Federal Utility Partnership Working Group
Spring 2012
Jekyll Island, GA

Energy Efficient Commercial Technologies

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Presented by:
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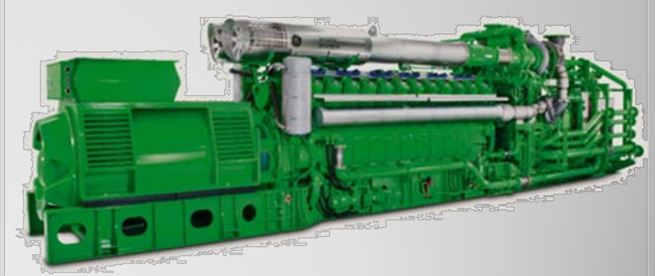
Todays Energy Efficient Technologies

- Water Heating
- Heating
- Air Conditioning
- Humidity Control
- CHP / Cogeneration



Traditional Tank Style Water Heating

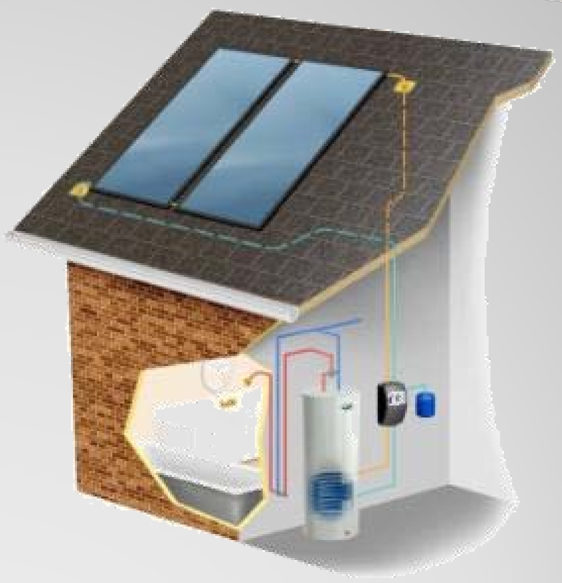
Atmospheric | **Direct Vent** | **High Efficiency**

.7 EF Atmospheric water heaters now available

97 % efficient tank water heaters now available

Newer Water Heaters

- Tankless Water Heaters
  - EF = .82 Standard Unit
  - EF = .97 Condensing
- Solar Water Heaters
  - With H.E. gas back up systems



Water Heater Life Cycle Cost

Life Cycle Costs	Electric Tank Water Heater	Gas Water Heater (Power Vent)	Standard Gas Tankless Water Heater	Condensing Gas Tankless Water Heater
Installed Cost Yr 1	$750	$1,200	$1,800	$2,500
Tank Replacement Yr 12	$750	$1,200	$0	$0
Year 1 Operating Costs	$574	$238	$195	$166
10 Year Life Cycle Cost	$6,755	$3,580	$3,750	$4,160
20 Year Life Cycle Cost	$14,139	$7,160	$5,700	$5,820

* Assumes that electric pricing increases 1% a year, and that gas prices will hold stable for the foreseeable future.

The payback on the initial tankless investment alone does not consider the much longer equipment life of this product. Tankless models have the lowest life cycle cost compared to tank models.

High Efficiency Heating Products

- Boilers
- Rooftop Units
- Infrared Heaters

Sectional Boilers

- Contains multiple cast sections
- Unit sizing up to 150 hp
- New condensing boilers available

Company *	Size	Efficiency
Burnham Boiler	262 - 5,733 MBH	Up to 89%
Crown Boiler – Std. Efficiency	342 - 1,852 MBH	78%
Crown Boiler – BIMINI	70 - 425 MBH	96.1%

* Numerous other manufacturers exist

Fire Tube Boilers

- Combustion gasses pass inside boiler tubes and heat water around tubes
- Incorporate high efficiency burners and combustion controls

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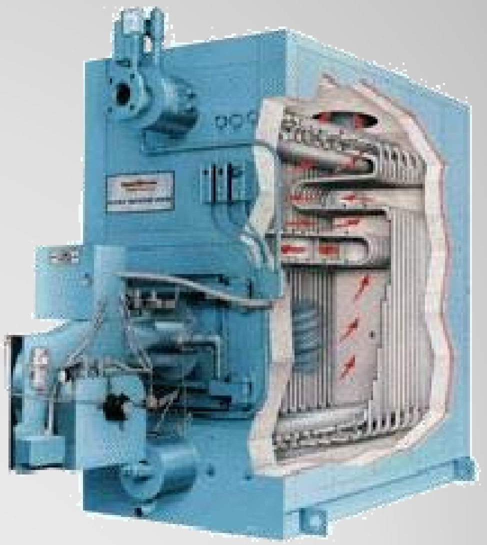
Water Tube Boilers

- Water passes through tubes
- Exhaust gasses remain in the shell passing over the tube surfaces



Fire Tube / Water Tube Boiler Manufacturers

Company	Size	Efficiency
Bryan Boilers – Flex Tube Atmos.	29 – 155 HP	80%
Bryan Boilers – Flex Tube Forced	6 – 527 HP	80-85%
Clayton Boilers – Water Tube	8 – 1000 HP	80-83%
Cleaver Brooks – Water/Fire Tube	100 – 1800 HP	82%
Cleaver Brooks – Super Boiler	3,600 – 29,000 lb/hr	93-94%
Columbia Boiler – Water Tube	4 – 60 HP	80%
Hurst Boiler – Fire Tube	15 – 800 HP	81% min.
Johnston Boiler – Fire Tube	50 – 2500 HP	Up to 99%

Condensing Boilers

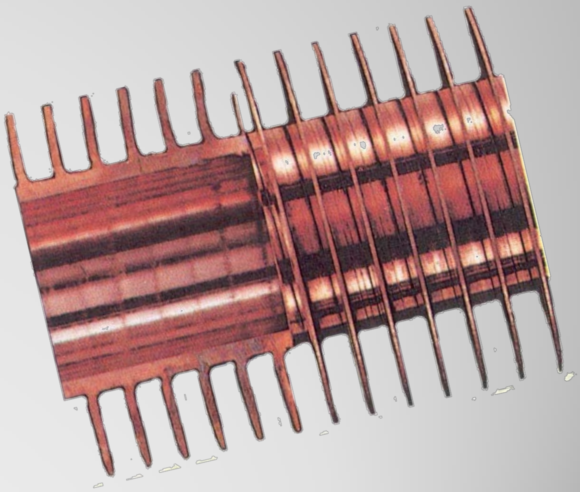
- Water vapor produced during combustion condenses back into liquid form, releasing the latent heat
- Efficiencies of 90 to 96 percent

Condensing Boiler Manufacturers

Company	Size	Efficiency
Cleaver Brooks – ClearFire	500 – 2500 MBH	Up to 99%
Crown Boiler - BIMINI	70 – 425 MBH	96.1%
Fulton – Pulse or Vantage	300 – 6000 MBH	90 – 99%
GasMaster	200 – 4000 MBH	92 – 99.8%
Hurst Boiler (start here)	6 – 100 HP	
Laars Heating Systems	150 – 2500 MBH	90 – 98%
Lochinvar	1000 – 1500 MBH	Up to 98%
Peerless	80 – 1000 MBH	Up to 96.6%
Thermal Solutions - Evolution	750 – 3000 MBH	Up to 97%

High Efficiency
Copper Fin Tube Boilers

- Water tube design – flows through copper pipe fitted with fins
  - Increased heat transfer surface
  - Compact design
  - Fully-modulating with High-turndown (5:1)



High Efficiency
Copper Fin Tube Boiler Manufacturers

Company	Size	Efficiency
Allied Boilers – AAE Series	480 – 3000 MBH	80% min.
Allied Boilers – Mini-Star	70 – 280 MBH	86%
Lochinvar	400 – 2070 MBH	85%

Life Cycle Cost - Example

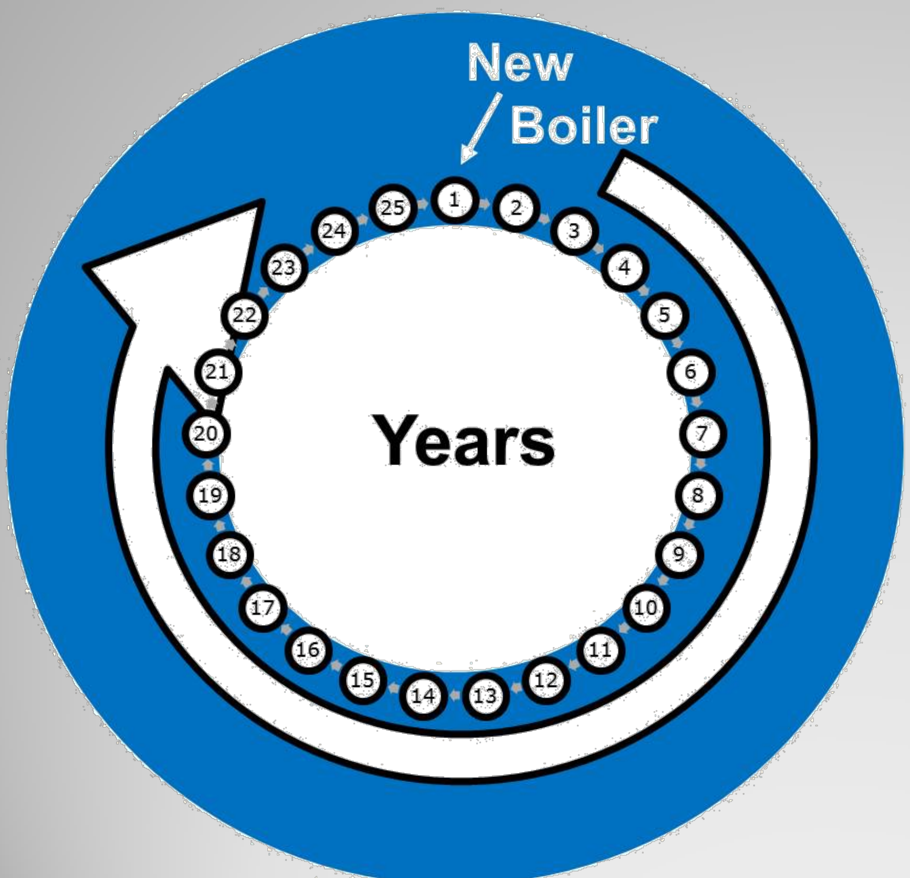
- Building is heated by a 60 HP Boiler that was installed in 1965
- Maintenance costs are much higher than they should be, averaging $2,000 a year for repairs on top of $2,000 a year to clean the boiler.

Energy Usage/ Cost

Boiler	Efficiency	Natural Gas Usage (MCF / Yr)	Natural Gas Cost per year	Total Installed Cost
Existing Boiler	67 %	1,452	$18,589	
New Standard Boiler	80 %	1,216	$15,568	$50,000
New High Efficiency Boiler	90%	1,081	$ 13,839	$60,000

- Usage estimated for this boiler in a 4,500 heating degree day climate.
- Using $8 /MCF commercial natural gas rate

Life Cycle Cost - Analysis



<u>New Boiler every 25 years</u>

Annual Costs include:

- Loan Payment
- Energy Cost
- Maintenance Costs

Assumptions:

- 1% Energy Inflation Rate
- 1% Maintenance Inflation rate
- Discount rate 7%

Boiler Life Cycle Costs

Option	Life Cycle Cost
Base Case: Try and keep existing boiler running another 25 years	$ 441K
Replace old Boiler with new Standard 80% efficiency Boiler	$ 439K
Replace old Boiler with new High Efficiency, 90% Boiler	$ 429K ✔

Lowest Life Cycle Cost

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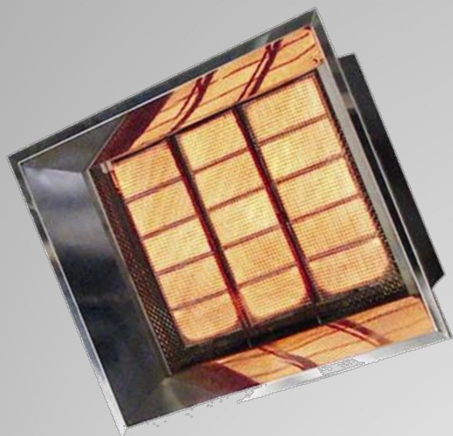
High Efficiency Rooftop Units

- New designs that employ modulating and condensing technology are now available
- Natural gas rooftop units provide comfort and efficiency, offering:
  - Fast morning warm-up and response times
  - Lower operating and maintenance costs
- Condensing Units have efficiencies over 90%

Infrared Systems



- Types of systems
  - High intensity units
  - Low intensity tubular units
- Generate radiant energy that is converted into heat when absorbed by objects in its path
- 20-50% fuel savings over conventional forced air units

Gas Air Conditioning

www.gasairconditioning.com

- Gas Cooling Equipment
  - Life Cycle Cost Analysis
- Humidity Control Technologies

What is Gas Air Conditioning?

- Gas Air Conditioning is any form of space temperature and/or humidity control technologies that uses natural gas as the energy source
- Applications include:
  - Cooling
  - Humidity Control

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Unitary & Gas Heat Pumps

- Absorption systems (Standard or Heat Pump)
  - Can produce hot water
  - Geothermal available
  - 5 – 25 ton systems
- Engine-driven Heat Pumps
  - Variable speed loading/unloading
  - 8,10, & 16 Ton units
  - COP = 1.4 Cooling
  - COP = 1.6 Heating

This is equivalent to
160% efficient heater

Absorption Cooling

- Direct fired or steam/hot water options
- Utilize excess steam capacity during summer periods
- Efficiency
  - Single Effect – Typical COP .62 – .65
  - Double Effect – Typical COP 1.0– 1.3
- Simultaneously produce chilled and hot water
- Can incorporate into a CHP system

Engine Driven Cooling

- Uses traditional vapor compression refrigeration cycle
- High Coefficient of Performance (COP) using waste heat recovery
  - Air Cooled – Typical COP 1.0
  - Water Cooled – Typical COP 1.6
  - Water cooled w/ heat recovery = 2.4
- Excellent part load efficiencies
- Sized 8 to >= 400 Tons

Sample Payback Analysis

Natural Gas vs. Electric Air Conditioning

Size Chiller	400
Equivalent Full load Hours	1500

Energy Rates

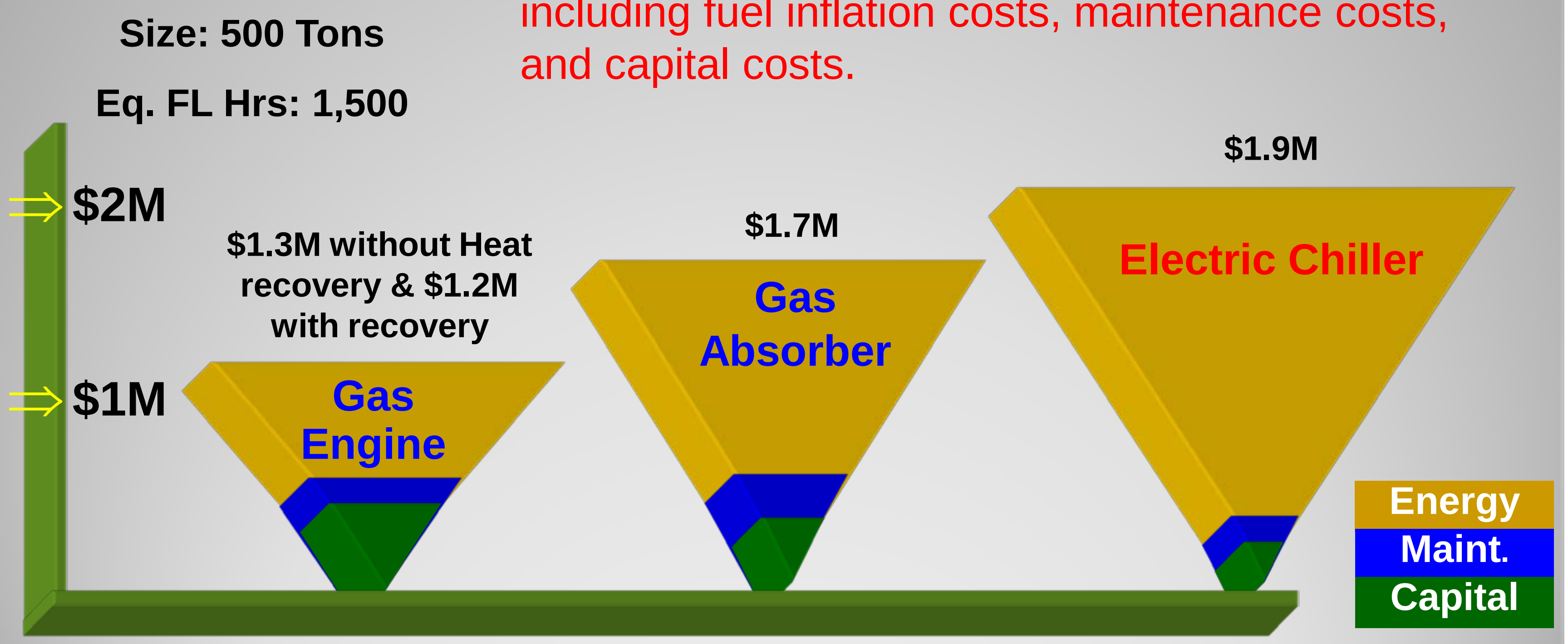
Average Electric Rate	$	0.10	/KWH
Electric Demand Charge	$	9.00	/KW
Natural Gas Rate	$	0.85	$/Therm

	Capital Cost ($/ton)	Installed Cost ($/ton)	Ave. Maint. Cost ($/Ton-Hr/Year)	Equipment Life (years)	Efficiency	Electric Demand (KW)	Gas Usage (BTU/Ton)
Electric Centrifugal Chiller	250	50	0.004	20	0.7 kw/ton	280	
Single Affect Absorption	250	50	0.006	20	0.65 COP	10	15000
Double Effect Absorption	435	50	0.006	20	1.3 COP	10	9200
Engine Driven Chiller	550	100	0.01	20	1.57 COP	5	5700
Engine Driven /w Heat Recovery	550	130	0.01	20	1.89 COP	5	5700

	Electric Centrifugal	Single Effect Absorption Chiller	Double Effect Absorption Chiller	Engine driven Chiller	Engine driven Chiller with heat recovery
Size Chiller (Tons)	400	400	400	400	400
Equivalent Full Load Hours	1500	1500	1500	1500	1500
Capital Cost Equipment ($/ Ton)	$ 250	$ 250	$ 435	$ 550	$ 550
Installation Cost ($/Ton)	$ 50	$ 50	$ 50	$ 100	$ 130
Total Installed Cost	**$ 120,000**	**$ 120,000**	**$ 194,000**	**$ 260,000**	**$ 272,000**
Ave.Maintanance Cost ($/Ton-Hr/Year)	$ 0.004	$ 0.006	$ 0.006	$ 0.01	$ 0.01
Annual Maintenance Cost	**$ 2,400**	**$ 3,600**	**$ 3,600**	**$ 6,000**	**$ 6,000**
Equipment Life (Years)	20	20	20	20	20
Efficiency	0.7	0.65	1.3	1.57	1.89
Efficiency Units	kw/ton	COP	COP	COP	COP
Average Electric Rate ($ / KWH)	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.10
Monthly Demand Charge($/KW)	$ 9.00	$ 9.00	$ 9.00	$ 9.00	$ 9.00
Electric Demand (KW)	280	10	10	5	5
Demand Charge (per Year)	**$ 30,240**	**$ 1,080**	**$ 1,080**	**$ 540**	**$ 540**
Electric Usage (KWH)	420,000	15,000	15,000	7,500	7,500
Usage Charge	**$ 42,000**	**$ 1,500**	**$ 1,500**	**$ 750**	**$ 750**
Electric Cost	**$ 72,240**	**$ 2,580**	**$ 2,580**	**$ 1,290**	**$ 1,290**
Average Gas Rate ($/Therm)	-	$ 0.85	$ 0.85	$ 0.85	$ 0.85
Gas Demand (BTU / Ton)	-	15000	9200	5700	5700
Gas Usage (Therms)	-	90000	55200	34200	34200
Gas Cost ($)	**0**	**$ 76,500.00**	**$ 46,920.00**	**$ 29,070.00**	**$ 29,070.00**
Recovered Heat (Therm/Hr)					4.80
Value of hot water generated					**$ (6,120.00)**
Total Operating Cost	**$ 72,240**	**$ 79,080**	**$ 49,500**	**$ 30,360**	**$ 24,240**
Savings (gas versus electric)			$ 22,740	$ 41,880	$ 48,000
Incremental installed cost			$ 74,000	$ 140,000	$ 152,000
Simple Payback (Years)			3.25	3.34	3.17

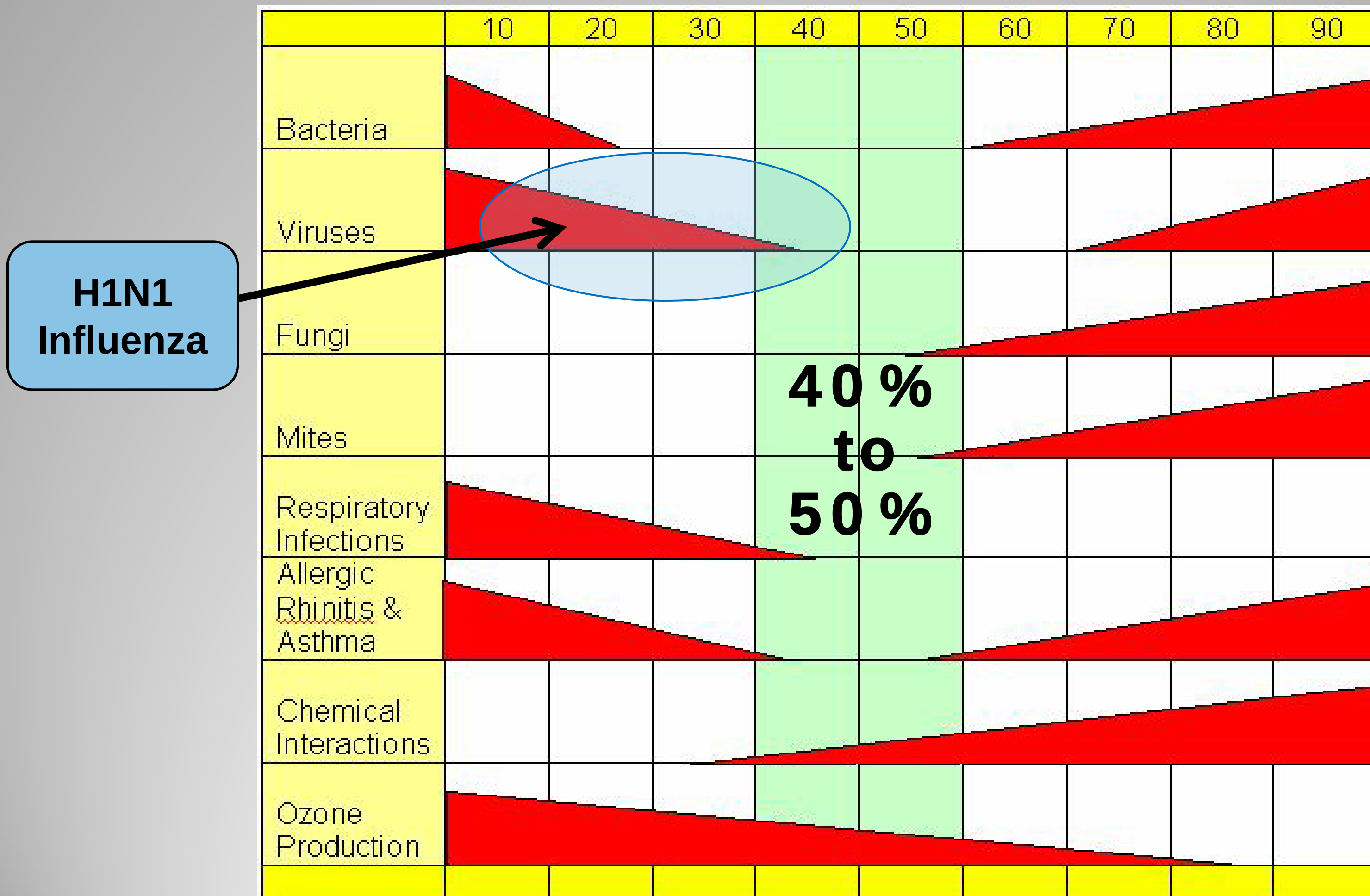
Life Cycle Cost of Ownership

Life Cycle Costs consider the full costs of ownership over the life of the equipment including fuel inflation costs, maintenance costs, and capital costs.



Continued savings on utility bills add to the bottom line

Humidity Control is Very Important



Why Control Humidity?

- Uncontrolled humidity negatively impacts:
  - HVAC systems
  - Energy costs
  - Building structure and systems
  - Furnishings, equipment and supplies
  - Comfort of building occupants
  - Health of building occupants

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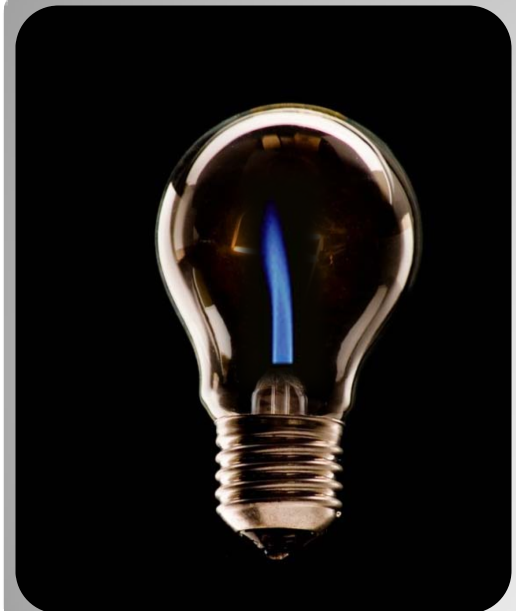
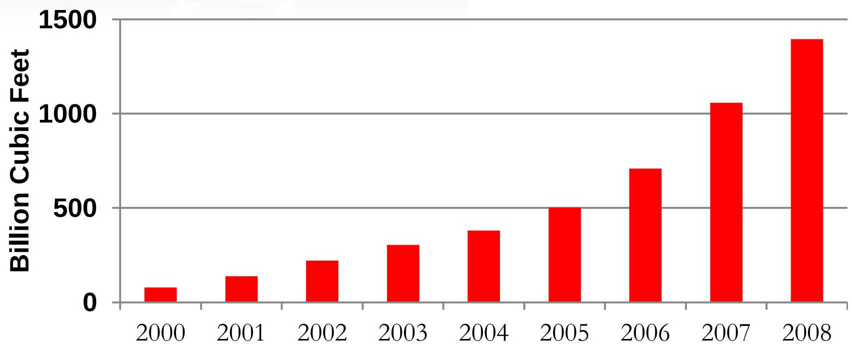
Humidity Control Technologies

- Natural Gas Desiccant Dehumidification
  - Allows for independent control of humidity and temperature.

- Natural Gas Fired Humidifiers
  - Can handle minerals left behind when water is boiled

Onsite Power Generation Is Now the Time?

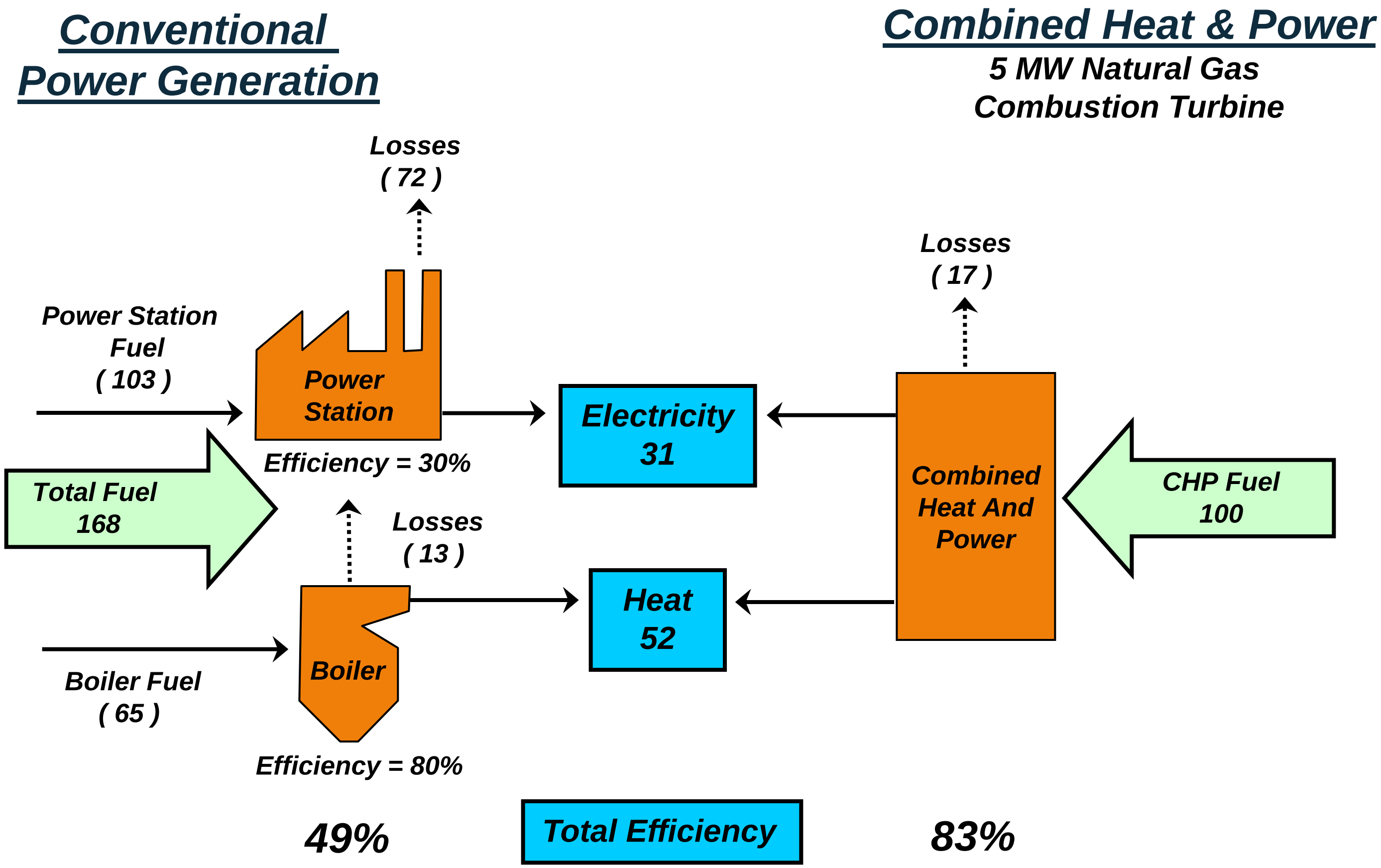




Barnett Shale Production of Unconventional Gas

Gas supply projections reach all time high - ~40% increase providing over 100 yrs in potential resources!

Comparing the Efficiency of Conventional Power Generation vs. CHP



Note: These figures use national averages for electricity produced for the grid and also incorporate transmission losses.

Source: *United States Combined Heat and Power Association Report – Natural Gas Impacts of Increased CHP by Energy and Environmental Analysis, Inc - October 2003*

Commercial CHP

- Total system efficiencies of 75% to 85%
- Cut energy costs by as much as 40%
- Produce power at rates lower than electric utility
- Reduce peak electric energy costs and demand charges
- Recover and turn heat lost during power generation into usable thermal energy

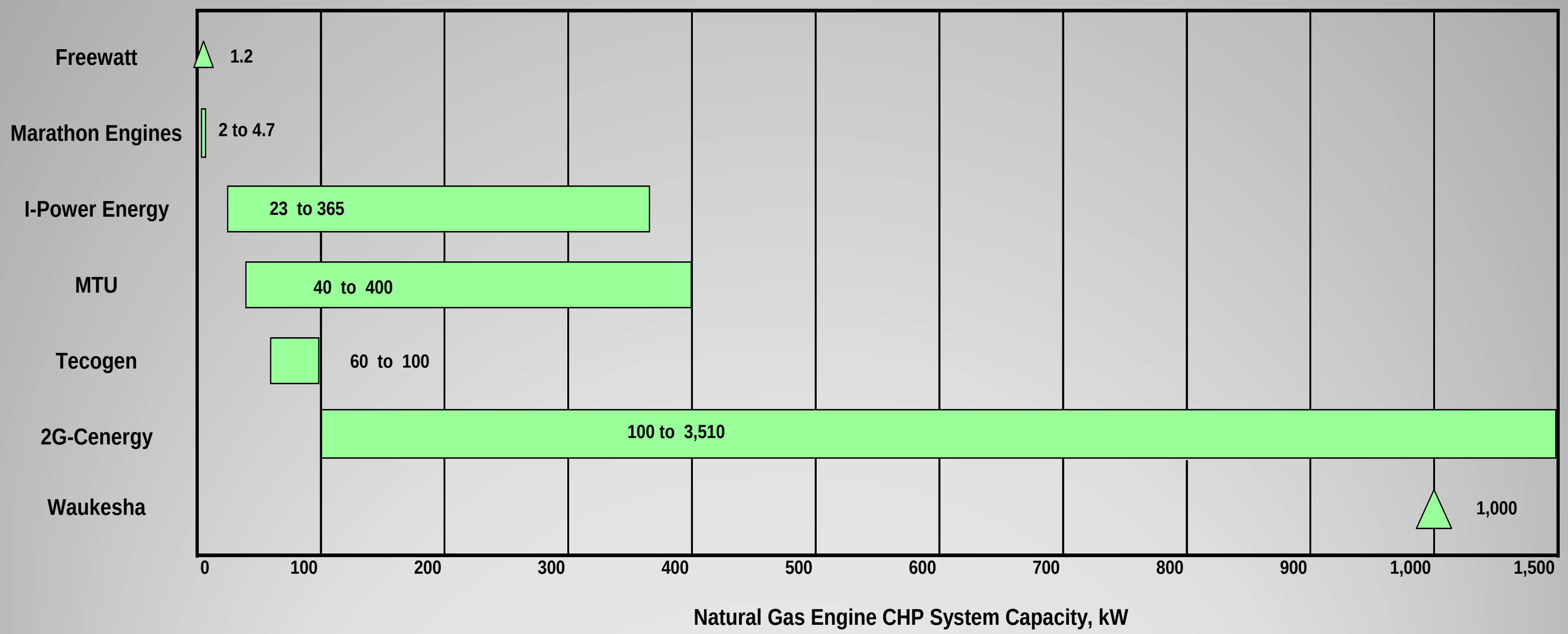
<u>Prime Movers</u>

- Engine Driven Systems
- Micro Turbine
- Fuel Cells
- Combustion Turbines

Engine Driven System

- Can reduce energy costs
- Can increase the reliability of facilities electric service
- 80^{+}% system efficiencies
- CHP systems generally recover the waste heat to produce hot water

Engine-Based CHP Manufacturers



Now available from the factory in sizes from 1 kW to 1 MW +

For all prime mover vendor charts, see Vendor Guide at www.PowerOnsite.org

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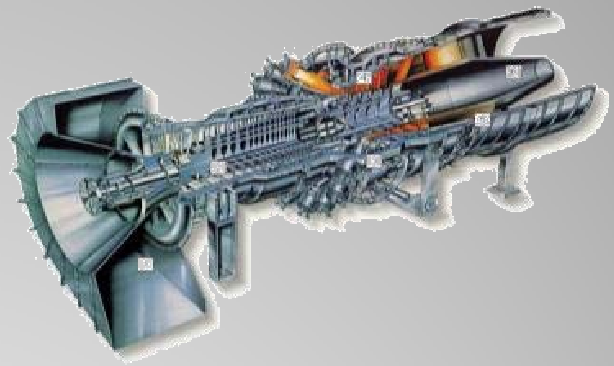
Micro Turbines

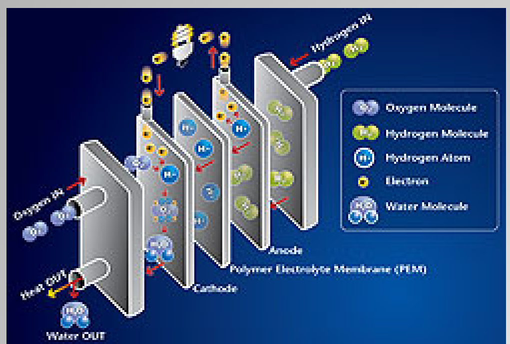
- Total system efficiencies of 75% to 85%
- Cuts energy costs by as much as 40%
- Produces power at rates lower than electric utility
- Reduces peak electric energy costs and demand charges

Gas Turbines



- Advantages
  - High reliability
  - Low emissions
  - Produce high quality heat for:
    - Steam generation for process use, district/process heat, activation of absorption cooling
      or to drive a steam turbine in a combined-cycle plant
  - Sizes: 500 kW to over several hundred megawatts

Fuel Cells



- <u>Five Basic Types</u>
  - **Alkaline**
  - **Phosphoric Acid**
  - **Molten Carbonate**
  - **PEM (Polymer Electrolyte Membrane)**
  - **Solid Oxide**

- A fuel cell is an <u>electrochemical process</u> that converts a stream of fuel into an electric current and thus has few moving parts.
- Can attain energy conversion efficiencies exceeding 85 percent, however, <u>cost and methane reforming to produce hydrogen</u> remain as key challenges to the deployment of fuel cells.

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Comparisons for Reference: Installed Costs, O & M Costs & More

Technology	Steam Turbine[1]	Recip. Engine	Gas Turbine	Microturbine	Fuel Cell
Power efficiency (HHV)	15-38%	22-40%	22-36%	18-27%	30-63%
Overall efficiency (HHV)	80%	70-80%	70-75%	65-75%	55-80%
Effective electrical efficiency	75%	70-80%	50-70%	50-70%	55-80%
Typical capacity (MW_e)	0.5-250	0..01-5	0.5-250	0.03-0.25	0.005-2
Typical power to heat ratio	0.1-0.3	0.5-1	0.5-2	0.4-0.7	1-2
Part-load	ok	ok	poor	ok	good
CHP Installed costs ($/$kW_e$)	430-1,100	1,100-2,200	970-1,300 (5-40 MW)	2,400-3,000	5,000-6,500
O&M costs ($/$kWh_e$)	<0.005	0.009-0.022	0.004-0.011	0.012-0.025	0.032-0.038
Availability	near 100%	92-97%	90-98%	90-98%	>95%
Hours to overhauls	>50,000	25,000-50,000	25,000-50,000	20,000-40,000	32,000-64,000
Start-up time	1 hr - 1 day	10 sec	10 min - 1 hr	60 sec	3 hrs - 2 days
Fuel pressure (psig)	n/a	1-45	100-500 (compressor)	50-80 (compressor)	0.5-45
Fuels	all	natural gas, biogas, propane, landfill gas	natural gas, biogas, propane, oil	natural gas, biogas, propane, oil	hydrogen, natural gas, propane, methanol
Noise	high	high	moderate	moderate	low
Uses for thermal output	LP-HP steam	hot water, LP steam	heat, hot water, LP-HP steam	heat, hot water, LP steam	hot water, LP-HP steam
Power Density (kW/m^2)	>100	35-50	20-500	5-70	5-20
NO_x (lb/MMBtu) (not including SCR)	Gas 0.1-.2 Wood 0.2-.5 Coal 0.3-1.2	0.013 rich burn 3-way cat. 0.17 lean burn	0.036-0.05	0.015-0.036	0.0025-.0040
$lb/MWh_{TotalOutput}$ (not including SCR)	Gas 0.4-0.8 Wood 0.9-1.4 Coal 1.2-5.0.	0.06 rich burn 3-way cat. 0.8 lean burn	0.17-0.25	0.08-0.20	0.011-0.016

Data are illustrative values for typically available systems. Costs are in 2007 $

[1] For steam turbine, not entire boiler package

Courtesy ICF/EEA

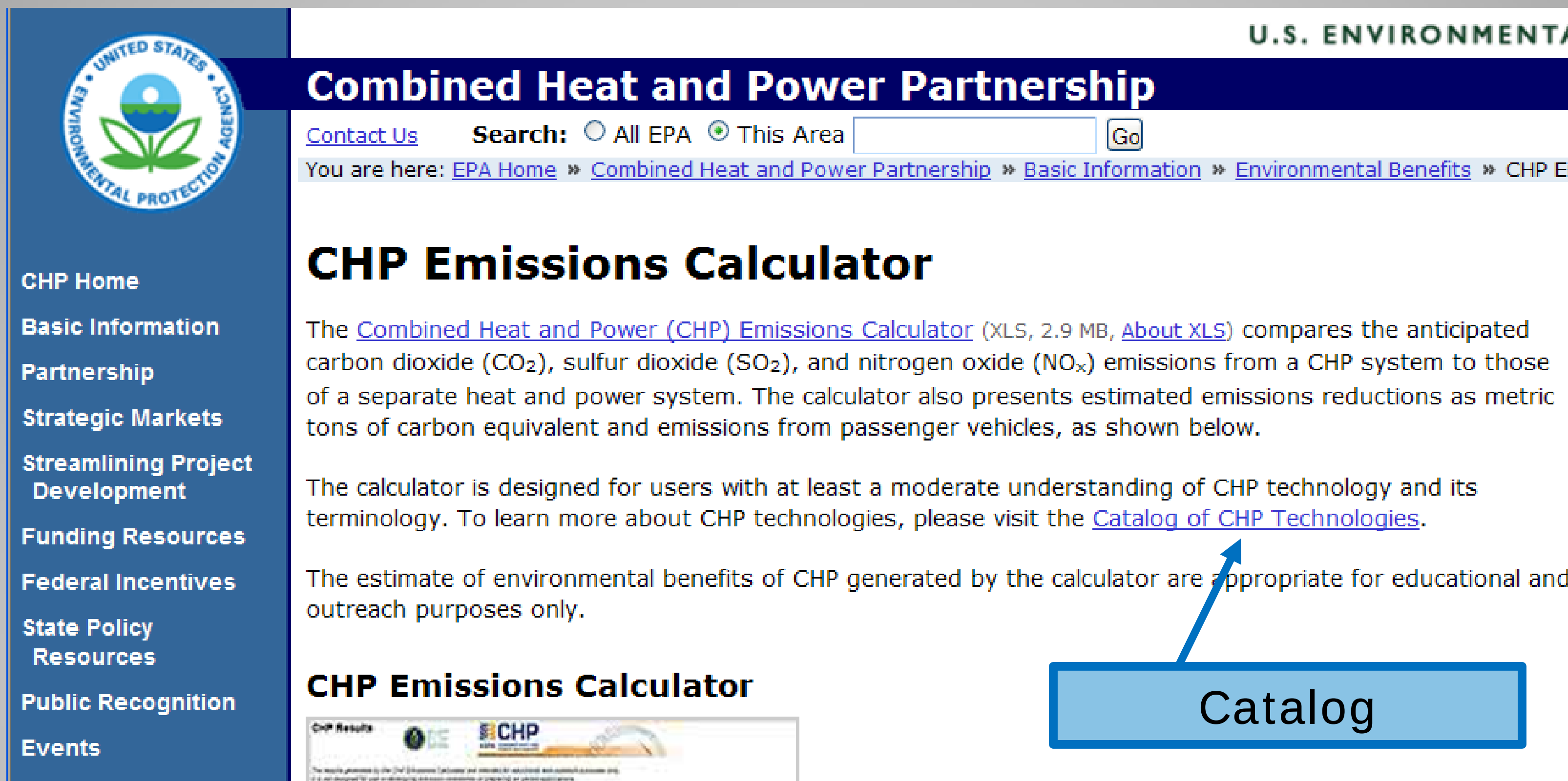
To Calculate Potential CHP Savings

Navigate to:

Is Cogeneration "Right" for your Facility at

www.PowerOnsite.org

CHP Emissions Calculator



www.epa.gov/chp/basic/calculator.html

The Environmental Benefits of Natural Gas

- The cleanest burning fossil fuel.
- It produces virtually no emissions of sulfur dioxide or particulate matter and far lower levels of "greenhouse" gases and nitrogen oxides than oil or coal.
- Produces virtually no solid waste.
- Natural gas is delivered to the customer with around 90% efficiency.

…..and the Price is Right!

Questions?

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