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NEWEA 2013 - Combined Heat & Power

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CHP Executive Summary

- Combined Heat and Power (CHP) solutions represent a proven and effective near-term energy option to help the United States enhance energy efficiency, allow energy independence, ensure environmental quality, promote economic growth, and foster a robust energy infrastructure.
- It is not a single technology but a group of technologies that can use a variety of fuels to provide reliable electricity, mechanical power, or thermal energy at a factory, university campus, hospital, or commercial building—wherever the power is needed.
- CHP's efficiency comes from recovering the heat that would normally be wasted while generating power to supply the heating or cooling needs of the user.

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Proven Technology & Results

- CHP has been around in one form or another for more than 100 years; it is proven, not speculative.
- Despite this proven track record, CHP remains underutilized
- Current market conditions, lack of understanding, and technical barriers continue to impede full realization of CHP's potential.

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Benefits of CHP Applications

- **CHP positively impacts the health of local economies and supports national policy goals in a number of ways. Specifically, CHP can:**
  - *Enhance our energy security* by reducing our national energy requirements and help businesses weather energy price volatility and supply disruptions
  - *Advance our climate change* and environmental goals by reducing emissions of CO2 and other pollutants
  - *Improve business competitiveness* by increasing energy efficiency and managing costs
  - *Increase resiliency of our energy infrastructure* by limiting congestion, load reduction, offsetting transmission losses, and disaster recovery
  - *Improve energy efficiency* by capturing heat that is normally wasted

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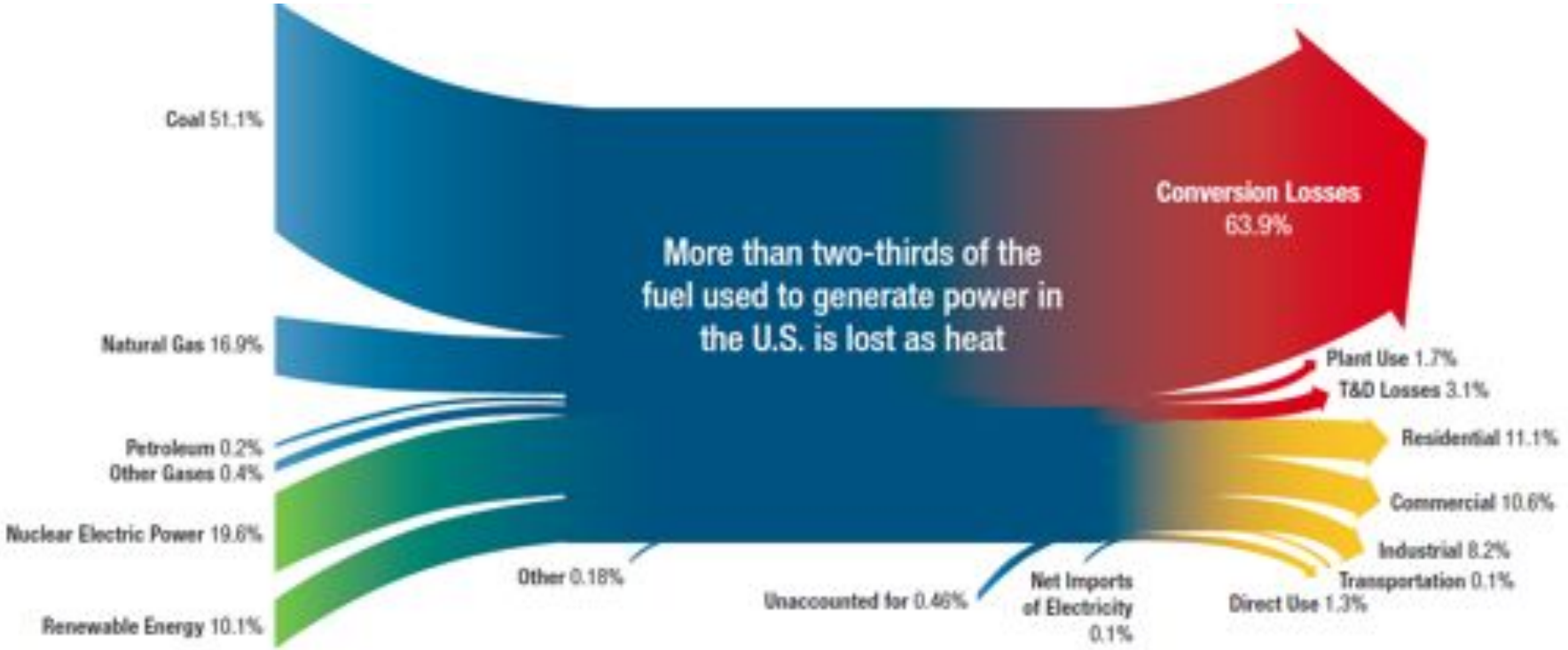
Traditional System Losses



Source: DOE Energy Information Administration Annual Energy Review 2007

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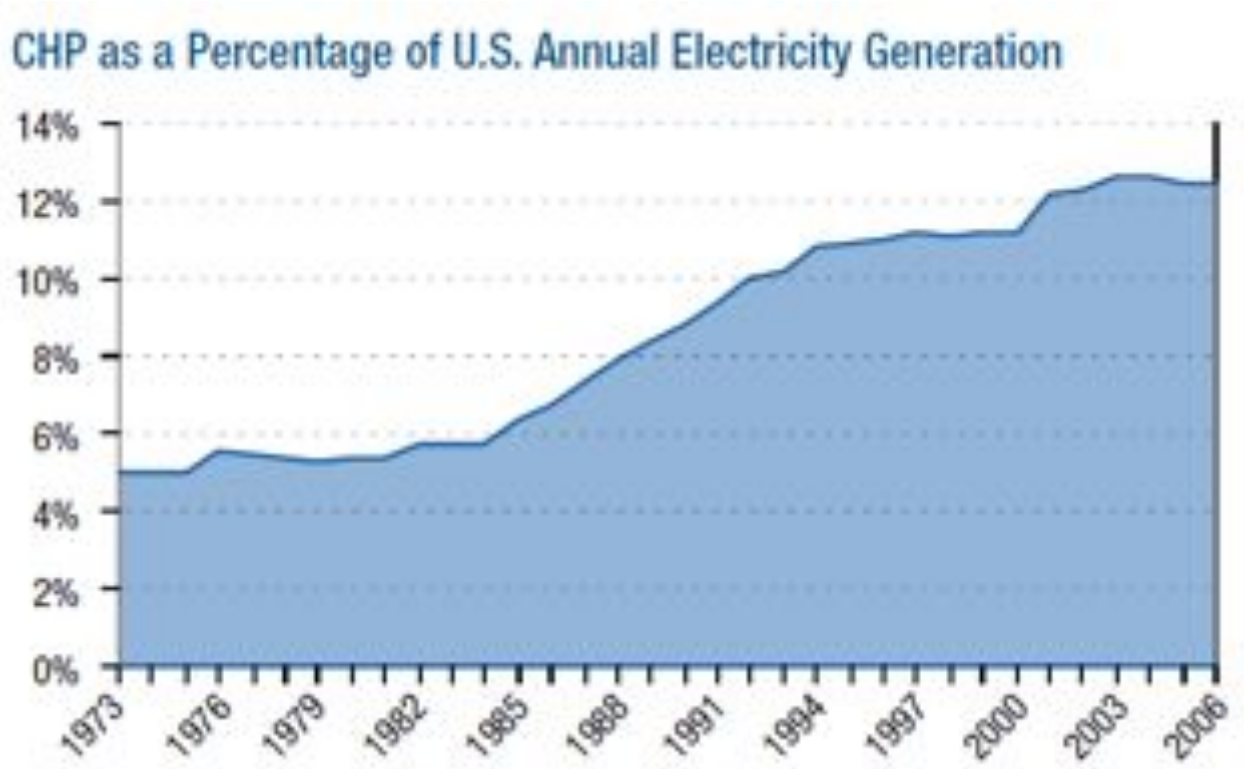
CHP Is Gaining Popularity & Growing



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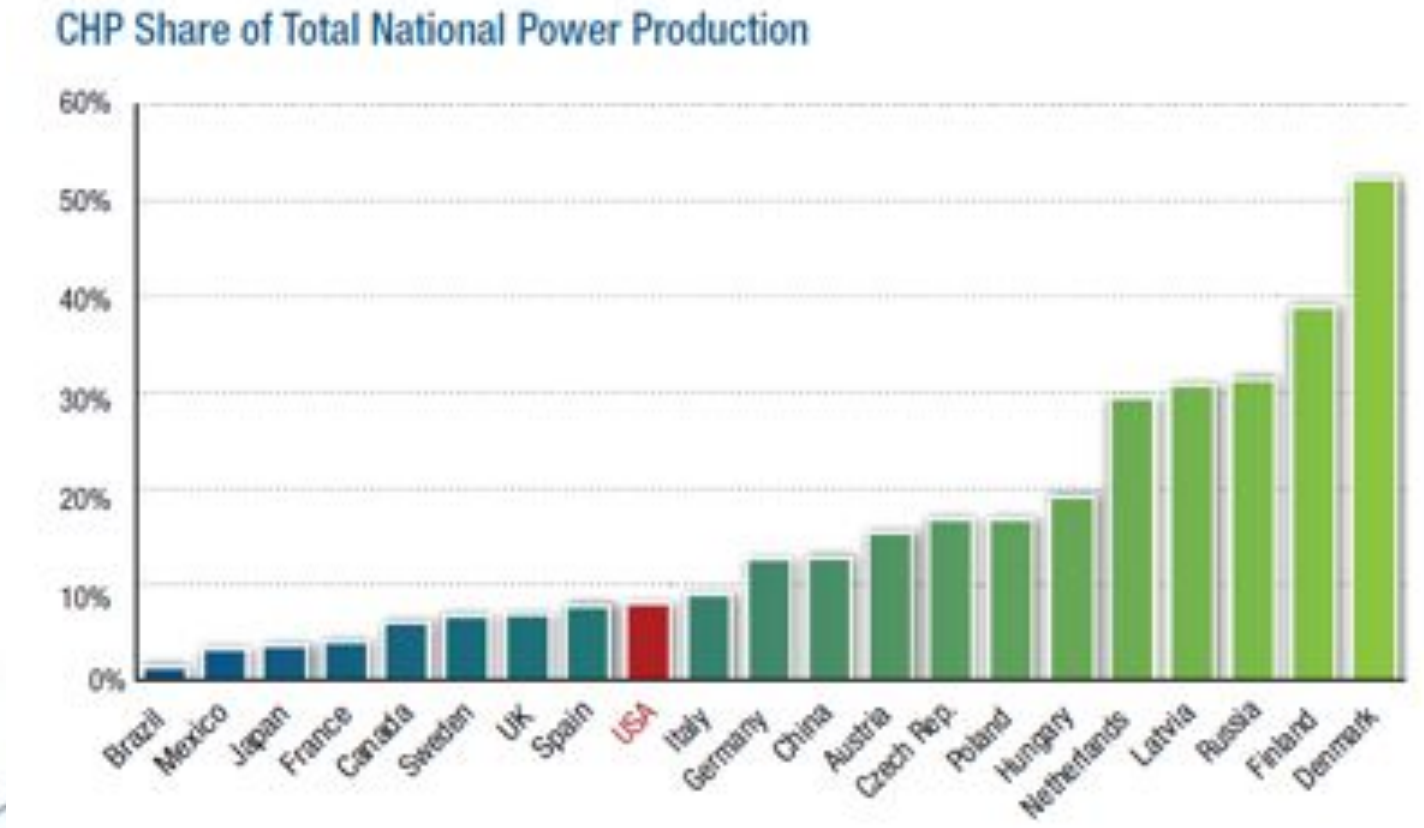
Worldwide Comparison



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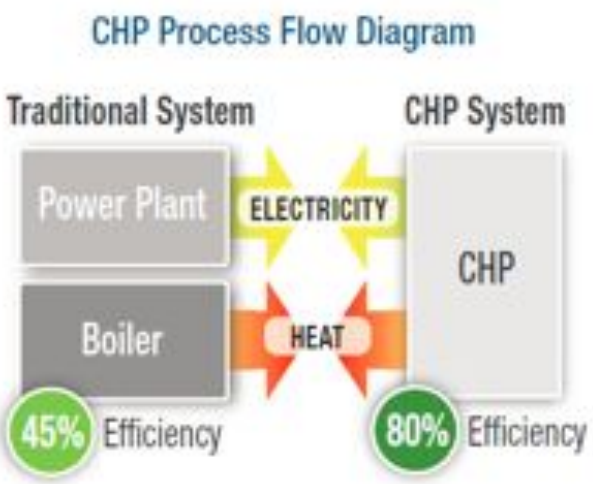
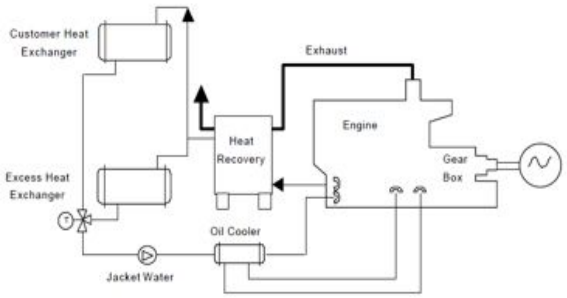
What is Combined Heat & Power (CHP)

- Also known as Cogeneration:
  - Concurrent production of electrical & thermal (heating / cooling) energy from a single fuel source.
  - Two (or more) outputs for a single input
- Technology
  - Prime Mover (Mechanical) burning fuel source coupled to an electric generator (Electric) and heat recovery unit (Thermal)
  - Sized to meet users thermal base load
- Distributed Generation
  - Located at or near the point of consumption
  - Avoids electrical transmission losses





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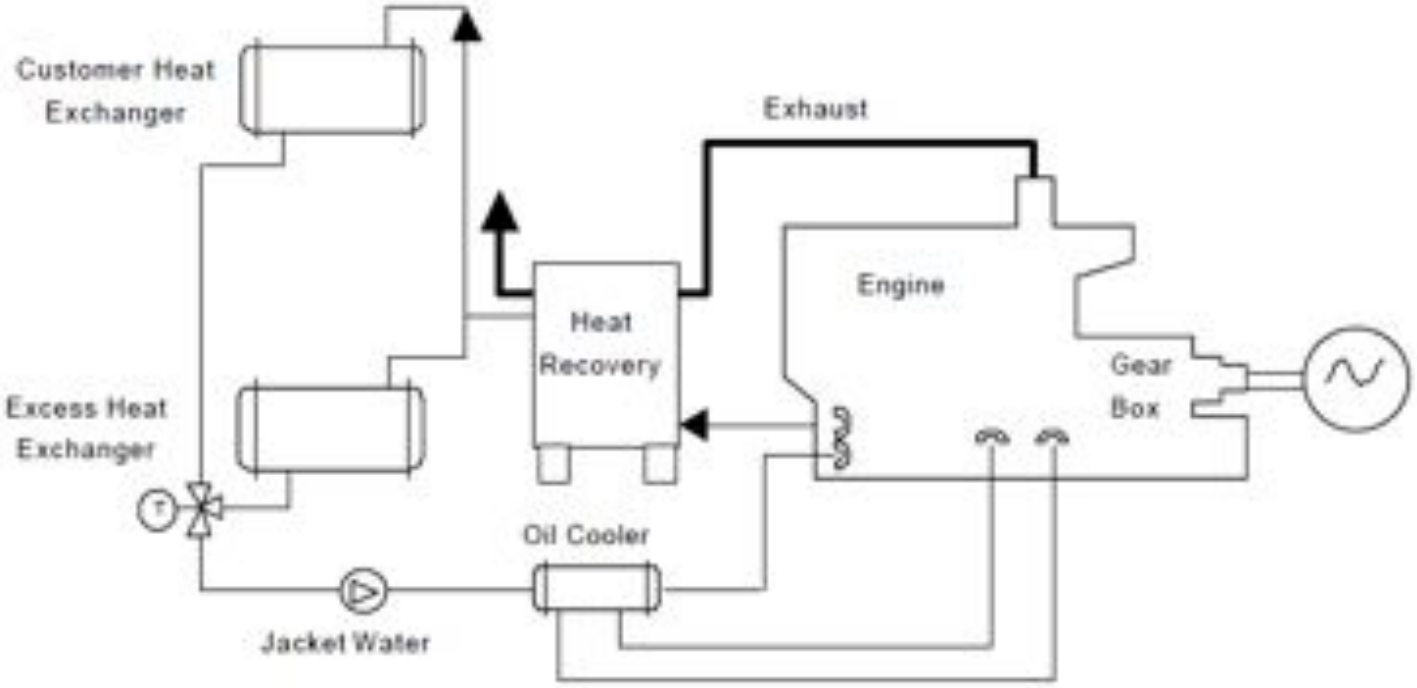
CHP Flow Diagram – Recip Engine



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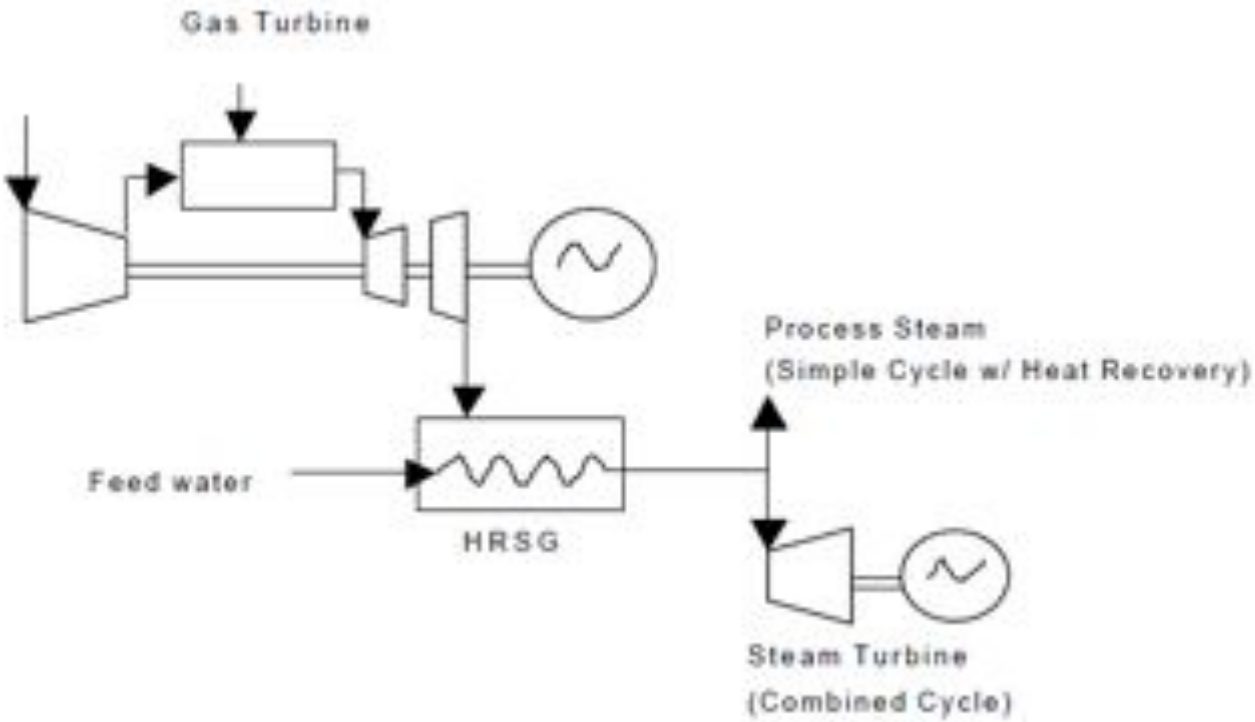
CHP Flow Diagram – Combined Cycle



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CHP Technologies

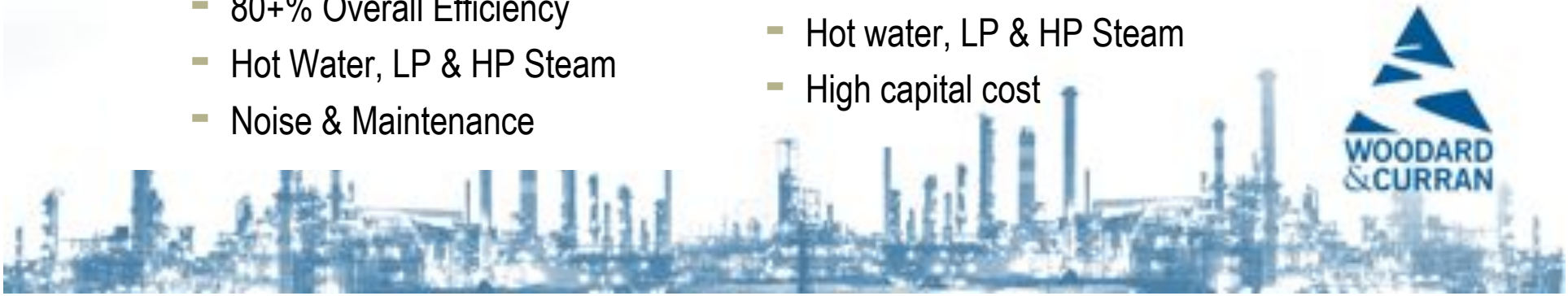
- **Combustion Turbine**
  - 500kW to 250 MW
  - 75+% Overall Efficiency
  - High Pressure Steam
  - Noise & HP Gas Supply
- **Micro-Turbine**
  - 30 kW to 250 kW
  - 75+% Overall Efficiency
  - Hot Water or LP Steam
- **Reciprocating Engine**
  - Up to 5 MW
  - 80+% Overall Efficiency
  - Hot Water, LP & HP Steam
  - Noise & Maintenance

Biomass Boiler / Backpressure Steam Turbine

- 30 kW to 500 MW
- 80% Overall Efficiency
- LP or HP Steam
- Long startup

Fuel Cell

- 5 kW to 2 MW
- 85% Overall Efficiency
- Hot water, LP & HP Steam
- High capital cost



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CHP Technology Comparison

Technology	Available Sizes	Power Efficiency	Overall Efficiency	Part Load	Est. Installed Cost ($/Kwe)	Est. O&M Costs ($/Kwe)	Availability	Hours to Overhaul	Startup Time	Fuel Press (psig)	Fuel Types	Noise Level	Thermal Output	Advantages	Disadvantages
Steam Turbine	50kW to 250 MW	15-38%	80%	Fair	430-1,100	< 0.005	Near 100%	> 50,000	Long & depends on size	N/A	N/A	High	LP - HP Steam	Hi overall eff., wide range of heat output, long working life, hi reliability	Slow Startup, Low power to heat ratio
Recip Engine	≤ 5MW	22-40%	70-80%	Good	1,100-2,200	0.009-0.022	92-97%	25,000-50,000	< 1 minute	1.0 - 45	Natural gas, biogas, propane, landfill gas, diesel fuel	High	hot water & LP steam	Hi power eff thru range of output, flexibility, low cost, island mode operation, ease of maintenance, low press gas	Hi maintenance costs, lower heat output & limited applications, relatively hi emmissions, cooling requirements, noise
Gas Turbine	500 kW to 250 MW	22-36	70-75%	Poor	970-1,300	0.004-0.011	90-98%	25,000-50,000	10 min to 1 hr	100-500	Natural gas, biogas, propane, fuel oils	Moderate	heat, hot water, LP & HP steam	Hi overall eff., Low emmissions, High grade heat output, no cooling required	Require hi press gas, Poor eff at low loads, output falls as ambient temp rises
MicroTurbine	30 kW to 250 kW	18-27%	65-75%	Fair	2,400-3,000	0.012-0.25	90-98%	20,000-40,000	1-5 minutes	50-80	Natural gas, biogas, propane, fuel oils	Moderate	heat, hot water, LP steam	Fewer moving parts, compact size & lite weight, low emissions, No cooling required	Hi costs, low mechanical eff., limitted or lower temp. output & applications
Fuel Cell	5 kW to 2 MW	30-63%	55-80%	Good	5,000-6,500	0.032-0.038	> 95%	32,000-64,000	Long - 3 hrs to 3 days	0.05 - 45	hydrogen, natural gas, propane, methanol	Low	hot water, LP & HP steam	Low emmissions, low noise, hi eff over load range, modular	Hi costs, low durability, fuels require processing unless pure hydrogen is used

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CHP – Fuel Types & Markets

- **Fuel Types:**
  - Natural Gas – supplied from Utility, CNG, or LNG
  - Propane
  - Fuel Oil – Low Sulfur Diesel
  - Landfill Gas – requires scrubbing or cleaning of the gas
  - Biogas – Anaerobic Digesters (Municipal, Agricultural, Food Waste) and Wood Gasification
  - Hydrogen – Fuel Cell
  - Biomass – Wood, wood waste, Crop residue, MSW, Food waste
- **Markets**
  - Education – Colleges, Universities, and Schools
  - Hospitals & Nursing Homes
  - Real Estate – Apartment buildings, office complexes, neighborhoods
  - Hotels & Conference Centers, Spas, Ski Resorts
  - Food Services – Refrigerated storage, Food waste
  - Industrial / Process
  - Municipal – Public buildings, Water & Wastewater, Correctional Facilities
  - Misc. – Museums

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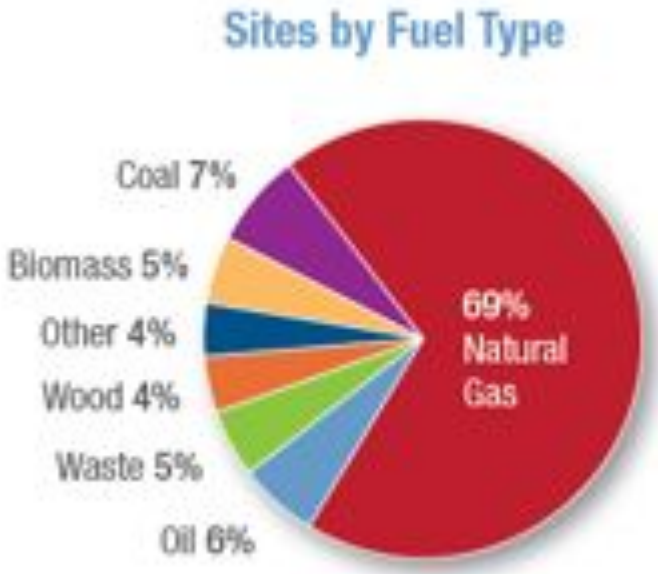
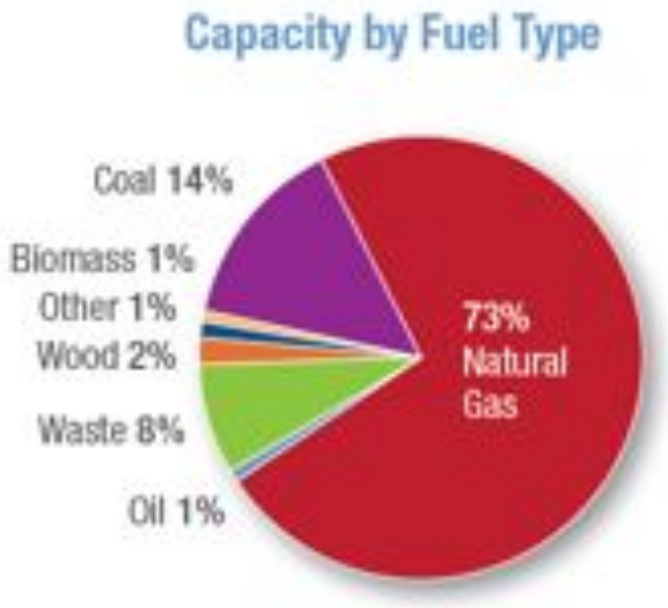
Existing CHP Capacity





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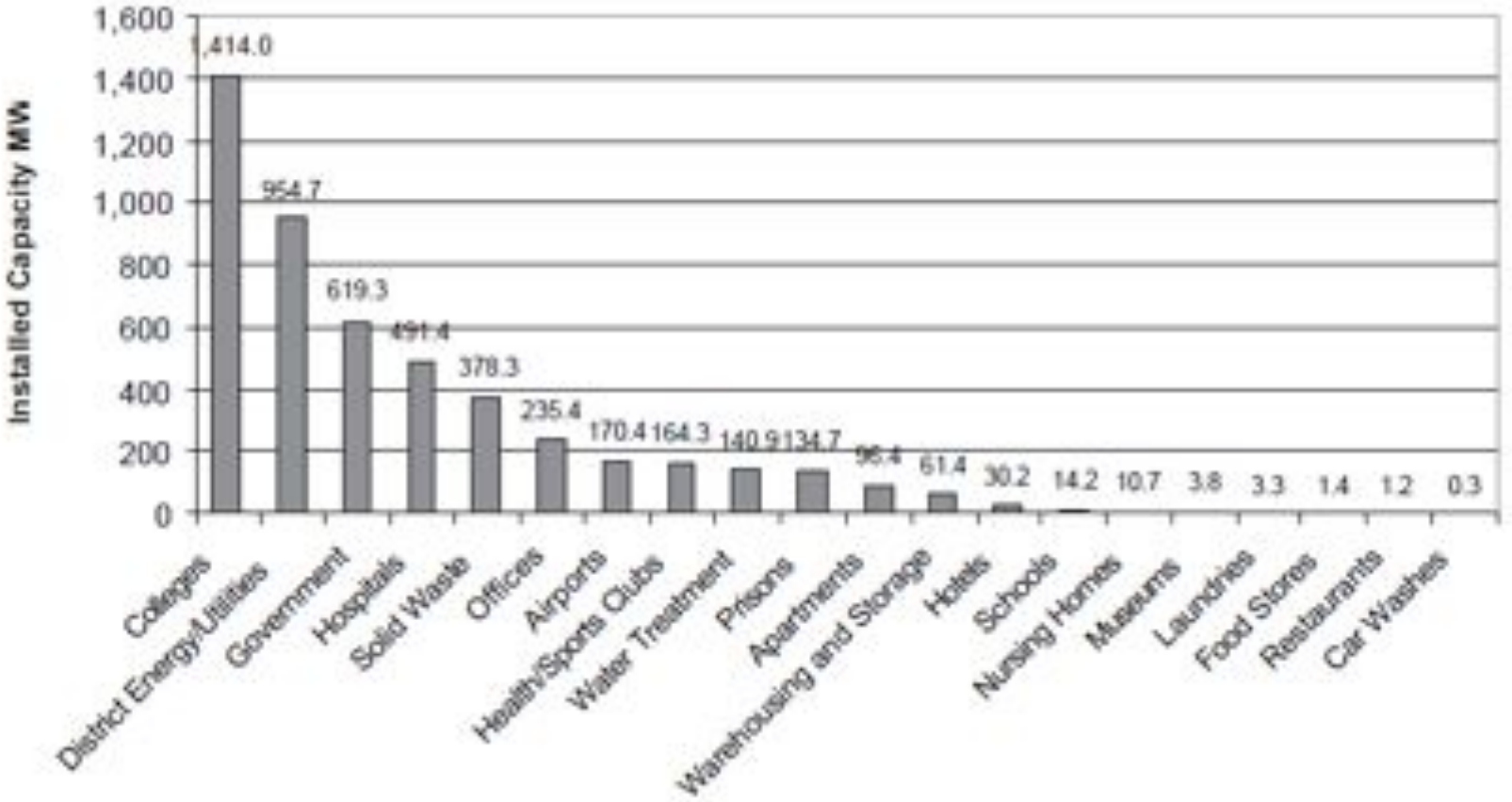
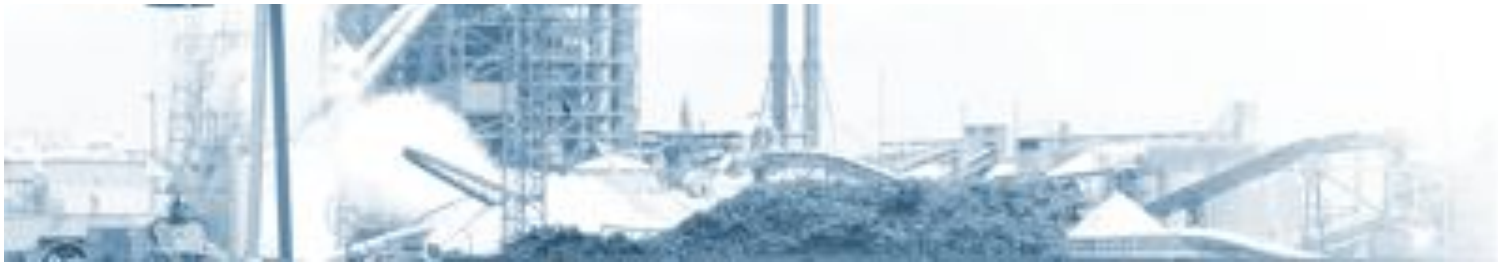
CHP Capacity by Market Type





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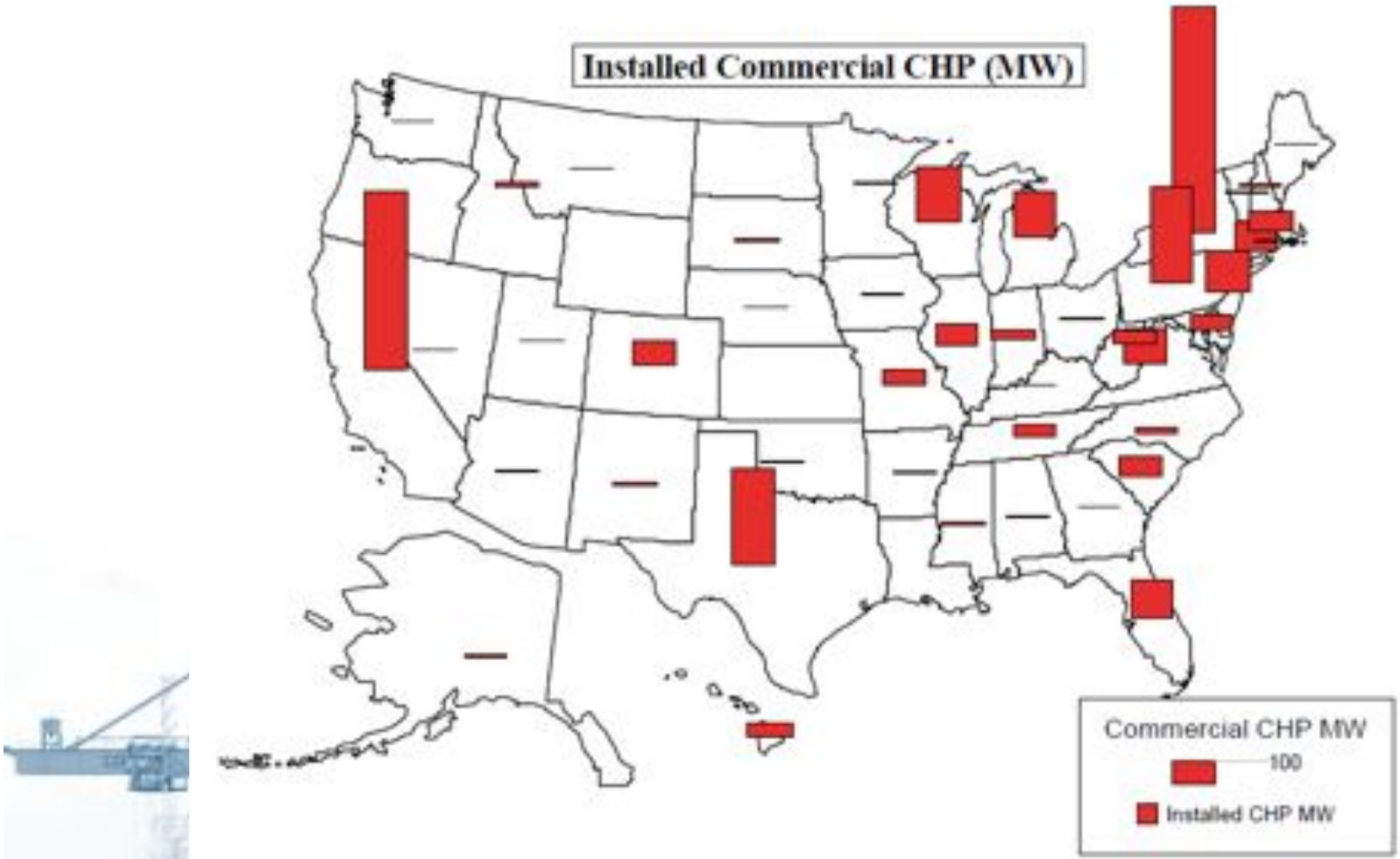
Installed CHP by State



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CHP Target Applications

- Relatively high electric and thermal loads
- Thermal energy loads – hot water, steam, or chilled water
- High operating hours or consistent load of greater than 4,000 hours per year
- Consistent load is beneficial

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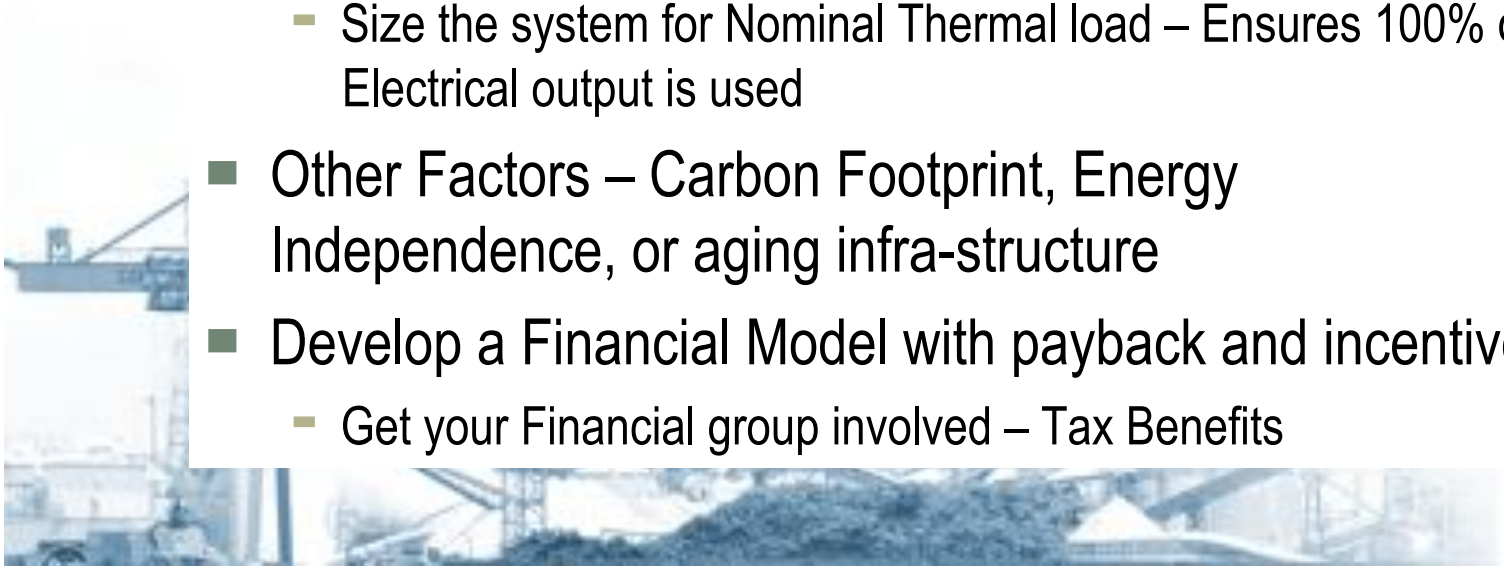
Identifying CHP Applications

- Energy Consumption & Map (Peak, Min, Average)
  - Identify your Electrical load (hourly data)
  - Identify your Thermal Load (hourly data)
    - Heating & Cooling
    - Process or other uses
  - Current Fuel sources, annual costs, and alternatives
- Sizing Dependent on Loads
  - Most applications Electrical > Thermal
  - Size the system for Nominal Thermal load – Ensures 100% of Electrical output is used
- Other Factors – Carbon Footprint, Energy Independence, or aging infra-structure
- Develop a Financial Model with payback and incentives
  - Get your Financial group involved – Tax Benefits



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Example Financial Model

CHP Thermal Applications

- Depends on the Process – Identify where and how
- Hot Water or Low Pressure Steam
  - Domestic Hot Water Supply
  - Building or District Heating & Cooling
  - Process / Manufacturing / Drying
    - Anaerobic Digesters
    - Pre-heating water
- High Pressure Steam
  - Additional Electric Generation or District Heating
  - Process / Manufacturing / Production
    - Pulp & Paper
    - Food Processing / Preparation
    - Laundry

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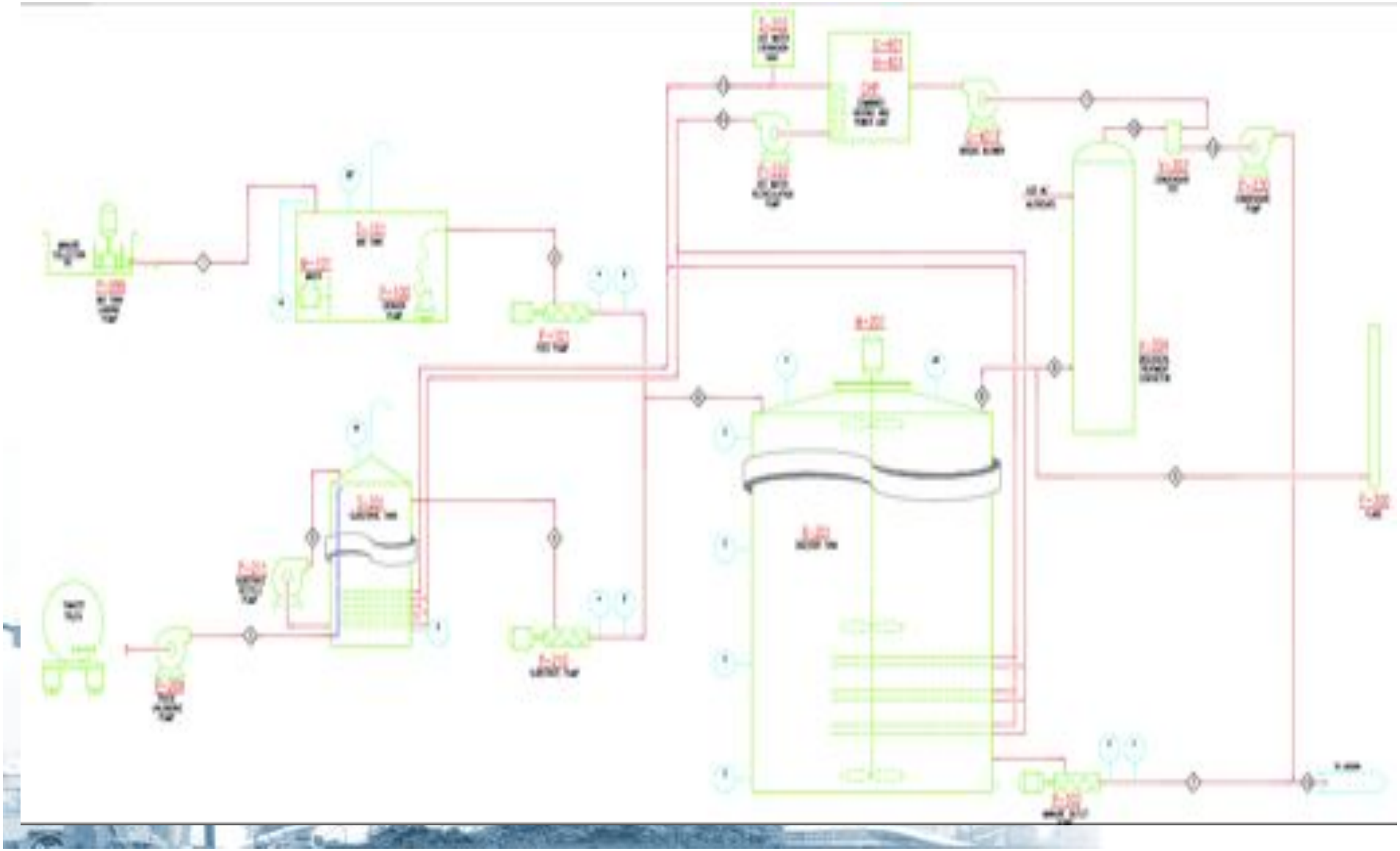
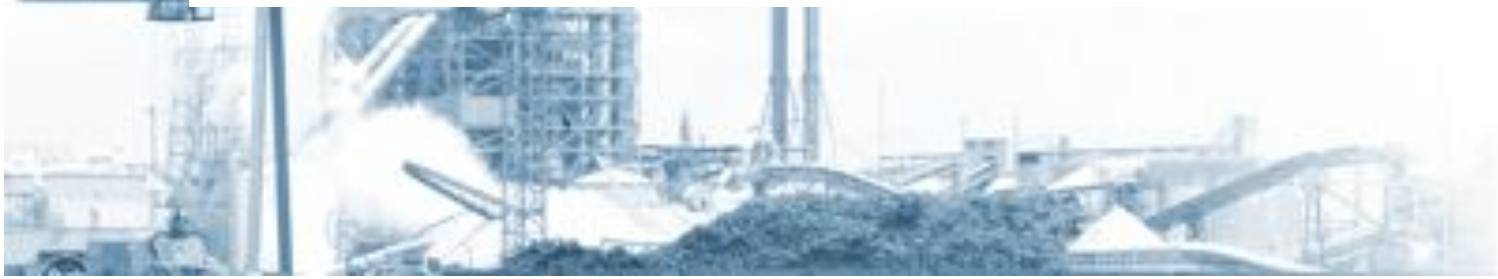
AD / CHP Process Flow Diagram



Waste Water Applications

- CHP Fuel – Biogas or Sludge Incineration
- Electrical Offset or Independence
- Waste Water Thermal Applications:
  - Anaerobic Digester Temperature Control and Biogas production
  - Fats, Oil, and Greases (FOG) Heating
  - Sludge Heating / Drying
  - Building Heat / Cooling
  - Domestic Hot Water



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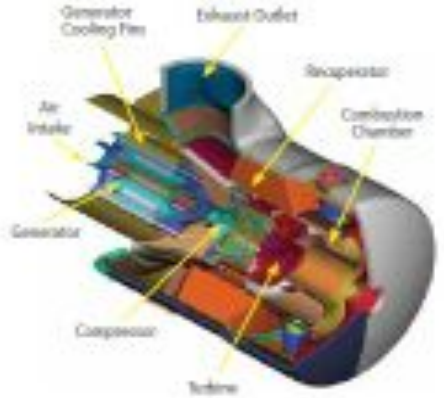
Alternatives for Biogas



- Combustion processes like CHP
- Compressed Natural Gas
  - Requires Scrubbing & Cleaning
  - Transportation / Vehicles
  - Natural Gas supplement – Supply & Onsite
    - Co-fire or used to fire existing boilers
    - Cooking / Kitchen use
    - Process firing – co-firing in duct burners or duct heaters

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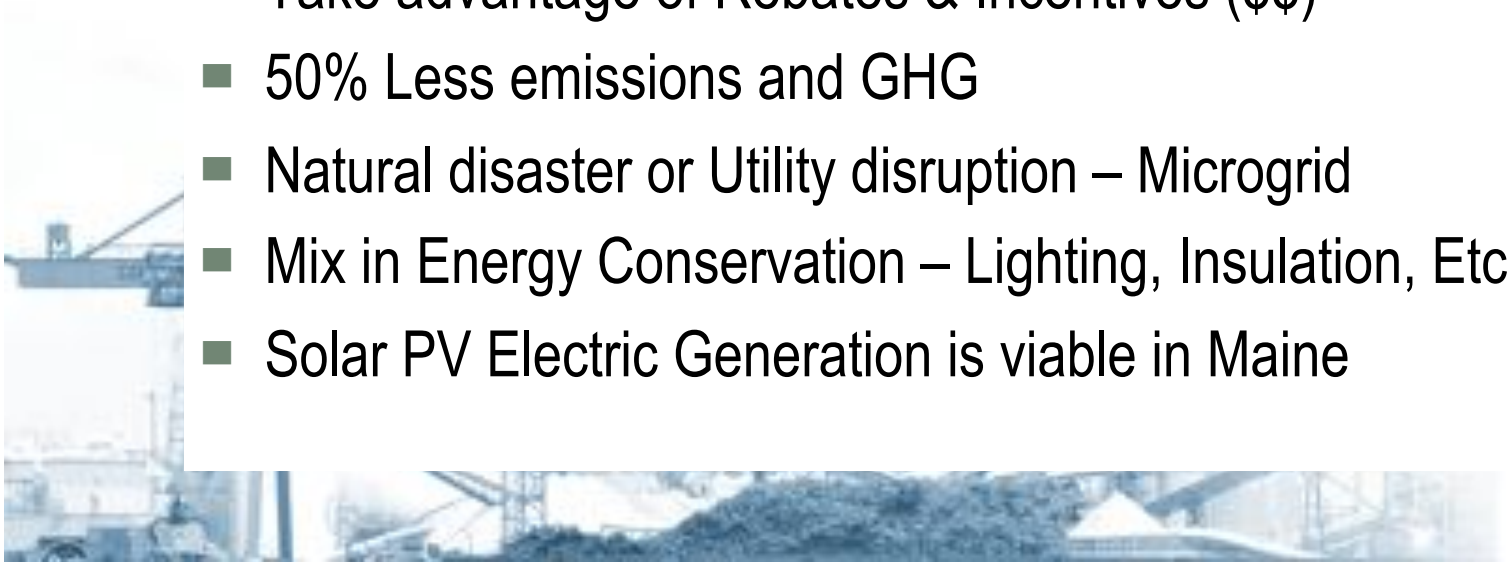
WWTP Energy Neutrality – Reduce your Dependency!

- Purchased Energy Costs will continue to increase with demand (Even Natural Gas)
  - Offset with Biogas or Biomass CHP
- Largest Single Energy Cost is Electricity
  - CHP provides electrical offset savings
- Traditional Systems are less efficient
  - CHP provides 2 outputs with one fuel input
- Take advantage of Rebates & Incentives ($$)
- 50% Less emissions and GHG
- Natural disaster or Utility disruption – Microgrid
- Mix in Energy Conservation – Lighting, Insulation, Etc.
- Solar PV Electric Generation is viable in Maine



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