Combined Heat & Power, 2013: Are We There Yet?

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What Is Combined Heat and Power?

- CHP is an *integrated energy system* that:
- Is located at or near a factory or building
- Generates electrical and/or mechanical power
- Recovers waste heat for
  - heating,
  - cooling or
  - dehumidification
- Can utilize a variety of technologies and fuels

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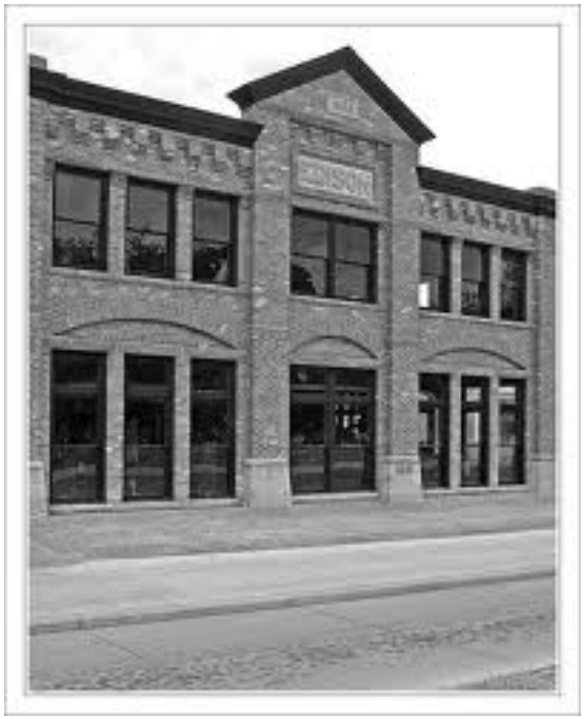
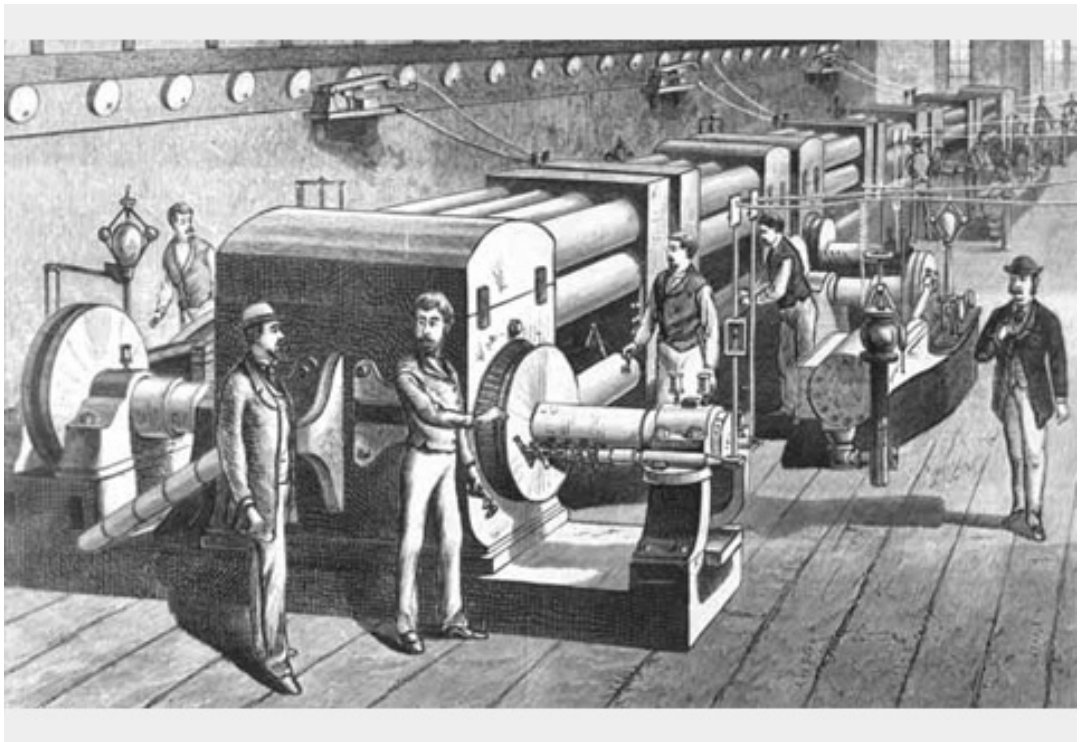
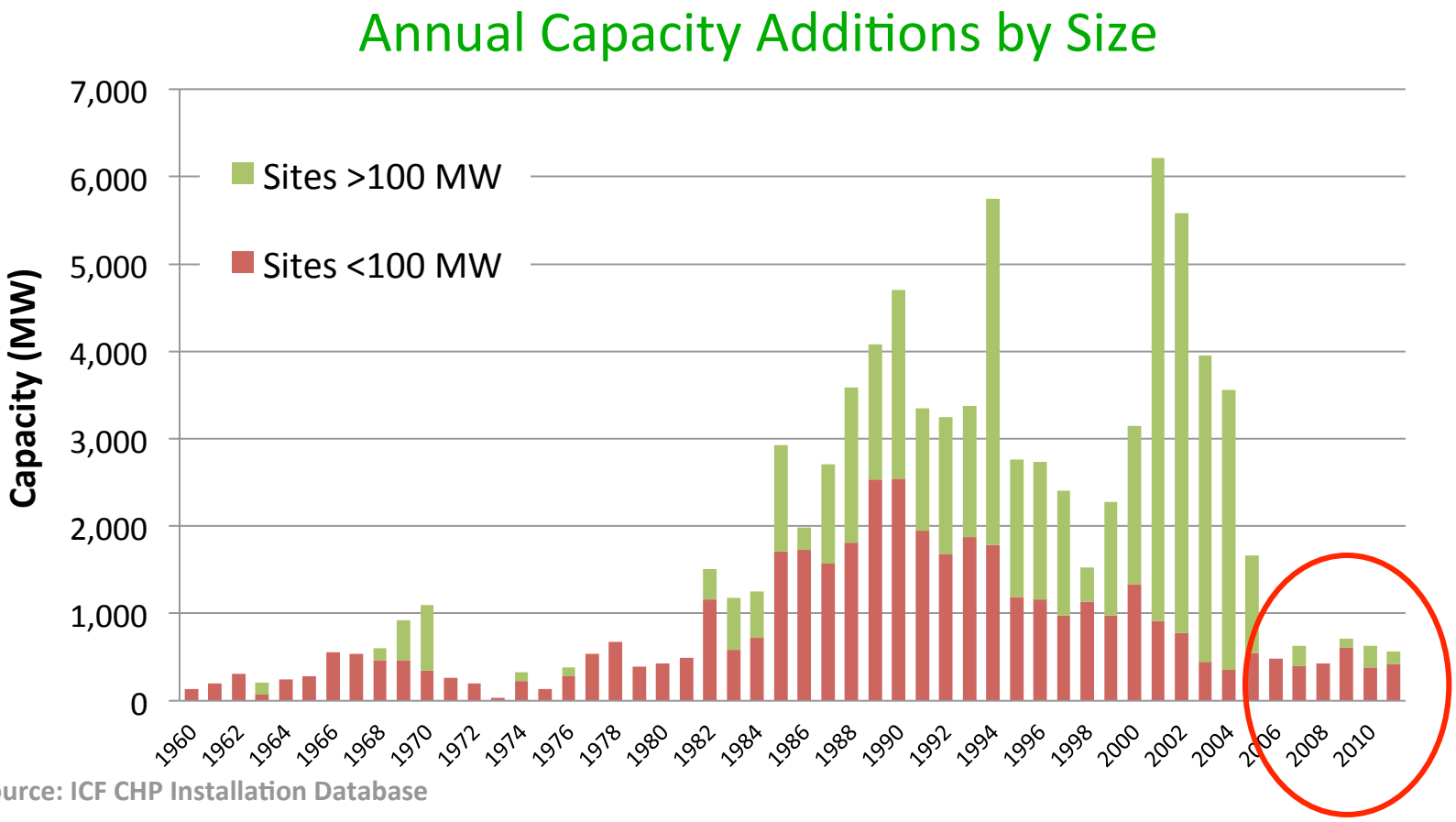
CHP: A Long History





CHP Annual Additions



Source: ICF CHP Installation Database

What Are the Benefits of CHP?

CHP is *more efficient* than separate generation of electricity and heat

Higher efficiency translates to *lower operating cost,* (but requires capital investment)

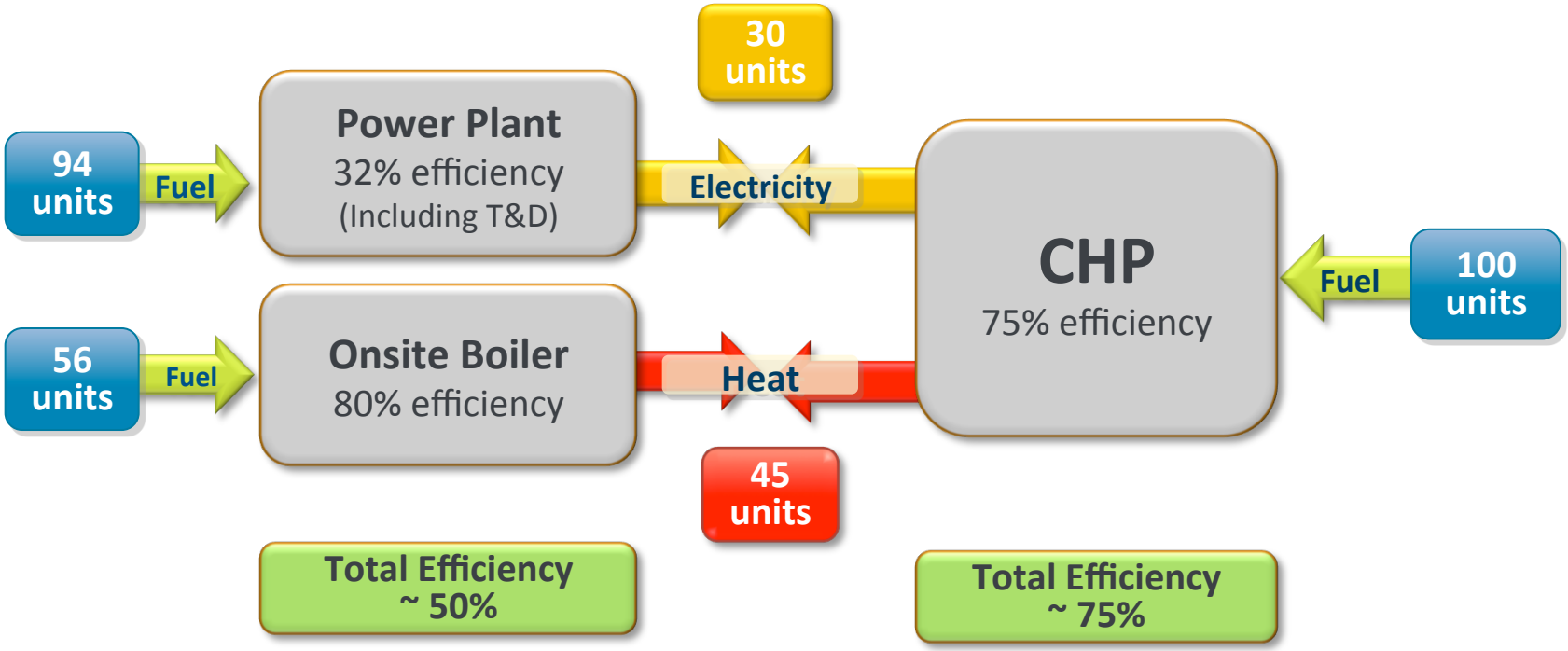
Higher efficiency *reduces emissions of all pollutants*

CHP can also *increase energy reliability and enhance power quality*

Can provide critical infrastructure *resiliency*

On-site electric generation *reduces grid congestion and avoids distribution costs*

CHP is Substantially More Efficient than Conventional Energy Services ……



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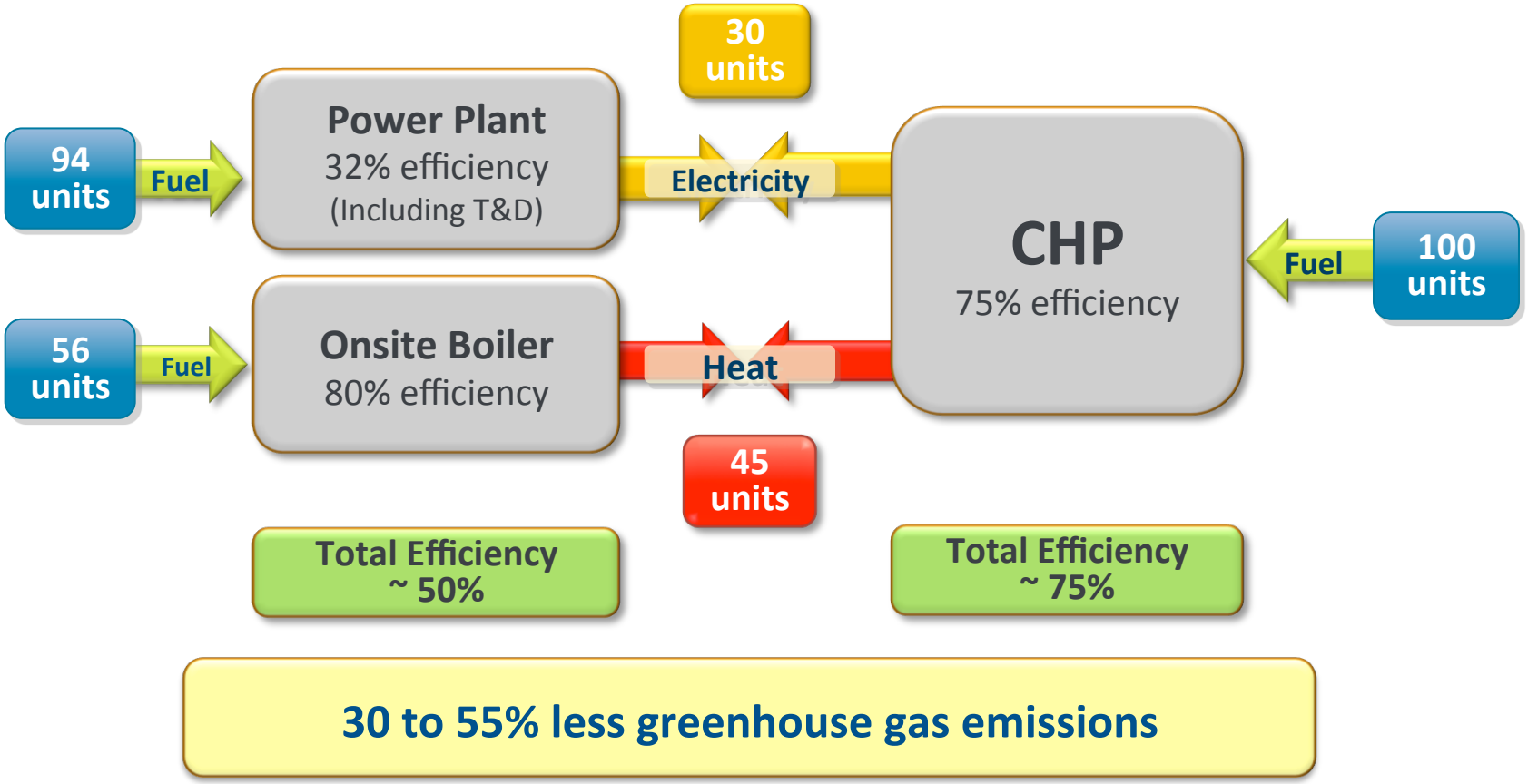
…..and Reduces Greenhouse Gas Emissions



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CHP Is Based on Proven Technologies and Practices

Industrial

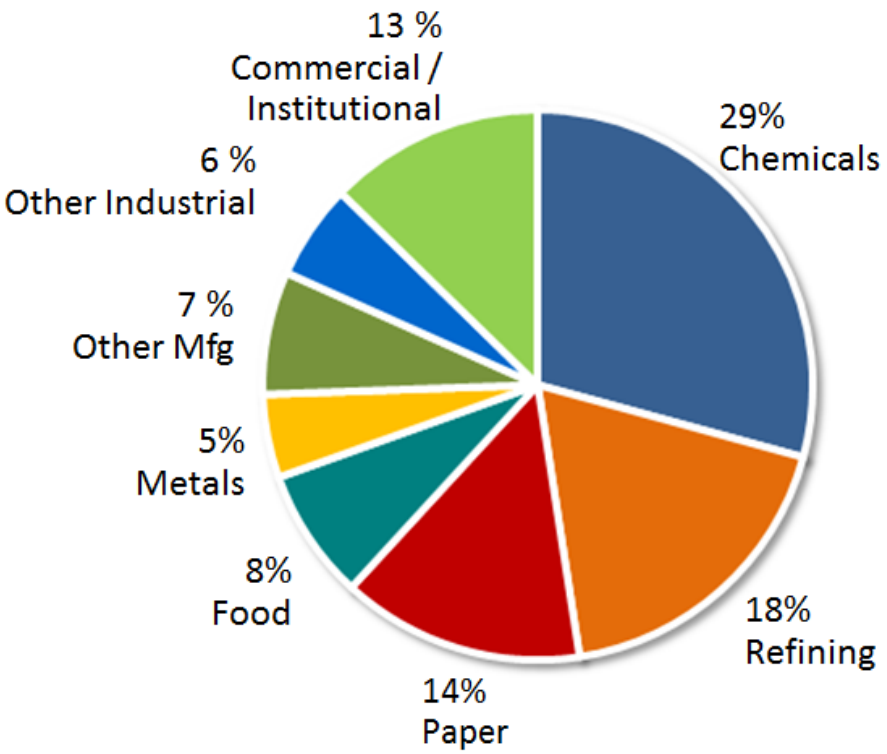
Institutional

Residential

Utility Scale

Commercial

CHP: Already an Important U.S. Energy Resource



Source: ICF CHP Installation Database

- **82 GW** of installed CHP at 4,100 industrial and commercial facilities (2012)
- 87% of capacity in industrial applications
- 71% of capacity is natural gas fired
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO_2** compared to separate production

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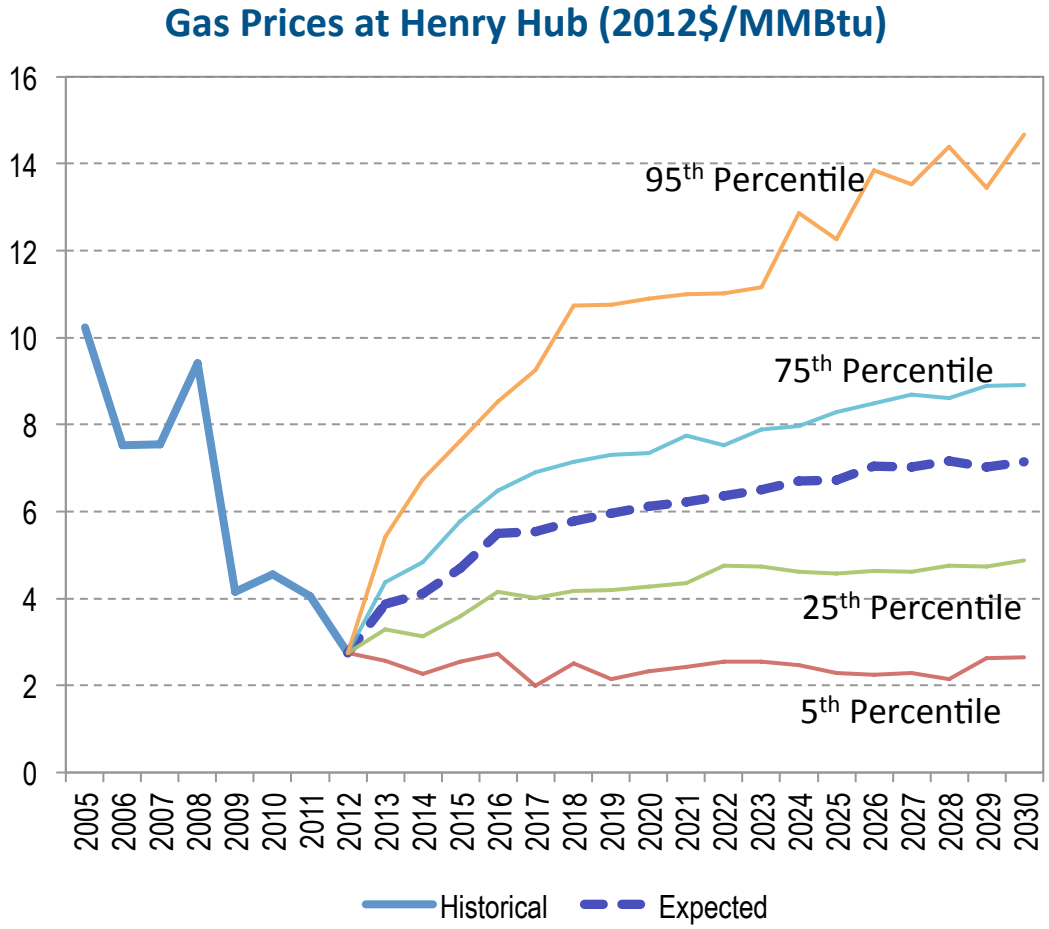
Gas Availability and Price are a Key Driver

- Broad consensus that Henry Hub natural gas prices will average between $4 and $7 per MMBtu through 2025.
- Natural gas outlook will drive manufacturing investment and technology choice.
- $4 to $7 gas prices are sufficient to support the levels of supply development in the projection, but not so high as to discourage market growth.



Source: Pace Global, a Siemens Business

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CHP Value Proposition

Technology (10 MW Fractional Basis)	CHP	Combined Cycle	Wind	Solar
Annual Capacity Factor	85%	60%	30%	16%
Avg. Power Production (per hr)	8.5 MWh	6.0 MWh	3.0 MWh	1.6 MWh
Total Fuel Consumption* (Gen/CHP + Steam Boiler + Grid Power)	140 MMBtu/ hr	174 MMBtu/ hr	168 MMBtu/ hr	184 MMBtu/ hr

- The CHP Value Proposition is most clear when considering the complete impact of the CHP Solution.
  - The Total Fuel Consumption for each of the above Cases is defined as that required to meet baseload energy requirements of 10MW and 65 mlb/hr steam.
    - = Generation/CHP fuel + Steam Boiler fuel + Supplemental Grid Power fuel
  - The high efficiency and baseload operation of a CHP creates a favorable economic and environmental advantage against other efficient and clean energy systems

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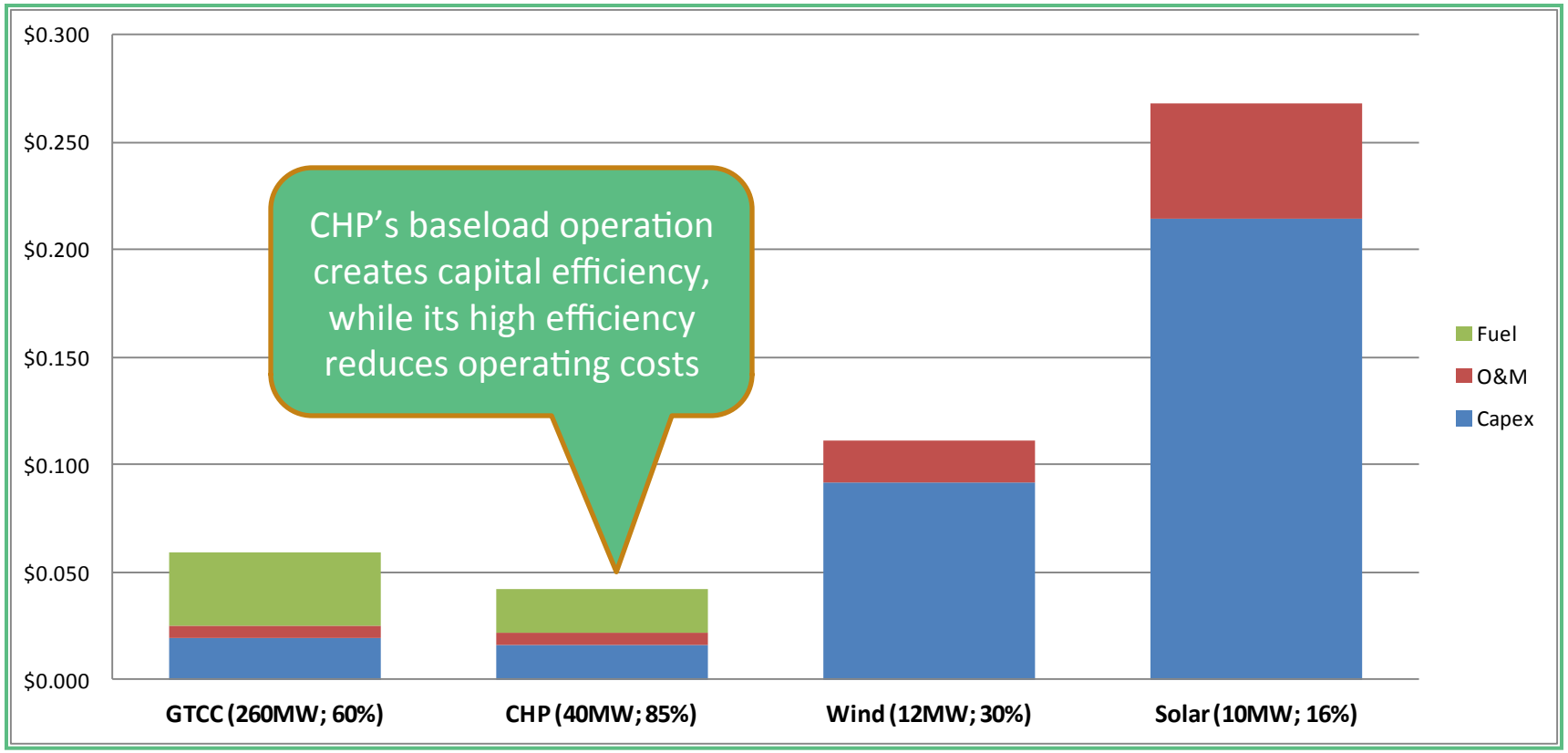
Source: Pace Global, a Siemens Business

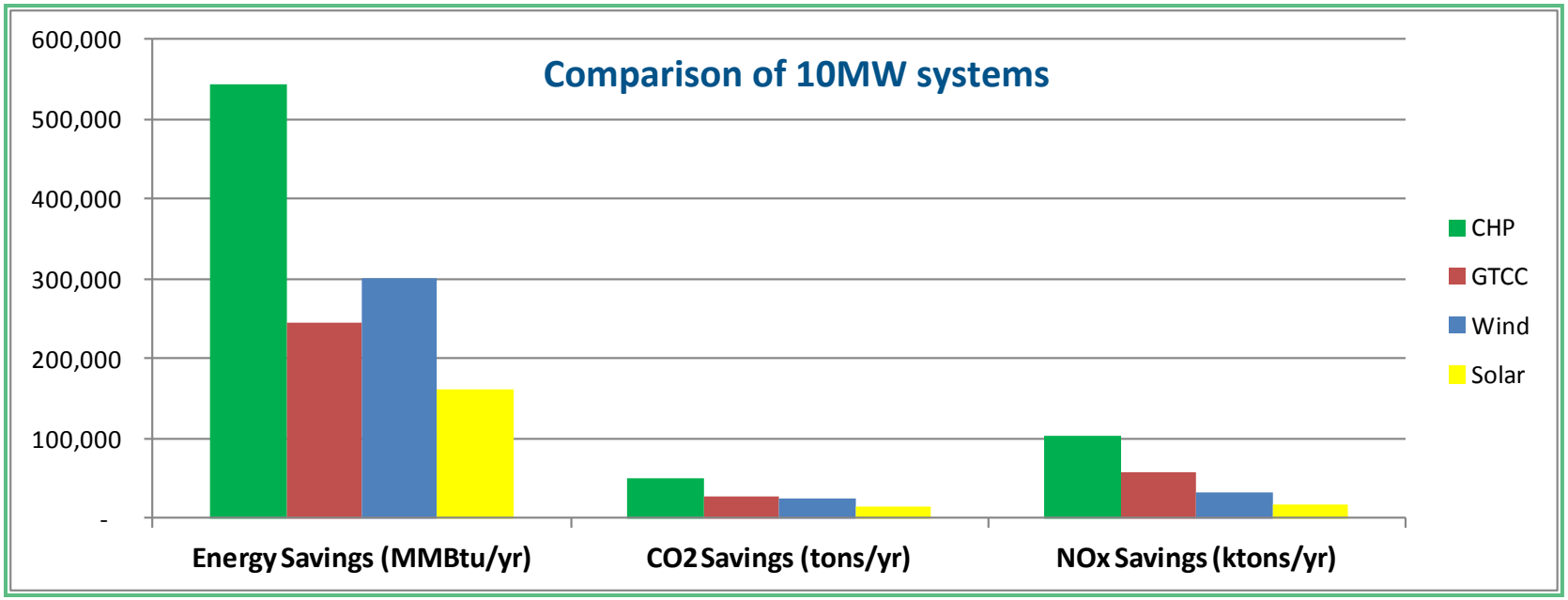
Unit Cost Comparisons of CHP and Several Competing Options



Source: Pace Global, a Siemens Business

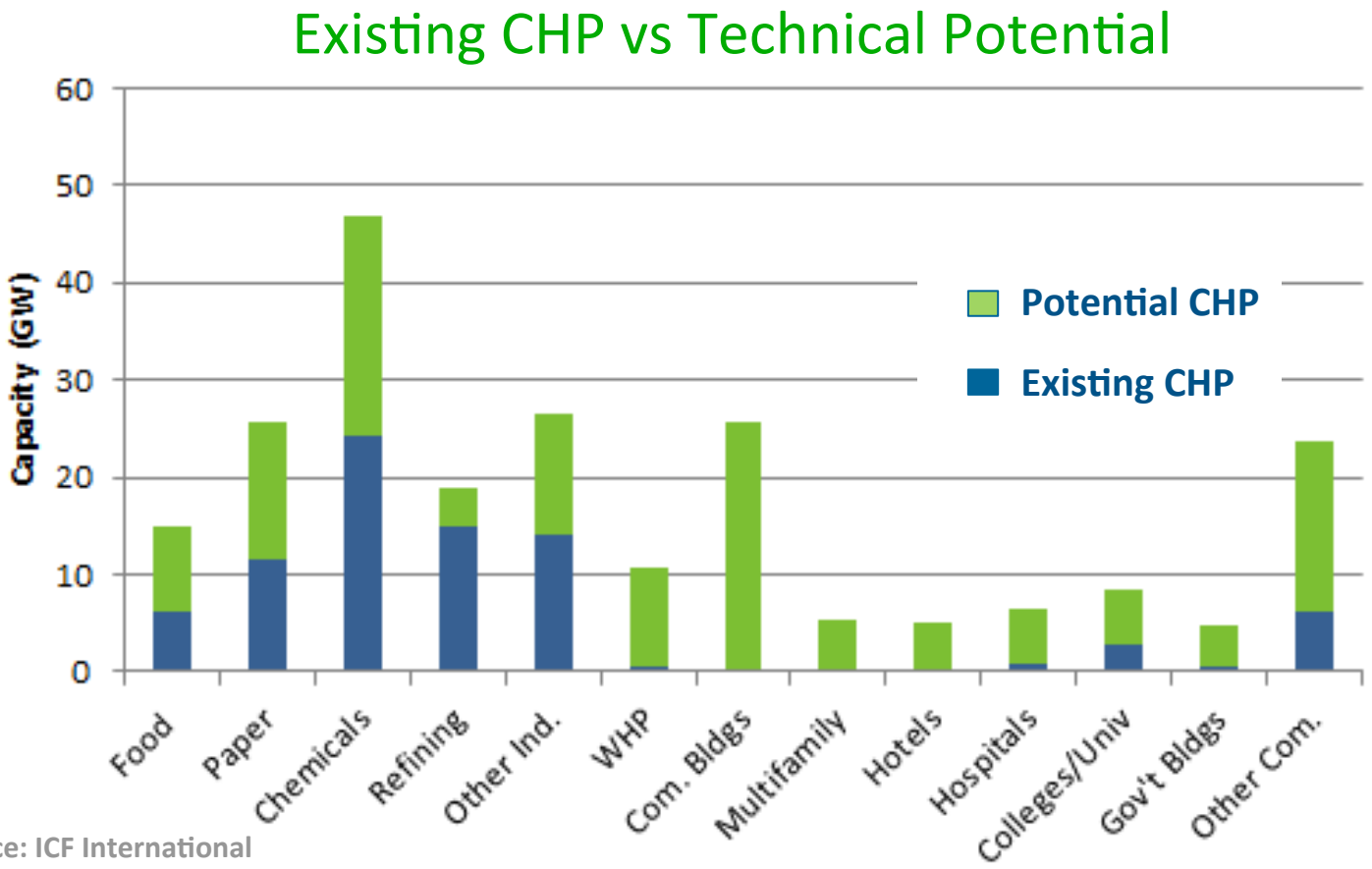
CHP Value Proposition (continued)

- The energy and emissions savings for CHP and lesser performing systems below are compared against meeting the 10MW and 65mlb/h baseload requirements via purchased power (based on national average generation efficiency and emissions factors) and an 84% efficient natural gas fired boiler system.



Source: Pace Global, a Siemens Business

Untapped Technical Potential of 140,000 MW



Source: ICF International

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Barriers to Increased Use of CHP

- Financial uncertainty
- Cost and performance uncertainty
- Regulatory uncertainty
- Utility uncertainty

Supportive CHP Policy Avenues:

- Standardized and simplified interconnection and permitting
- Reasonable standby and supplemental power rates
- Supportive and non-limiting net metering
- Inclusion of CHP in Renewable and Energy Efficiency Portfolio Standards
- Regulatory certainty related to emissions regulations
- Simple and attractive solutions for third-party financing and natural gas supply hedging
- Means of utilities participating in CHP
- Information, resources and tools to assist those interested in CHP

Fortunately, some of the above is already being promoted and pursued…..

Federal Support of CHP: President Obama Signs Executive Order, August 30, 2012

What:

- Promotes industrial energy efficiency & CHP
- Sets a new national goal of deploying 40 GW of new CHP capacity by 2020

How:

- Works with states, utilities, and owners and operators of industrial facilities
- Provide tools: workshops, guidance, technical analysis and information, data, incentives

Impacts:

- Increase total CHP capacity in the United States by 50 percent in less than a decade
- Result in $40-$80 billion in new capital investment in over the next decade
- Save energy users $10 billion per year

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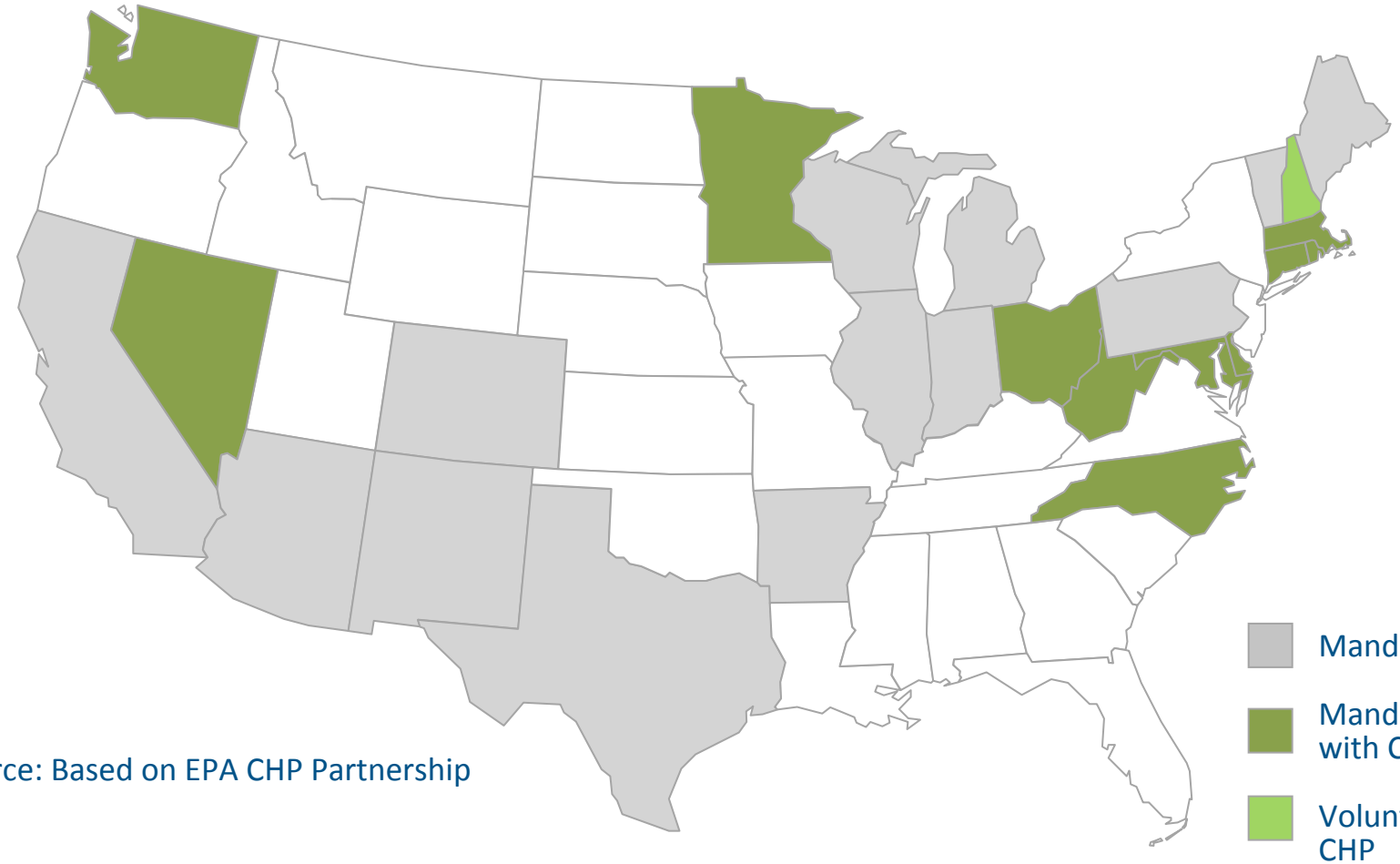
Energy Efficiency Resource Standards (EERS) that Include CHP



Source: Based on EPA CHP Partnership

MN EERS only includes WHP only

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Case Study: University Campus, Southwest

Current Condition
Mid-sized University with low-pressure steam system. Purchasing full electrical requirements from grid.
Desired improved electrical reliability and continuity of operations; as well as cost savings
Originally considered solely electrical emergency back-up generation solution to meet campus reliability needs.
Significant budget allocation for new emergency generation (EG) had little appeal as University had more interest in investments in efficiency and sustainability.

Current System

Case Study: University Campus, Southwest

Cogeneration Solution
Incremental investment in cogeneration recommended to provide cost savings AND improved campus power reliability.
Selected a hybrid solution: 2 centralized diesel generators and 1 natural gas fired cogeneration plant.
Power from cogeneration plant will provide half of emergency electrical requirements and 25% of projected power needs.
Thermal solution designed to match minimum steam demand, optimizing efficiency; Additional duct firing enhances capacity.

Technical Solution	
Cogen Power Output	4.0 MW
Cogen Steam Output	11,000 lbs/hr; 36,000 max with duct firing
Displaced Power Price	7.7¢/kWh
Current Fuel Cost	$5.58/MMBtu
Installed Cost	$9 MM
Net Annual Operating Savings	$1.54 MM/yr
Simple Payback	5.8 years

System will provide enhanced reliability, lower operating costs, and net savings of $1.5M/yr with sub-4 year simple payback when avoided Emergency Generation capital considered

Case Study: Industrial Application with Unique Financing Solution

Industrial Application
Facility with an existing Heavy Fuel Oil steam system and older vintage boilers. Current system out of balance with thermal requirements and pending emissions regulations forcing retrofit.
Transformation of natural gas market in U.S. made gas-fired combined cycle cogeneration plant the optimal solution.
Capital intensity of project and lack of a third party Power Purchase Agreement made it very difficult to finance on balance sheet, despite high ROI.
Solution: Third party lease solution with shared savings model provided "win – win" for the industrial. Simple payback was actually decreased, while reducing capital outlays and achieving the necessary emissions reductions.

Technical Solution	
Cogen Power Output	15.0 MW
Cogen Steam Output	105,000 lbs/hr
Displaced Power Price	12.3¢/kWh
Current Fuel Cost	$10.00/MMBtu
Installed Cost	$28 MM ($5MM w/Lease)
Net Annual Savings	$2.6MM/yr (w/ Lease)
Simple Payback	<2 years

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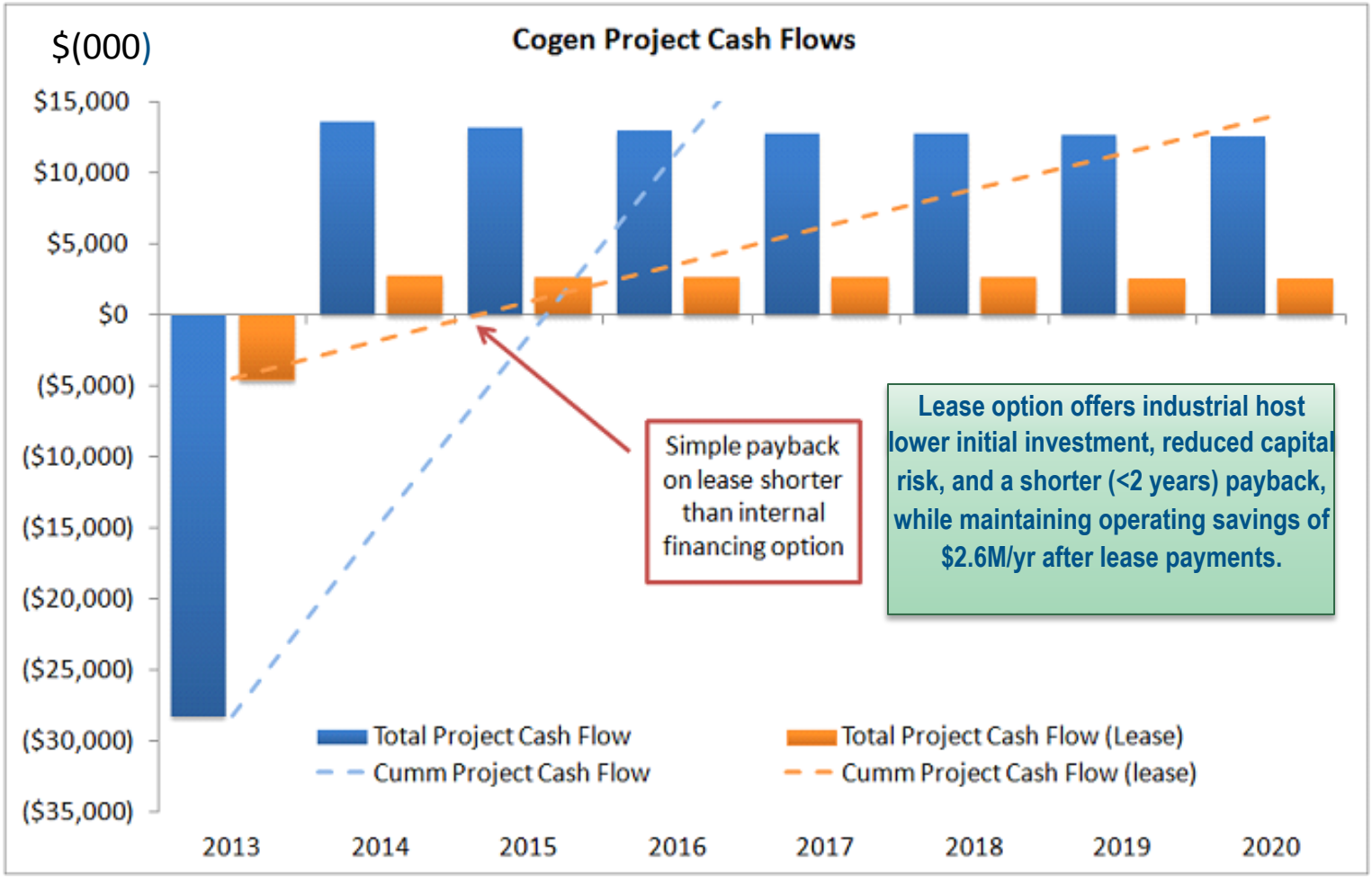
Case Study: Industrial Application with Unique Financing Solution



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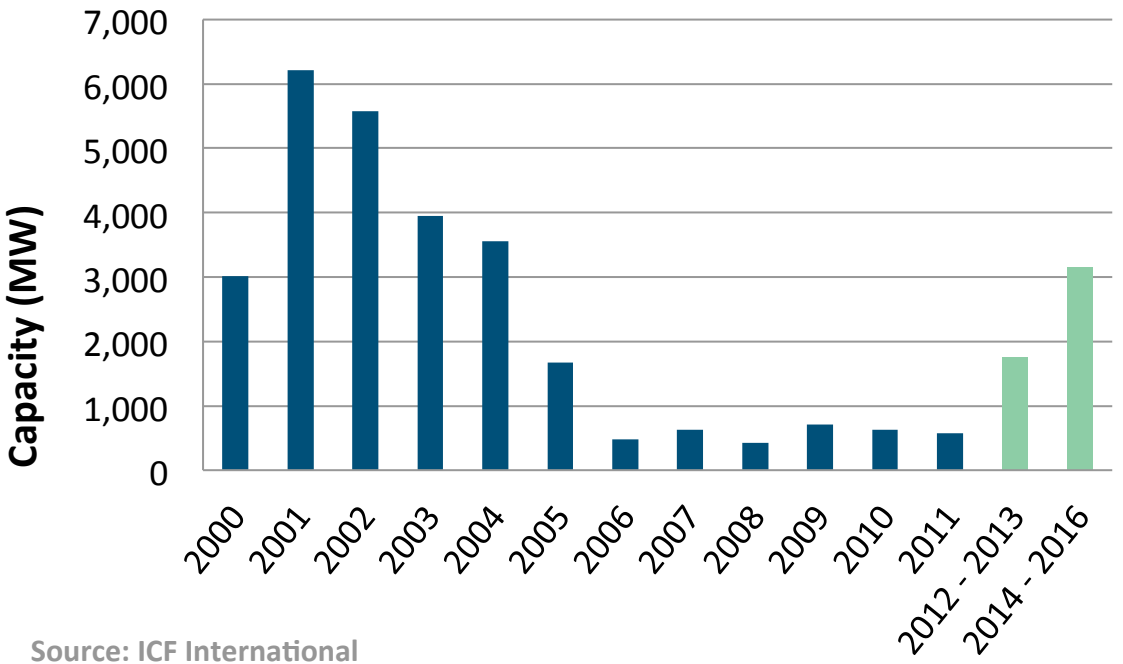
The Next Few Years for CHP

Changing natural gas outlook driving investments

Growing recognition of CHP benefits by state and federal policymakers

Opportunities created by:

- Environmental pressures
- Growing interest in grid resiliency



Source: ICF International

Over 4,500 MW announced/under construction

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Conclusions

In 2013, there are significant drivers for CHP growth:

- A resurgent economy with increased industrial demand
- Reshoring of energy intensive manufacturing
- More favorable treatment from Federal and State governments and by regulatory bodies
- Utility interest in becoming industry partners to implement CHP
- User recognition of CHP as an economic option with a variety of benefits

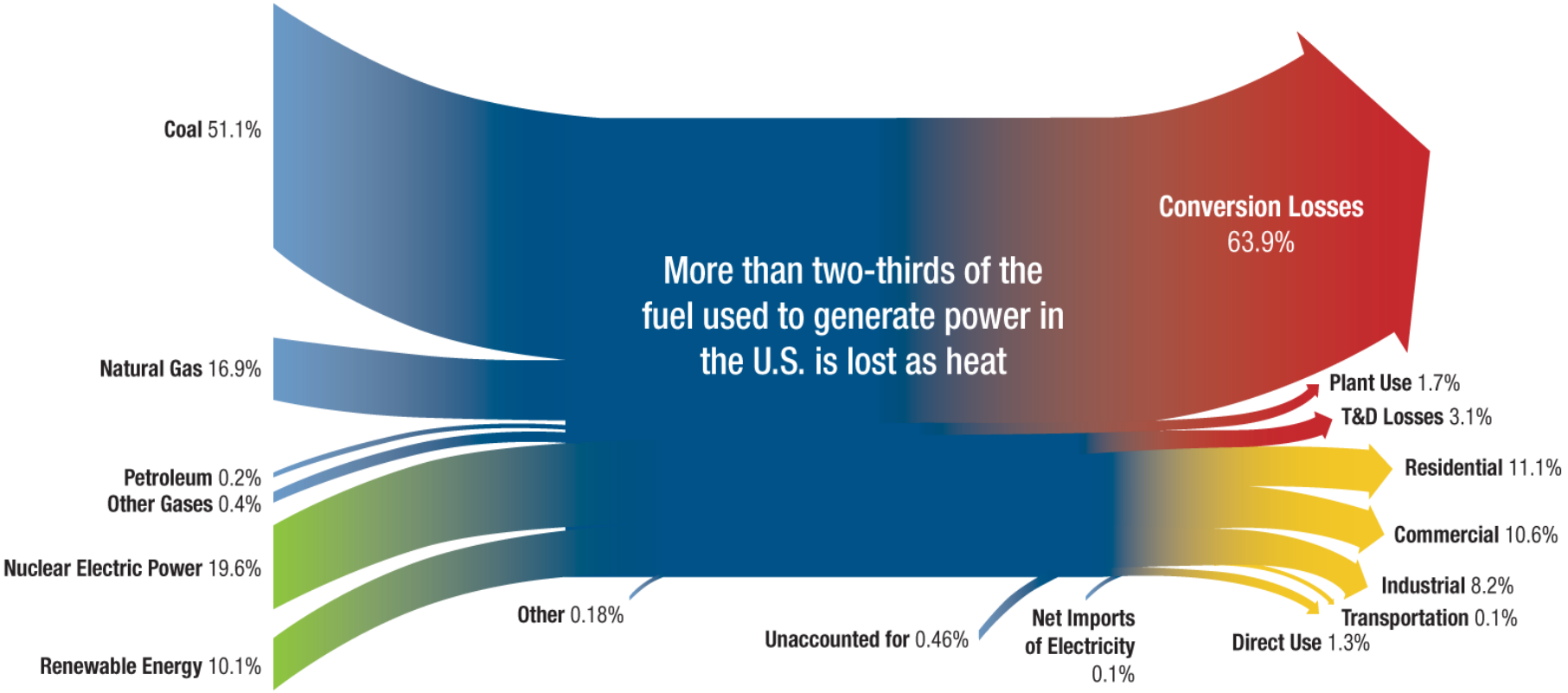
Uncertainties exist which are constraining CHP growth:

- Low gas prices and perceived long term availability
- Technical and economic feasibility of CHP in specific applications
- Regulatory policies and practices
- Financing availability and risks
- Global warming / carbon policies

Recommendations

- Develop and disseminate better feasibility studies, decision tools and awareness materials to convince users of reduced energy costs, increased reliability, and good ROI of CHP.
- Provide regulatory bodies with the policy options and suggested actions that can streamline CHP investments
- Establish models that allow utilities to have sufficient incentives to make them facilitators of CHP installations rather than barriers to CHP implementation.
- Identify, pilot, and document strong financing solutions for CHP investments which address market and technology risks .
- Encourage Federal and state governments to provide the kind of policy and financial support which could address the range of barriers to new CHP.

The Prize:
Over Two Thirds of the Fuel Used to Generate Power in the United States is Lost as Heat



Source: DOE EIA Annual Energy Review 2008

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Thank you