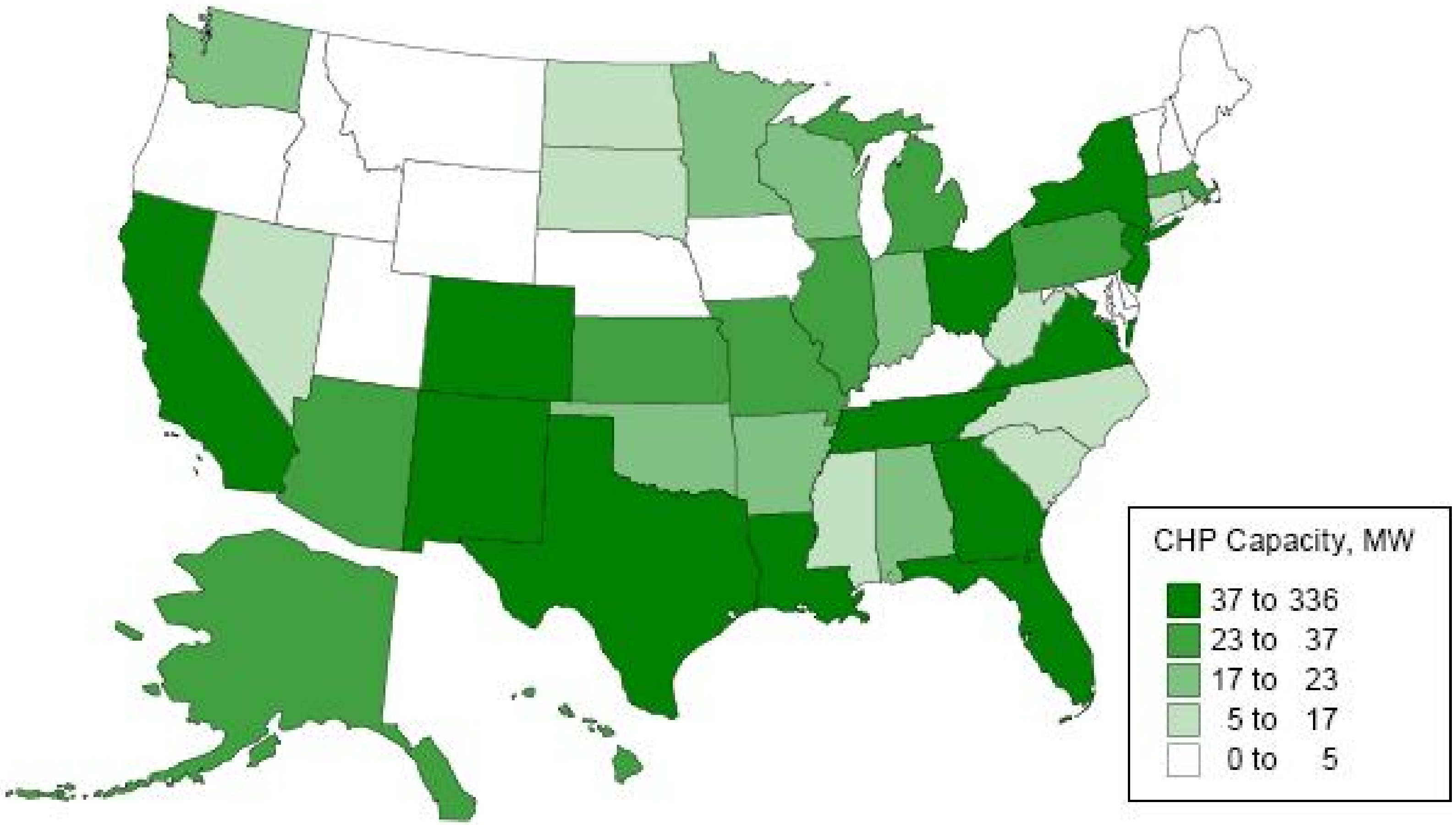
- Economic benefits
- Environmental benefits
- Technical benefits



The comparison of CCHP system and centralized power plant



Potential of CCHP in USA



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)

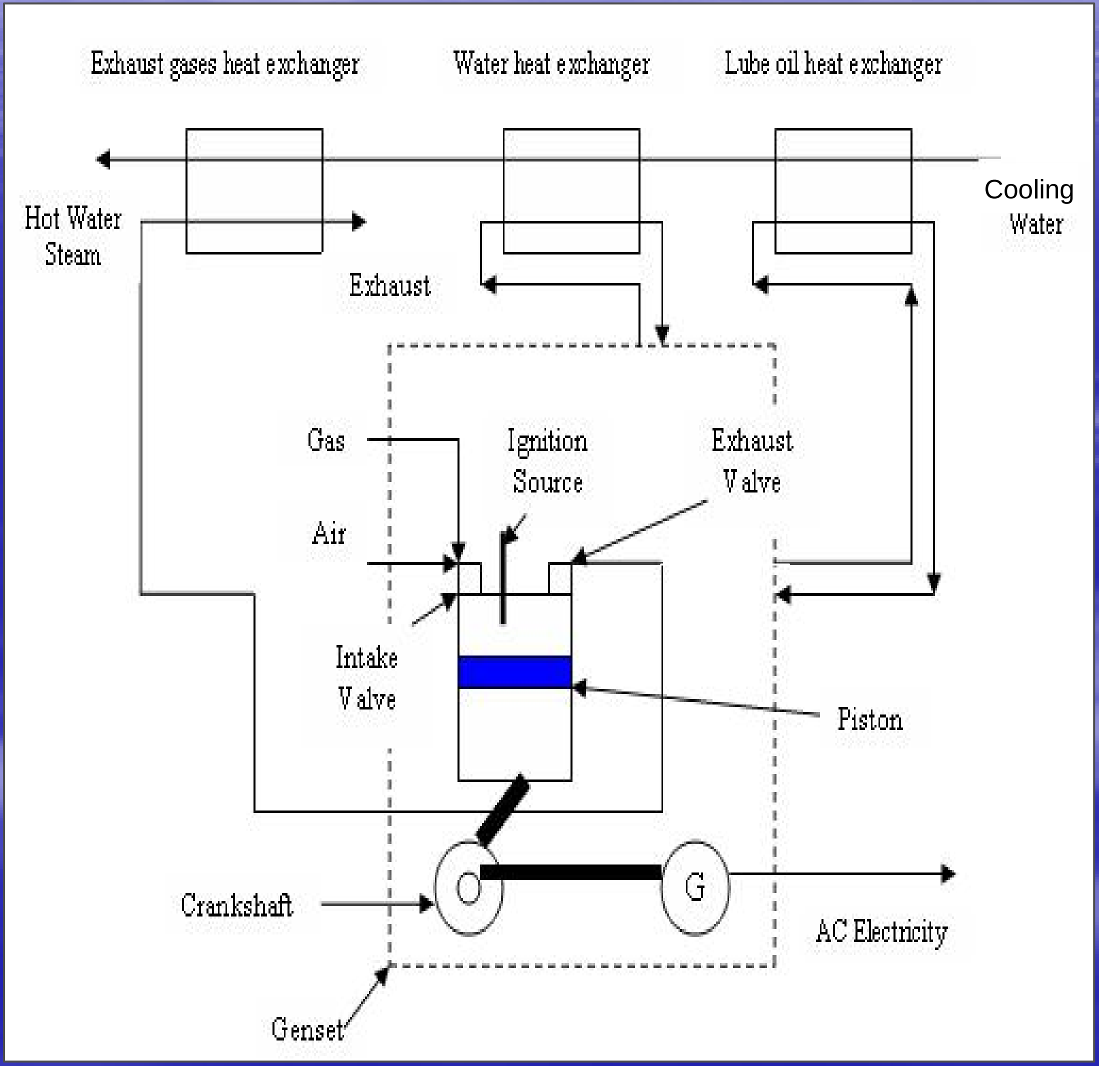
Power generation type \ Emissions	NOx	COx	SOx
Natural gas reciprocating engines	0.09-3.8	770	~0
Oil (2.2% sulfur) fueled steam turbines	3.0-3.7	1,770	25.4
Oil (0.3% sulfur) fueled combustion turbines	3.7-6.8	2,190	4.4
Coal fueled steam turbines	6.1-9.4	1,960-2,310	46.6
Diesel reciprocating engines	17.0	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

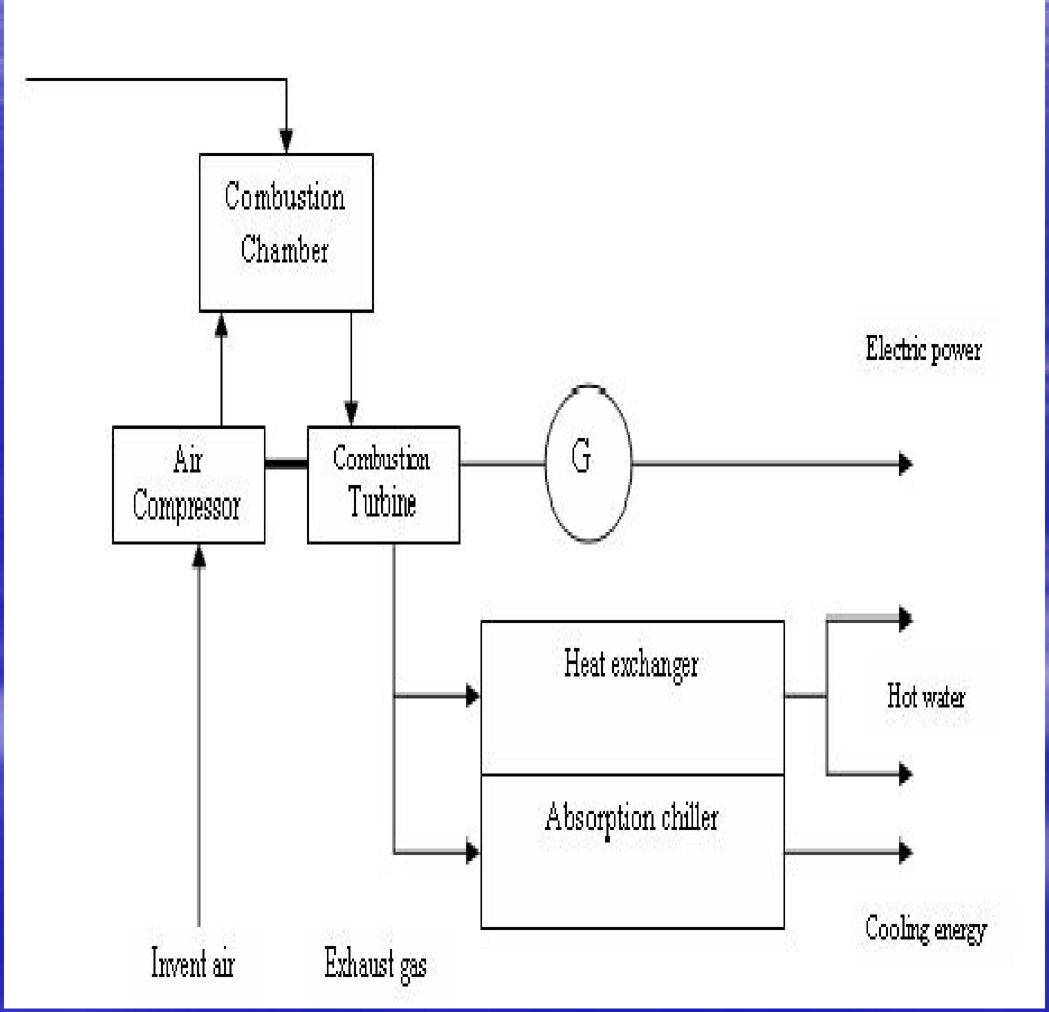
- Developed more than 100 years ago
- Most of reciprocating engines that used in power generation are four-stroke and operate in four cycles (intake, compression, combustion and exhaust).



Turbines

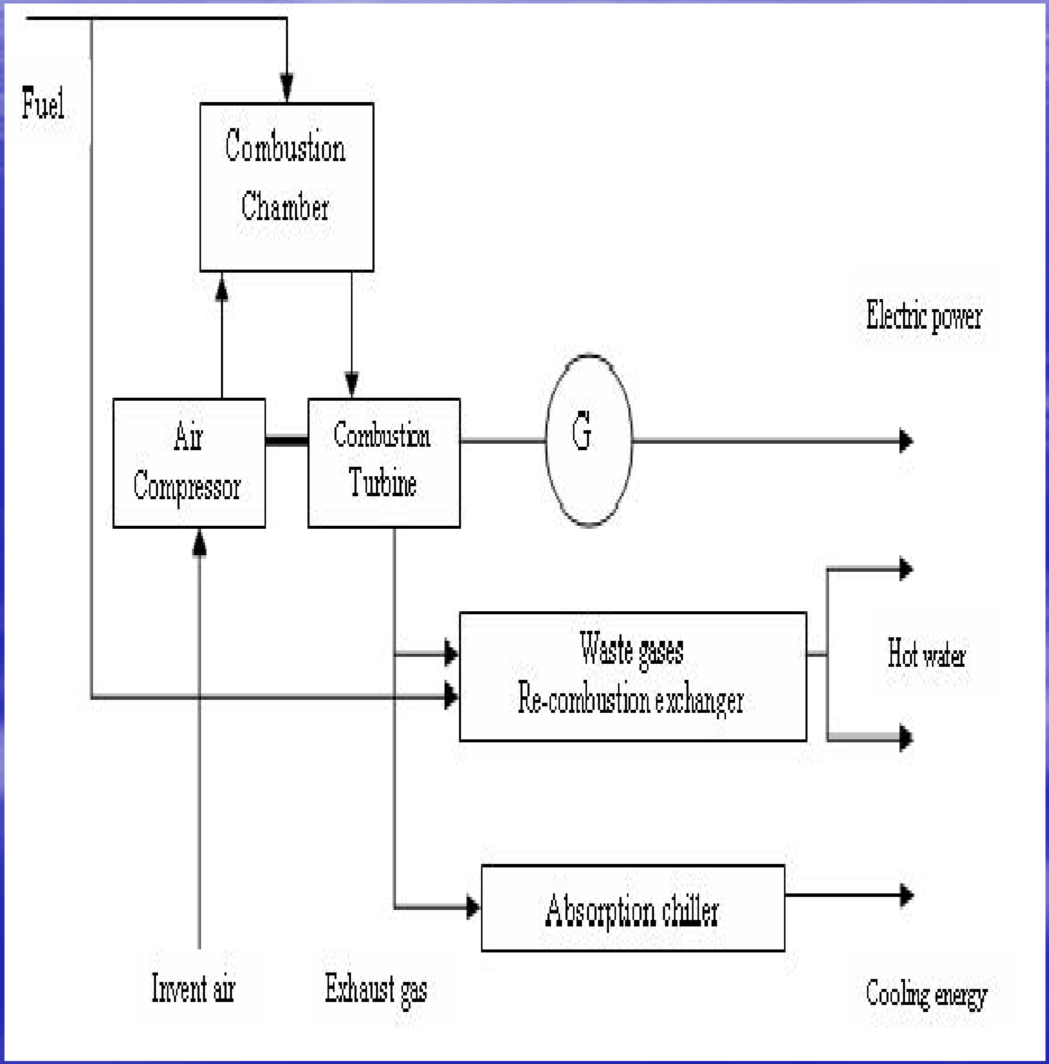
Turbines (1)

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



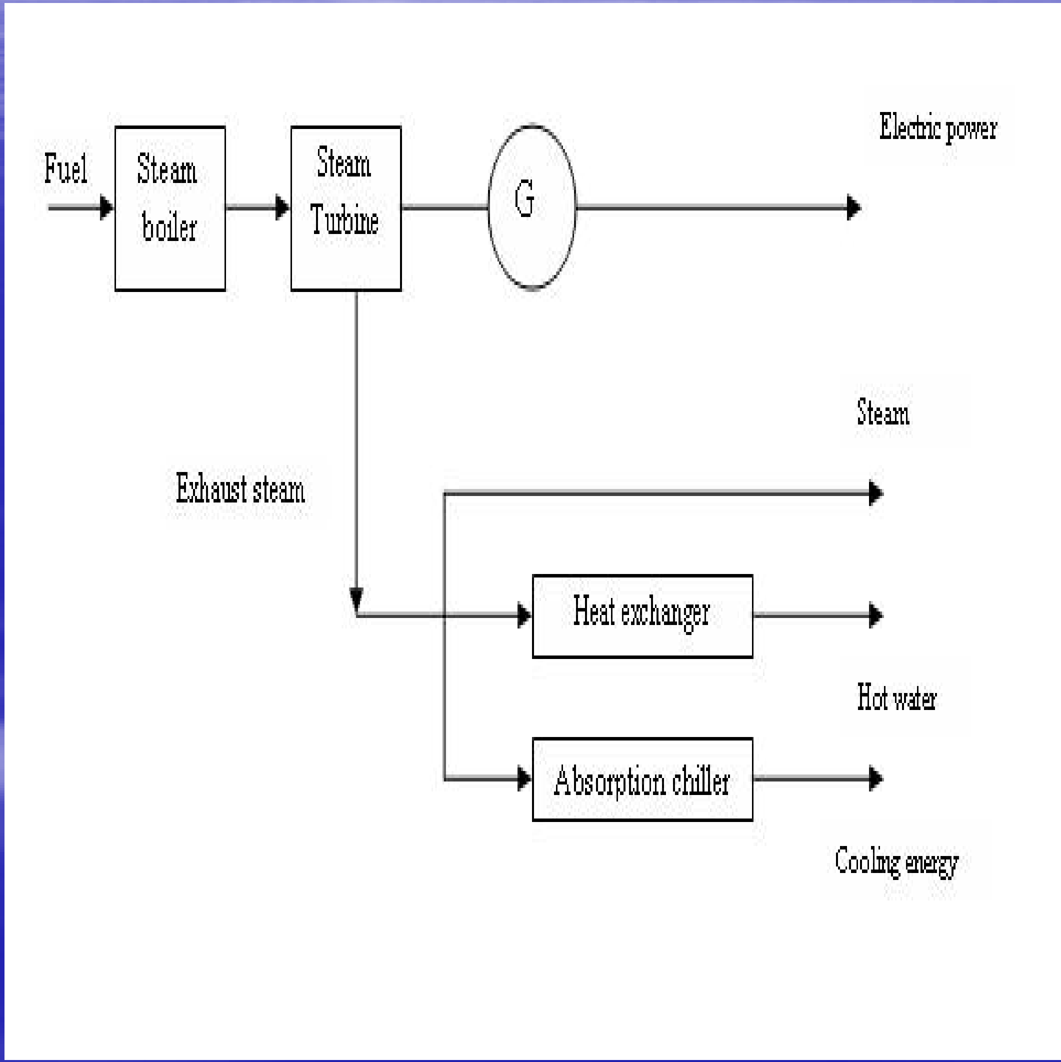
Turbines (2)

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



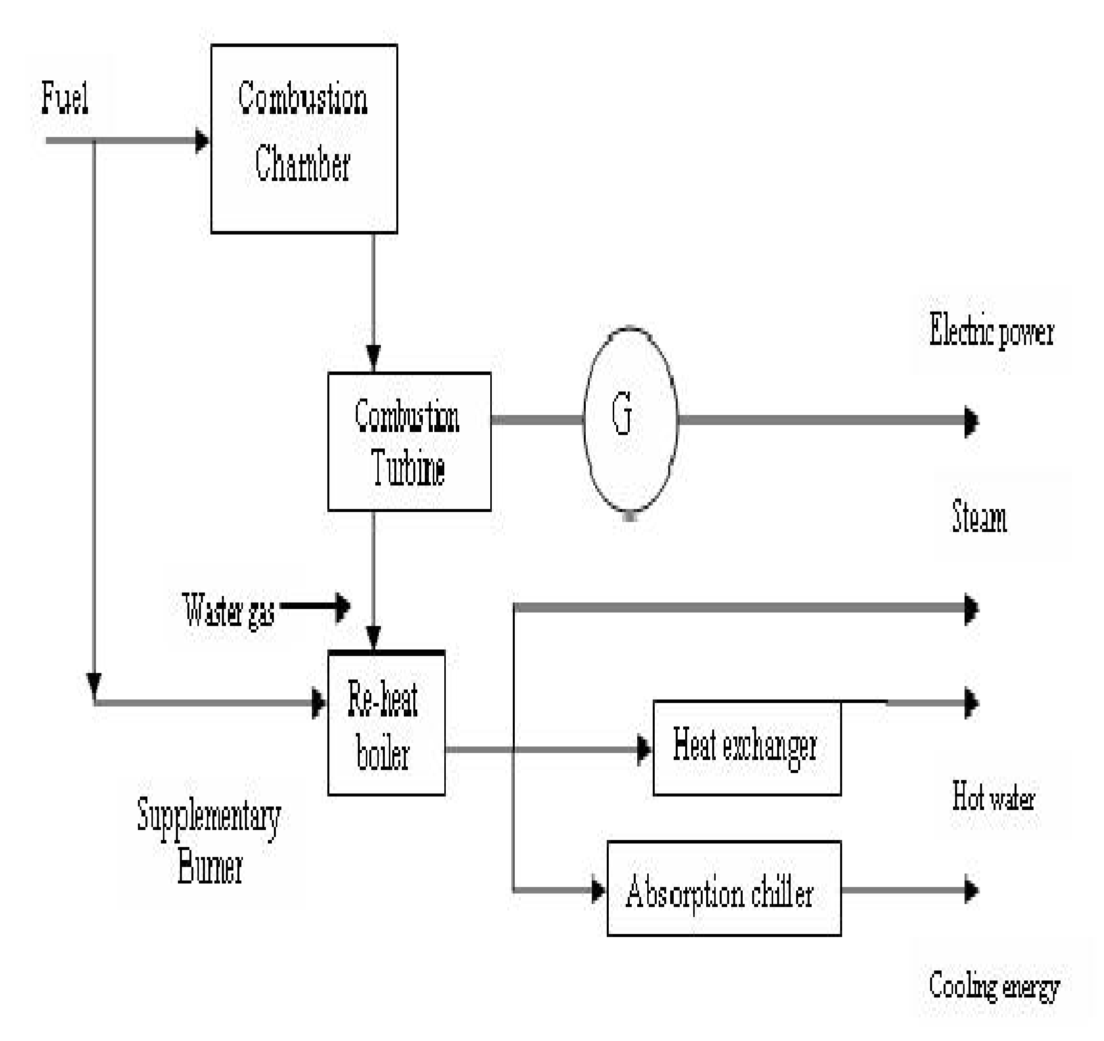
Turbines (3)

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



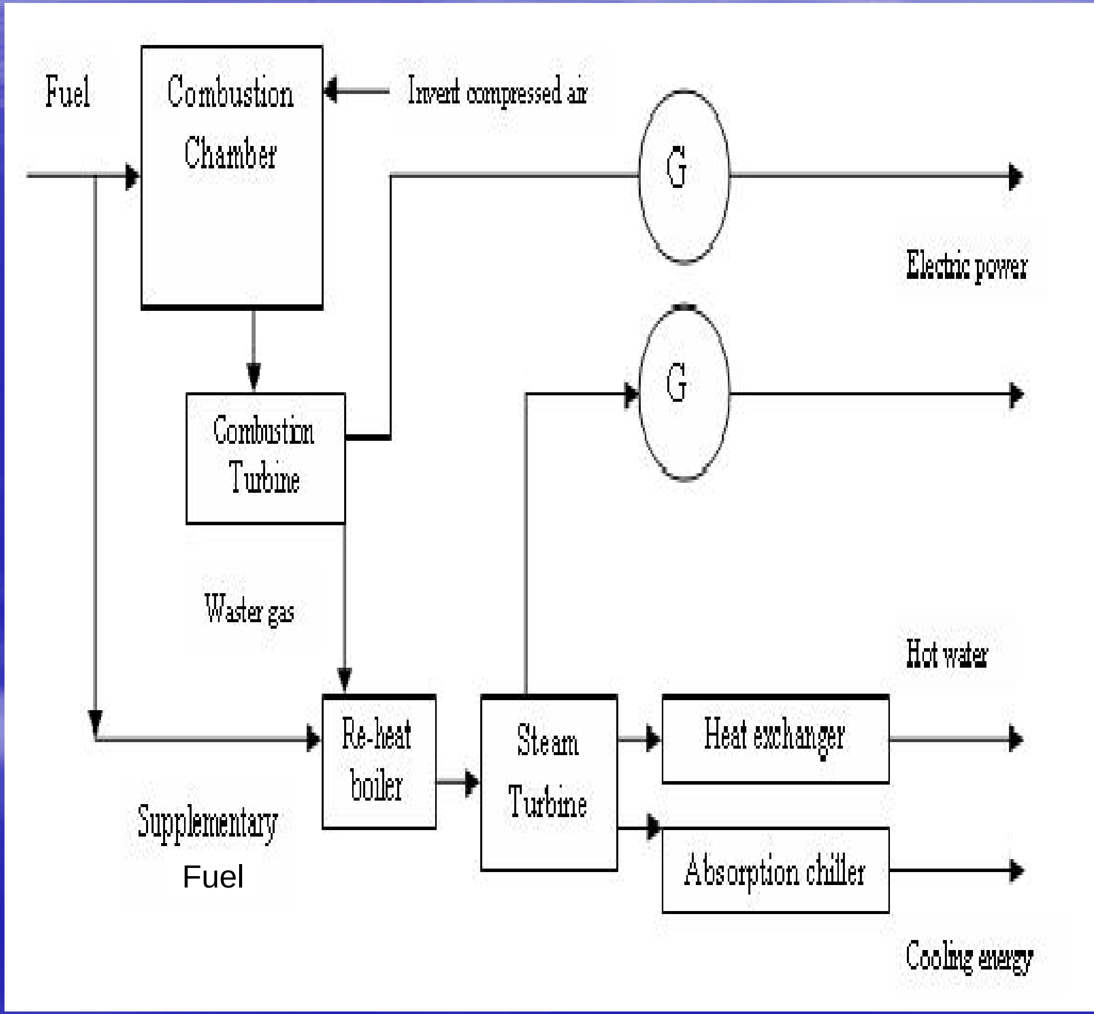
Turbines (4)

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

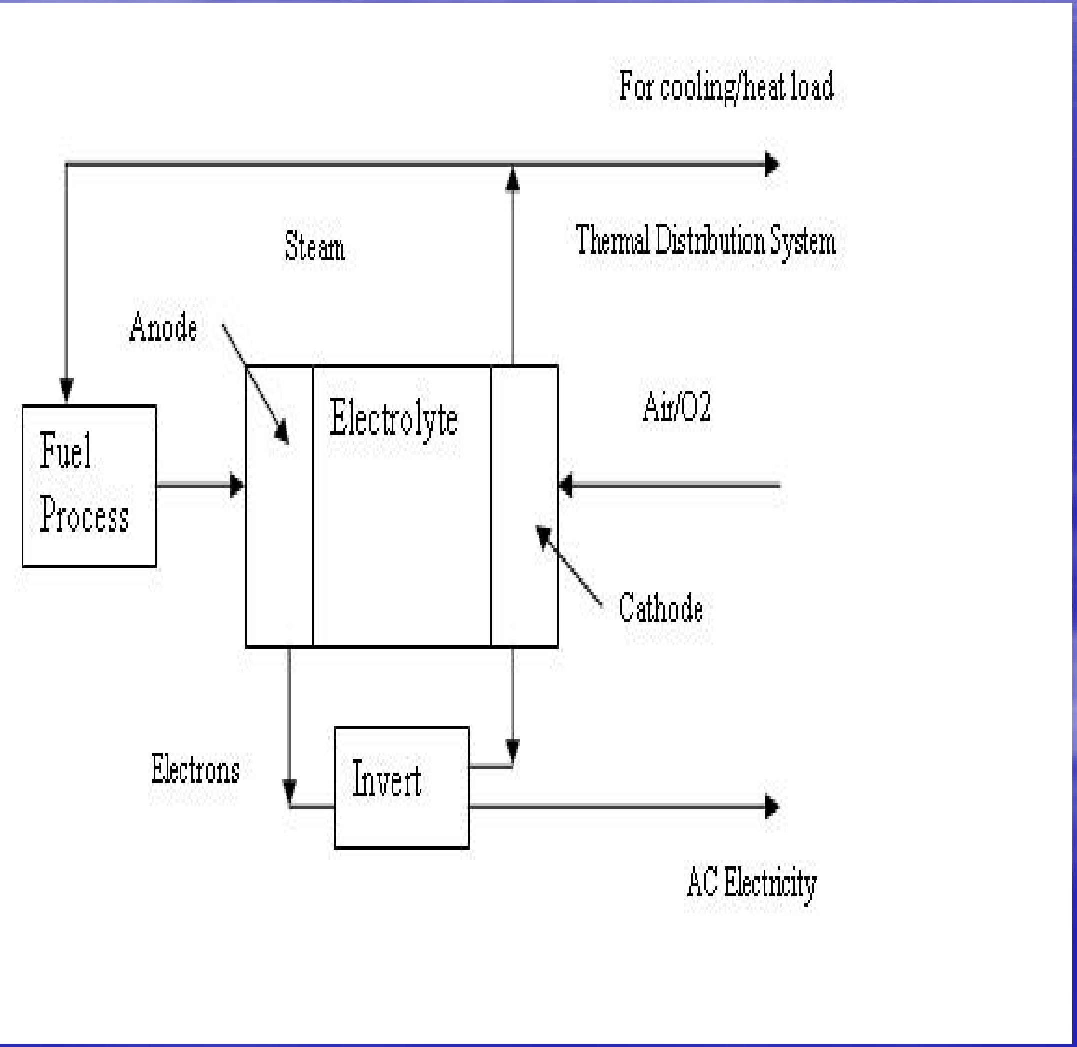


Turbines (5)

- 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.)

- [1] USCHPA 2001. United States Combined Heat and Power Association, in cooperation with DOE and EPA, National CHP Roadmap, Doubling Combined Heat and Power in the United States by 2010, October.
- [2] Analysis and Performance of Gas-Electric Hybrid Chiller Systems, D. E. Lilly, Georgia Institute of Technology, Atlanta, GA, March, 1998.
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- [4] Natural Gas Cooling Equipment and Services Guide, American Gas Cooling Center, Arlington, VA, January 1998.
- [5] RDC 2000. Resource Dynamics Corporation, Building Cooling, Heating, and Power (BCHP): A Market Assessment, Draft, May.
- [6] Advanced Stationary, Reciprocating Natural Gas Engine Workshop, Department of Energy, San Antonio, Texas, January 12-13, 1999.

Website

- FEMP http://www.eren.doe.gov/femp/techassist/der_resources.html
- http://www.eren.doe.gov/femp/prodtech/pdfs/chp_tf.pdf.
- DOE Office of Power Technologies http://www.eren.doe.gov/der/chp/
- Oak Ridge National Laboratory FEMP http://www.ornl.gov/femp/index.html
- United States Combined Heat and Power Association http://www.nemw.org/uschpa/

Thank you!

Question?