2014 International Workshop on Environment and Alternative Energy

Combined Heat & Power (CHP)

A Better Alternative

Michael Ellis
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AGL Energy Services

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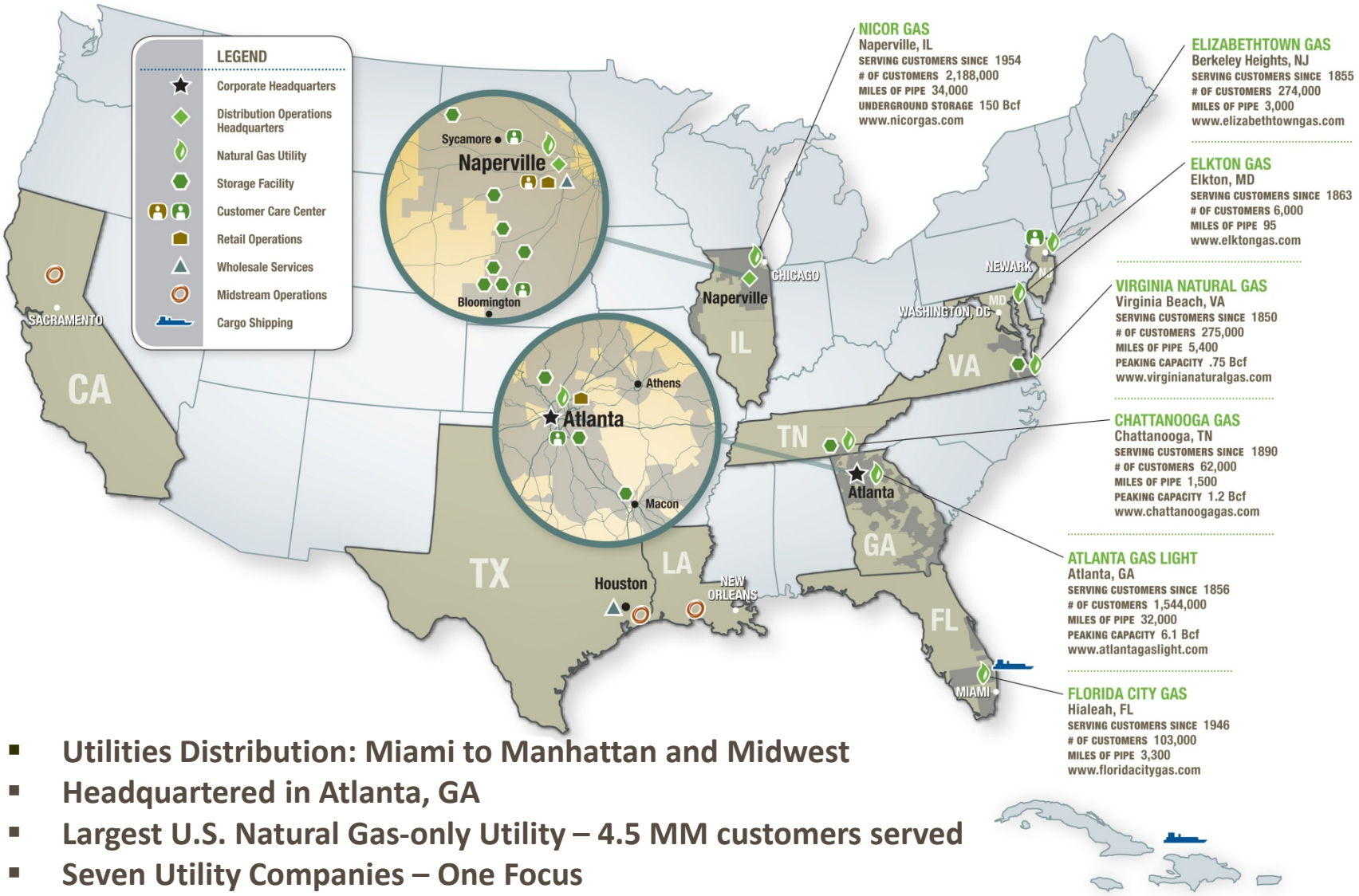
Section 1

Who We Are…

AGL Resources Overview



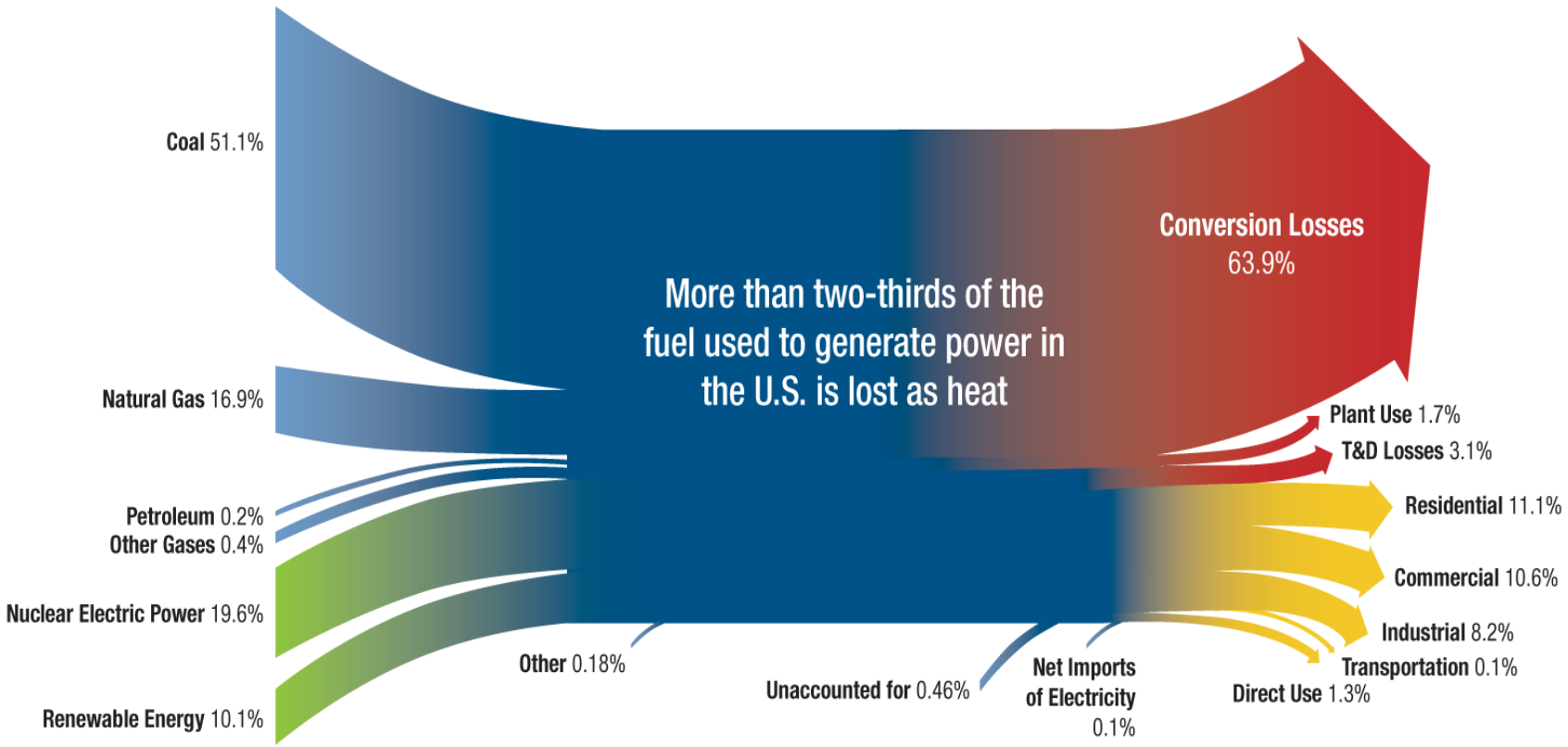
- **Utilities Distribution: Miami to Manhattan and Midwest**
- **Headquartered in Atlanta, GA**
- **Largest U.S. Natural Gas-only Utility – 4.5 MM customers served**
- **Seven Utility Companies – One Focus**

Section 2

What is CHP?

(Combined Heat and Power)

Over Two-Thirds of the Fuel Used to Generate Power in the U.S. Is Lost as Heat



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Power Plant Cooling Towers

Passive

Forced air

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Money Wasted!!!!

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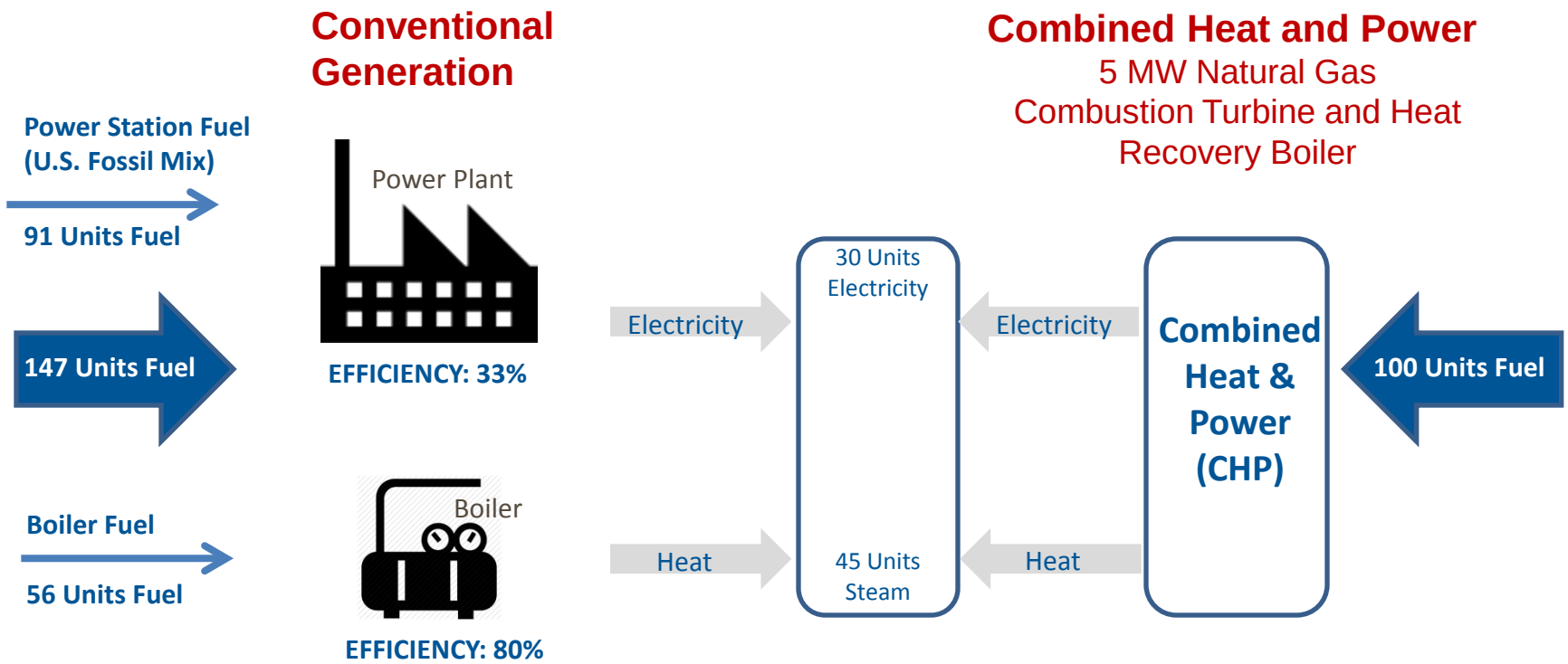
Big Picture: Direct Use is Most Efficient…



51% …OVERALL EFFICIENCY… 75%

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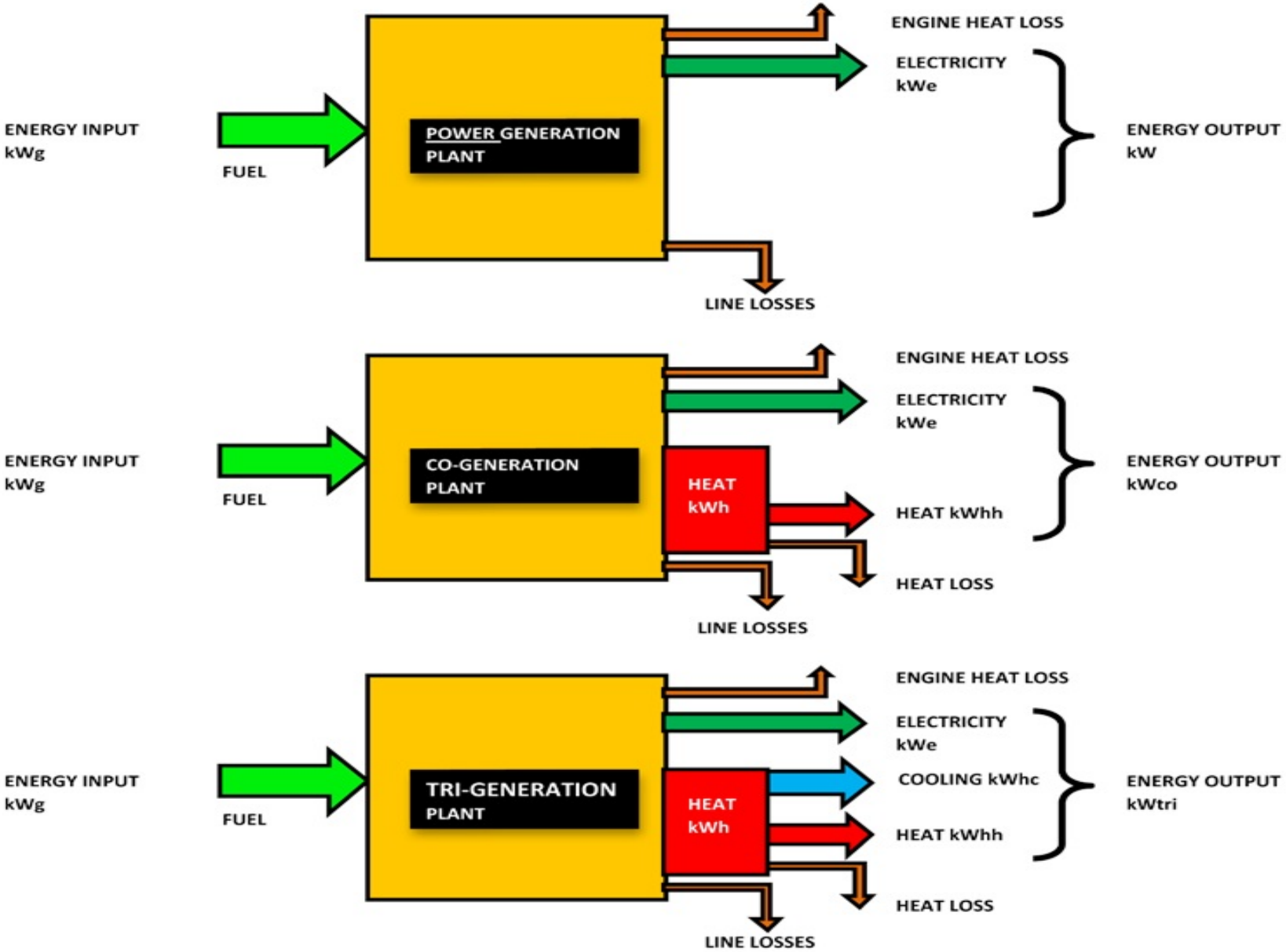
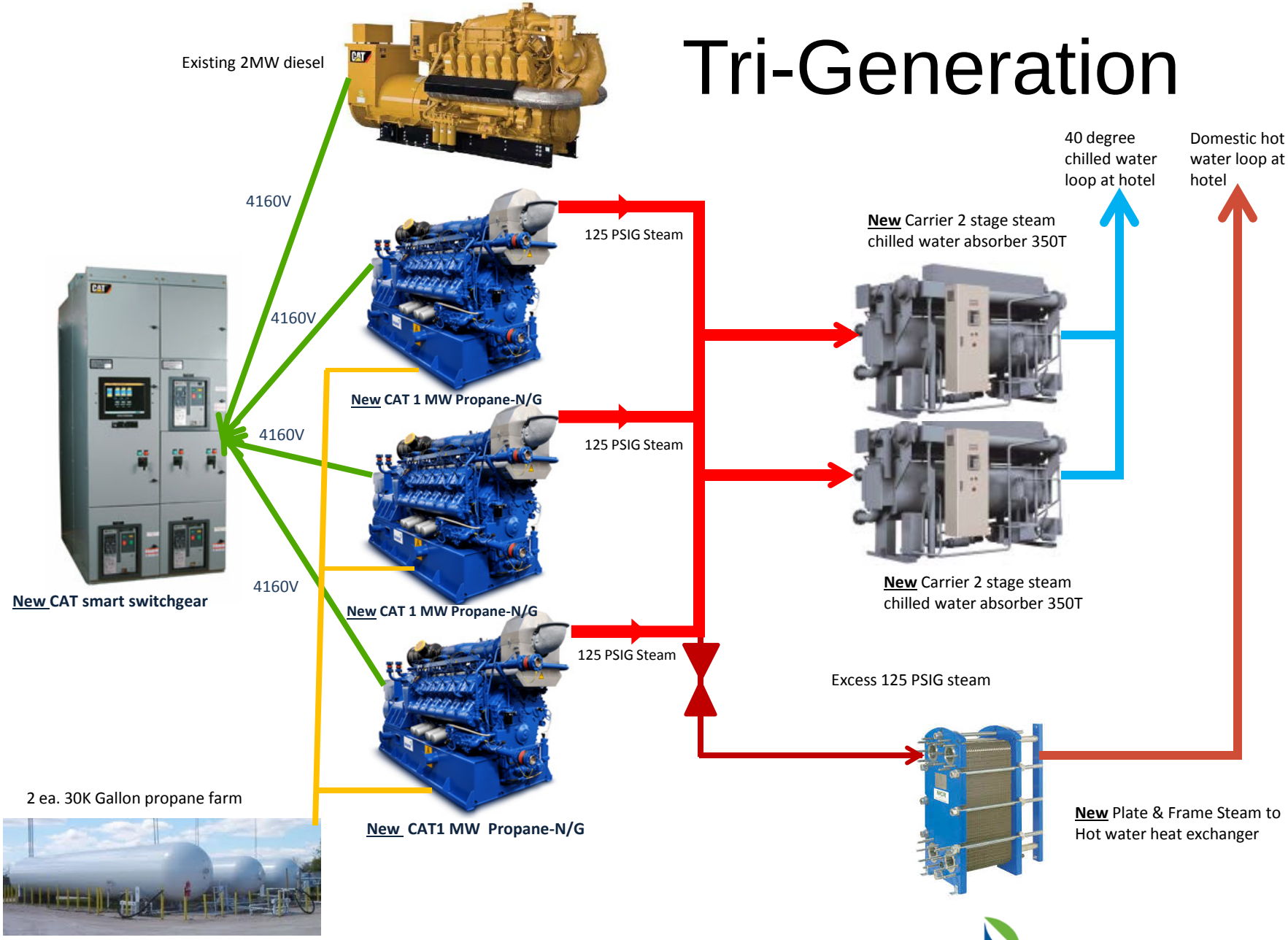
Generation, Co-Generation, Tri-Generation



Tri-Generation



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Positive Impacts and Benefits of CHP

- Enhance **U.S. energy security** by reducing our national energy requirements and help businesses weather energy price volatility and supply disruptions
- Advance U.S. climate change and **environmental goals** by reducing emissions of CO2 and other pollutants
- **Increase resiliency** of U.S. energy infrastructure by limiting congestion and offsetting transmission losses
- **Diversify energy supply** by enabling further integration of domestically produced and renewable fuels
- **Improve energy efficiency** by capturing heat that is normally wasted

Regulatory Drivers for CHP

Federal Drivers:

- EISA 2007
- EPAct 2005
- E.O. 13424 and 13514

Also:

Executive Order of August 2012
Accelerating Investment In Industrial Energy Efficiency

Recognizing the benefits of CHP and its current underutilization as an energy resource in the United States, the Obama Administration is supporting a new National goal to achieve 40 gigawatts (GW) of new, cost-effective CHP by 2020

Benefits of CHP to the U.S. Economy

Benefits identified in President Obama's Executive Order establishing a national goal of adding 40 GW of CHP applications by 2022.

- Spur $40 - $80 billion in new capital investments in plants/facilities
- Save American manufacturers and businesses $10 billion each year
- Save 1% of all energy use in the U.S. (one quadrillion Btu's energy)
- Reduce emissions by the equivalent of taking 25 million cars off road

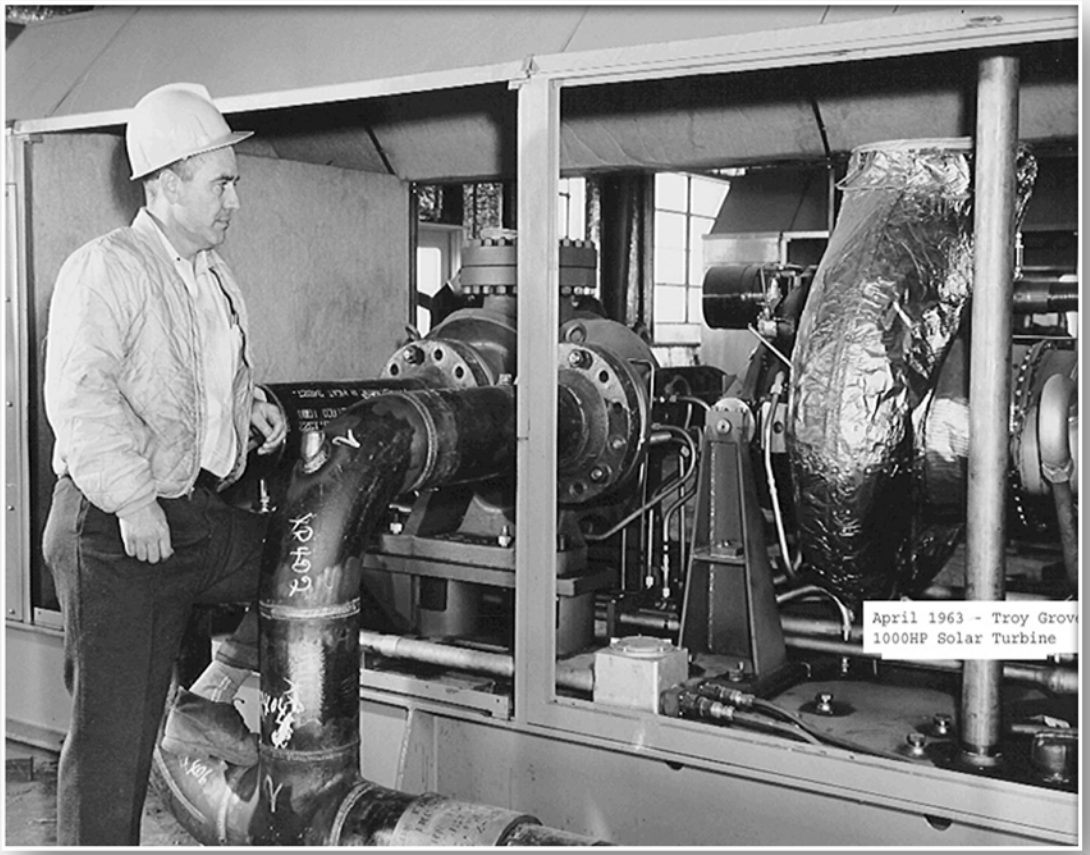
Source: U.S Department of Energy

Section 3

Then and Now…

50+ Years of Experience

CHP Plant in Troy Grove, Illinois – April 1963



NASA Mercury Space Capsule

50+ Years of Experience

Troy Grove, Illinois – Solar Taurus

NASA SpaceX

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Today's Technologies

Turbines

Micro-turbines

Engines

Fuel Cells

Which technology is "Right" for your Facility?

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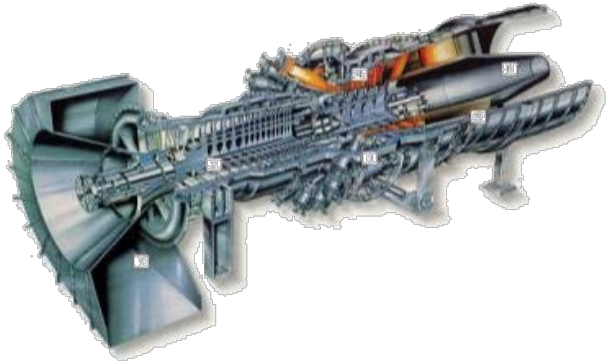
Gas Turbines



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: 5 MW to over several hundred megawatts

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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

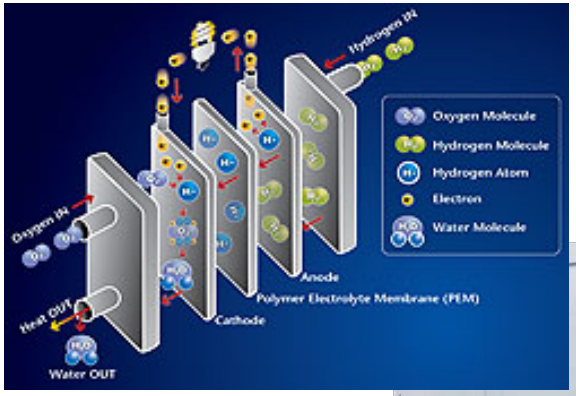
Engine Driven System

- 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

Fuel Cells

Five Basic Types

- **Alkaline**
- **Phosphoric Acid**
- **Molten Carbonate**
- **PEM (Polymer Electrolyte Membrane)**
- **Solid Oxide**



- A fuel cell is an electrochemical process 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, cost and methane reforming to produce hydrogen remain as key challenges to the deployment of fuel cells.

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

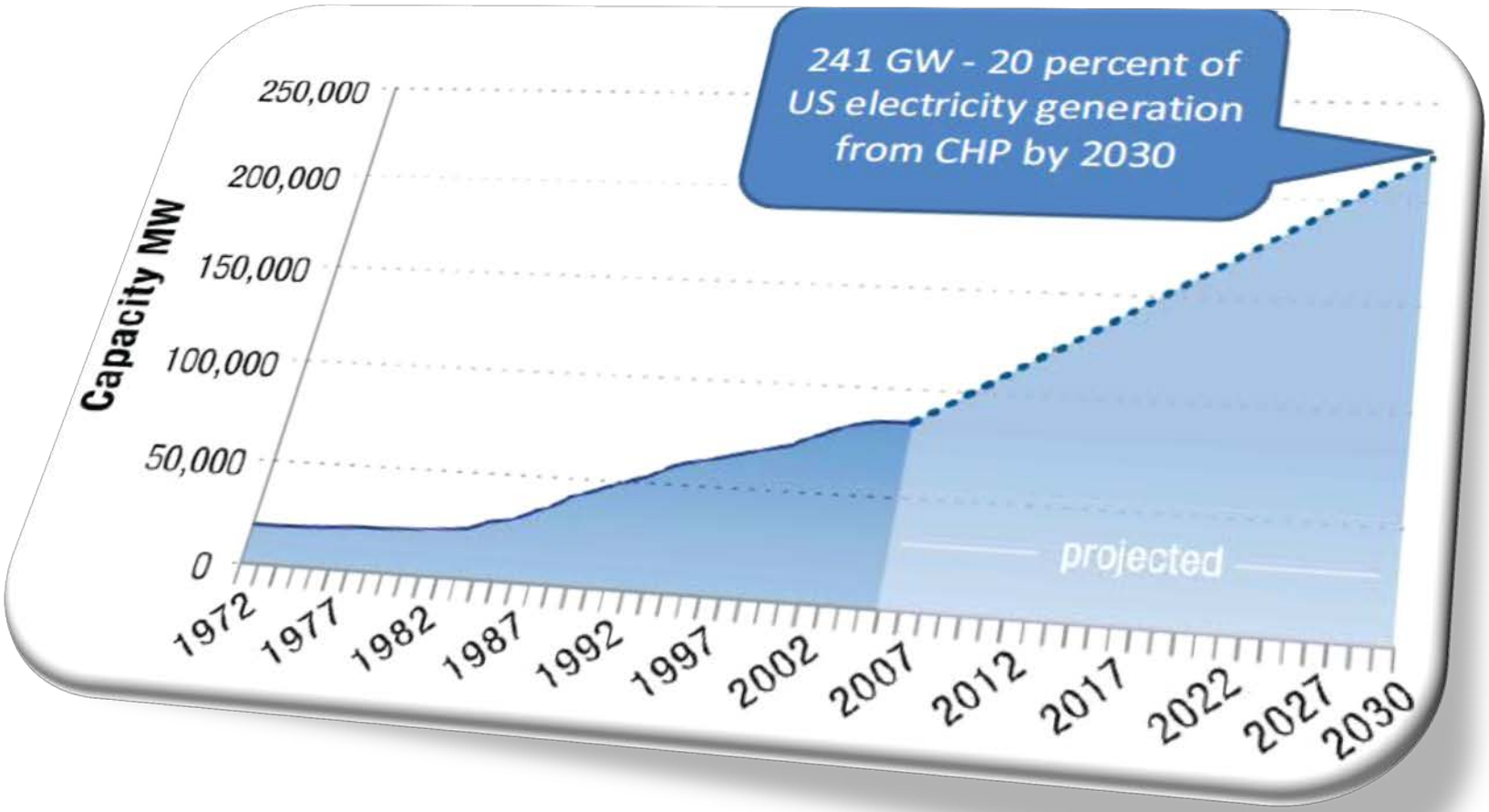
Technology	Steam Turbine[1]	Recip. Engine	Gas Turbine	Microturbine	Fuel Cell
Power efficiency (HHV)	15-38%	22-40%	22-36%	18-27%	30-63%
Overall efficiency (HHV)	80%	70-80%	70-75%	65-75%	55-80%
Effective electrical efficiency	75%	70-80%	50-70%	50-70%	55-80%
Typical capacity (MW_e)	0.5-250	0..01-5	0.5-250	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

U.S. CHP Generation Capacity Vision



Source: Combined Heat and Power: Effective Energy Solutions for a Sustainable Future
Sponsored by the U.S. Department of Energy

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Onsite Power Generation Is Now the Time?

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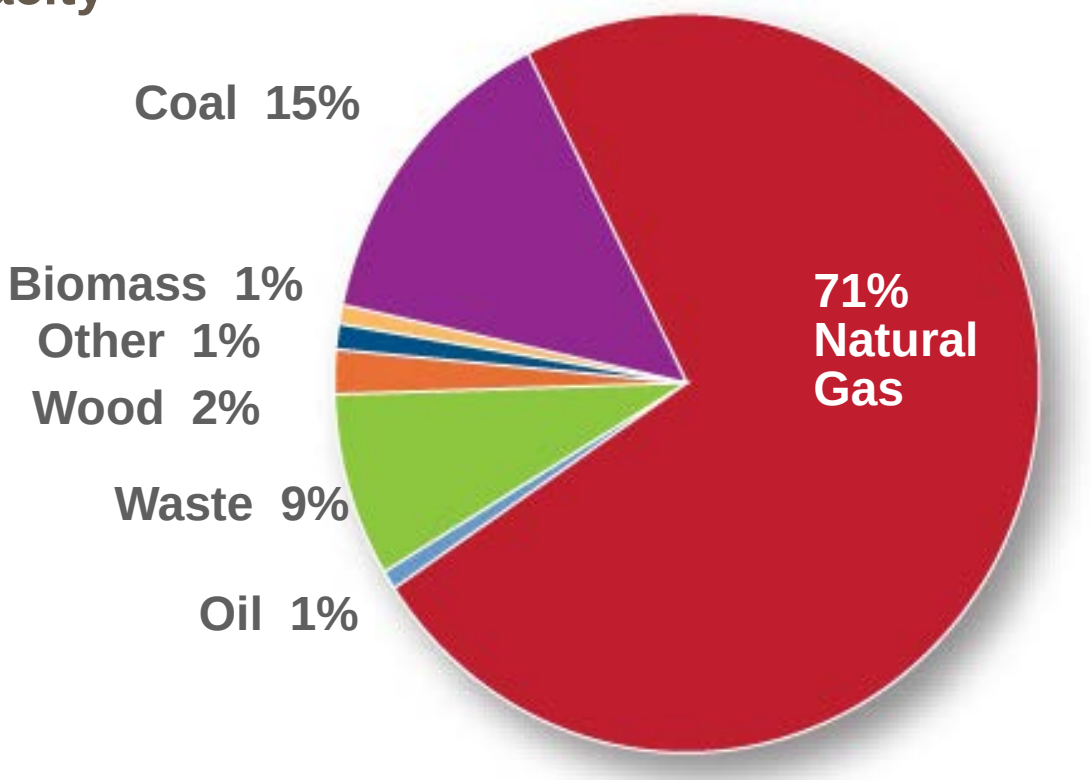
Natural Gas is the Dominant Fuel for Existing CHP

Existing CHP Capacity by Fuel – 82 GW



Source: ICF/CHP Installation Database

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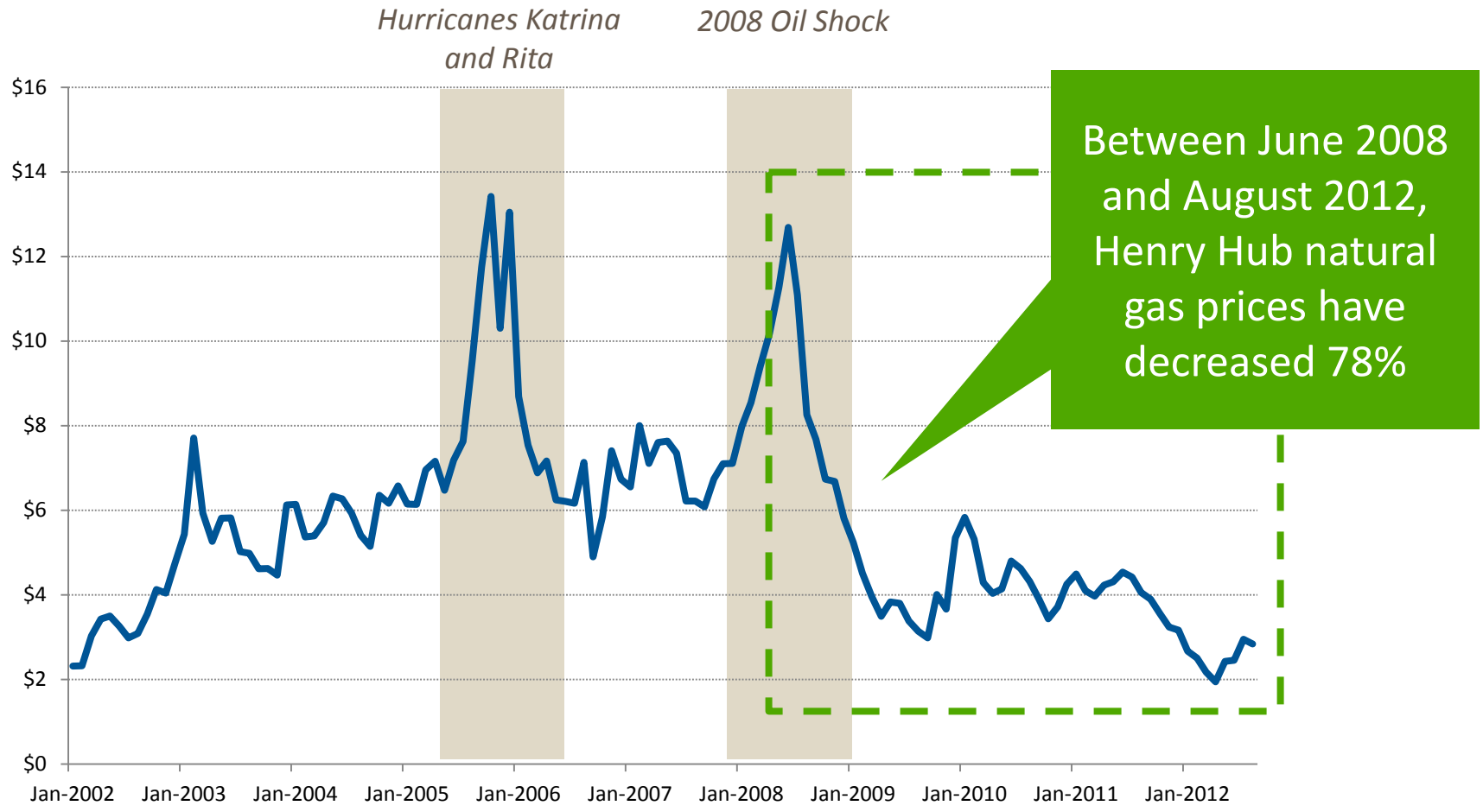
Changing Economics: Natural Gas Prices Exceptionally Low



Source: U.S. Department of Energy, Energy Information Administration

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Natural Gas: American, Abundant, Affordable

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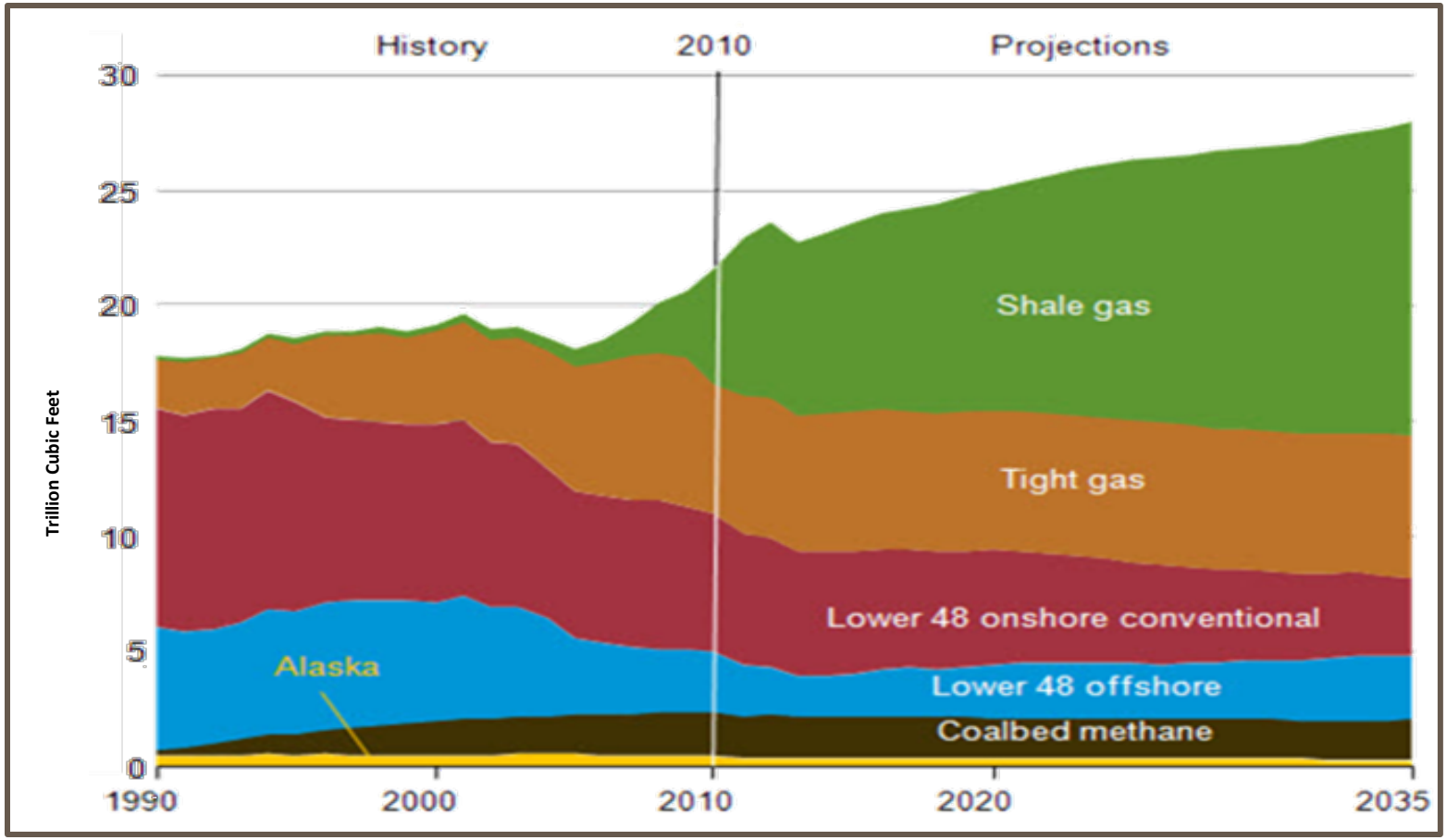
Natural Gas: American, Abundant, Affordable



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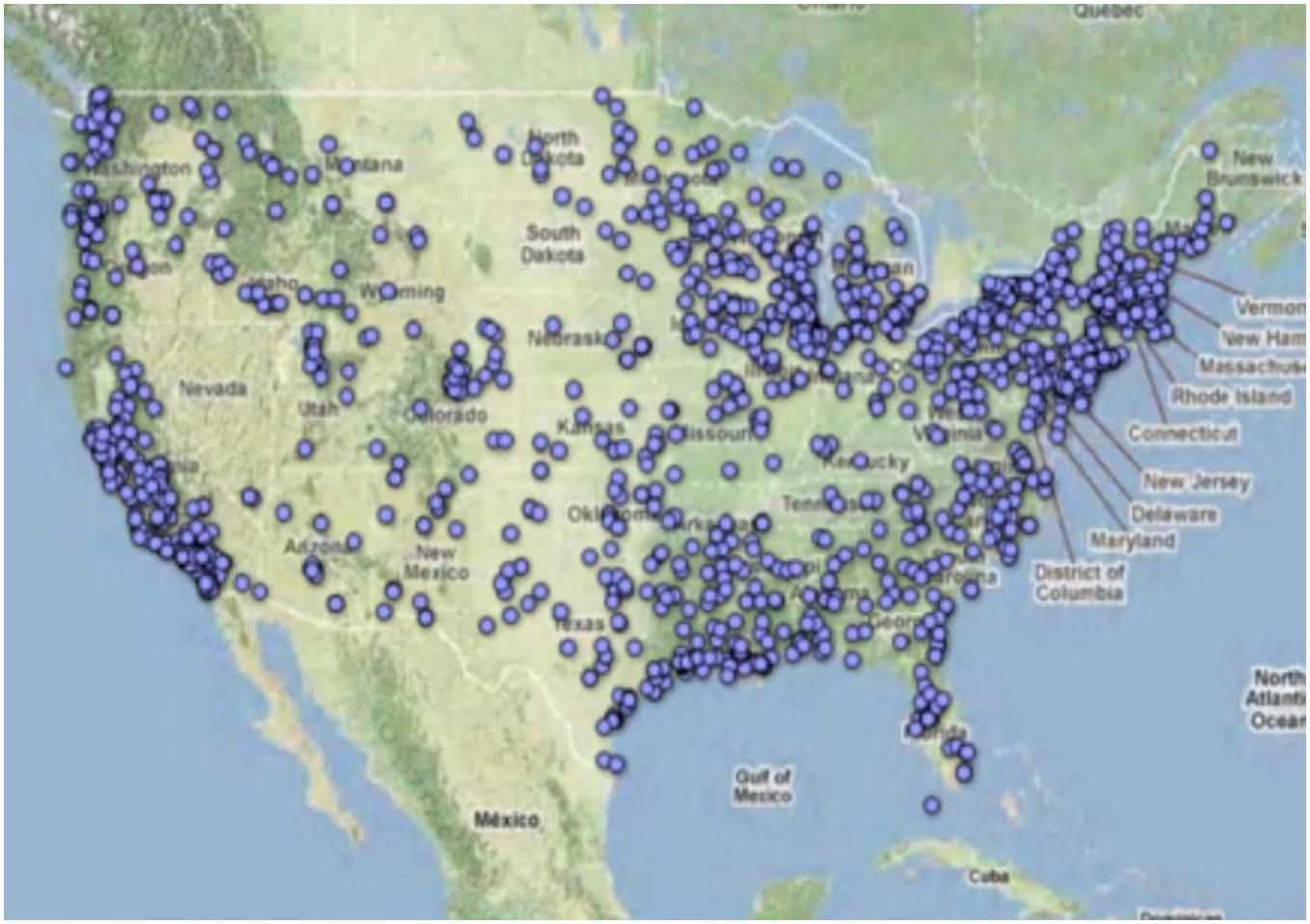
Locations of Existing CHP Capacity

Source: CHP Installation Database, ICF International



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Section 4

CHP Qualifiers

Ideal sites will fit the following profile, but sites meeting only a few of these characteristics may also have a cost-effective CHP opportunity

CHP Qualifiers

High electricity prices (>6 cents/kWh)

CHP Qualifiers

Average electric load >1 MW

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CHP Qualifiers

Ratio of average electric load to peak load > 0.7

CHP Qualifiers

A central or district heating and/or cooling system in place (or a need for process heat)

CHP Qualifiers

"spark spread" (difference in price per million site Btu between gas and electricity) >$12/MMBTU

Spark Spread Calculation Example

Current Average Electricity Price, $/kWh	***$0.1000***	*Current average price paid for electricity, per kWh*
CHP Fuel Costs, $/kWh	$0.0588	*The cost of fuel consumed by the CHP system, per kWh*
CHP Thermal Credit, $/kWh	($0.0312)	*The fuel cost avoided by having CHP provide thermal energy to the site, per kWh*
CHP Incremental O&M, $/kWh	$0.0090	*The non-fuel operationing and maintenance cost for the CHP system, per kWh*
Operating Costs to Generate Power, $/kWh	***$0.0366***	*The total operating cost to generate power, per kWh*
Spark Spread, $/kWh**	***$0.0634***	*The difference per kWh between the current delivered electricity price and the total cost to generate power with the CHP system*
Spark Spread, $/MMBTU**	***$18.59***	

Assumptions:
Electricity cost: $0.10/kWh
Fuel Cost: $5/MMBTU
CHP efficiency: 75%

*** The greater the spark spread, the higher the return on inve*

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CHP Qualifiers

High annual operating hours (> 6000)

CHP Qualifiers

Thermal demand closely matches electric load

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CHP Qualifiers

Energy security and reliability upgrades are valued or planned

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CHP Qualifiers

Access to on-site or nearby biomass resources
(i.e., landfill gas, farm manure, food processing waste, etc.)

Around the Globe

- **National Aeronautics and Space Administration (Lyndon B. Johnson Space Center in Houston, Texas)**— This 13.7 megawatt (MW) CHP system at the center is expected to net more than $29 million in energy savings over its lifetime.

- **Department of Defense (Army Aberdeen Proving Ground in Edgewood, Maryland)**— This 7.9 MW CHP system, executed under an Energy Savings Performance Contract, will replace a steam generation plant being decommissioned in 2016.

- **National Science Foundation (Arctic Program at Thule Air Base in Greenland)**—This 30 kilowatt (kW) CHP system will serve as a model for NSF facilities and assist agencies in evaluating the replacement of diesel generators at any remote, isolated government sites, such as DOD forward operating bases, FEMA emergency zones, forests and parks.

Regional Analysis of CHP Opportunities

- The southeastern U.S. enjoys below-average electric rates and average natural gas prices, so a poor spark spread to support CHP projects.
- The Midwest U.S. has generally poor spark spreads due to cheaper coal-fired plants providing average electric rates, and average natural gas prices.
- The mid-Atlantic U.S. has been recently viewed as a growing market due to unfavorable regulation, access to plentiful natural gas at very competitive pricing, higher electric prices and electric grid congestion.
- The northeastern U.S. has been the traditionally been viewed as having favorable spark spreads, due to high electric rates and natural gas pricing, and having progressive utilities with aggressive state and local energy policy.

Utility Partnerships to Advance CHP

- Greater utility partnerships on CHP are a win-win for the utility, the Government/end-user, and communities/ratepayers.
- Utilities can serve as important partners in the development of CHP projects in areas which the grid is currently congested and in need of support.
-
- Utilities recognize CHP as an investment opportunity to retain large industrial customers, as well as a solution to needed investments in new generation and T&D infrastructure
- Financing difficulties can also be relieved by utilities that typically have a lower cost of capital and longer investment time horizons than many of their customers.
- Bottom line- CHP benefits the Government and Utilities!

Utilities can get the generation and T&D infrastructure support they need, while providing the Government with stable financing and risk management to achieve Government mandates and energy policies.

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Helpful Tools & References

CONUS:

DOE CHP Technical Assistance Partnership

http://www1.eere.energy.gov/manufacturing/distributedenergy/chptaps.html

CHP Emissions Calculator

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

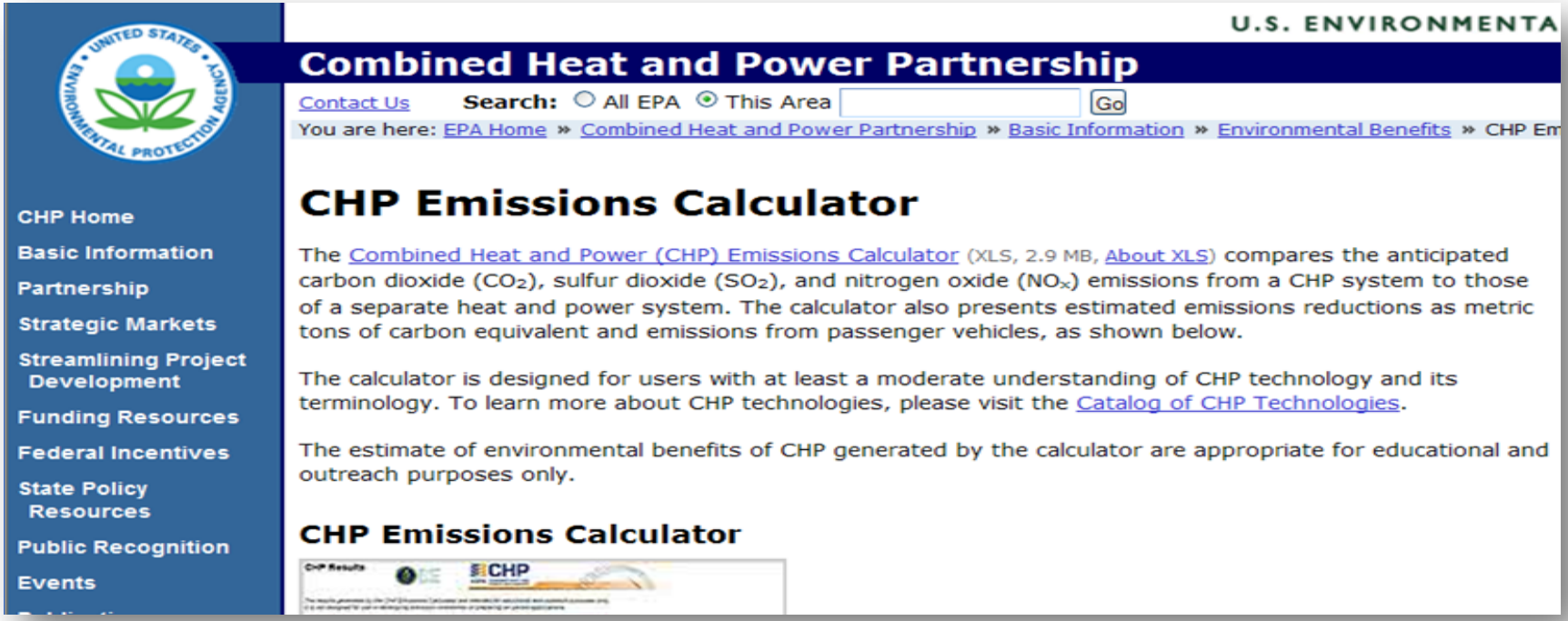
International:

German Co-gen project:

http://www.dlr.de/vt/en/desktopdefault.aspx/tabid-9006/15559_read-38403

Europe reference:

http://www.cospp.com/world-regions/europe.html



Thank You

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