



Energy Efficiency from CHP in Office Buildings

U.S. DOE Gulf Coast Clean Applications Center
November 3, 2010

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Eight U.S. DOE Clean Energy Application Centers

Support CHP, Waste Heat Recovery and District Energy through

1. Education and Outreach
2. Project Support
3. Policy Development



CHP Best User Profile

- ▶ Coincident electrical and thermal loads
- ▶ Continuous operation (24 hr x 365 days)
- ▶ Low seasonal variation in loads
- ▶ High power reliability needs



CHP – Commercial Sector

- ▶ Hotels
- ▶ Prisons
- ▶ Airports
- ▶ Hospitals
- ▶ Universities
- ▶ Data Centers
- ▶ Grocery Stores
- ▶ Wastewater Treatment
- ▶ Refrigerated Warehouses
- ▶ Emergency Management Facilities
- ▶ Homeland Security & Sanctuary Locations



Office Building – Cooling only CHP

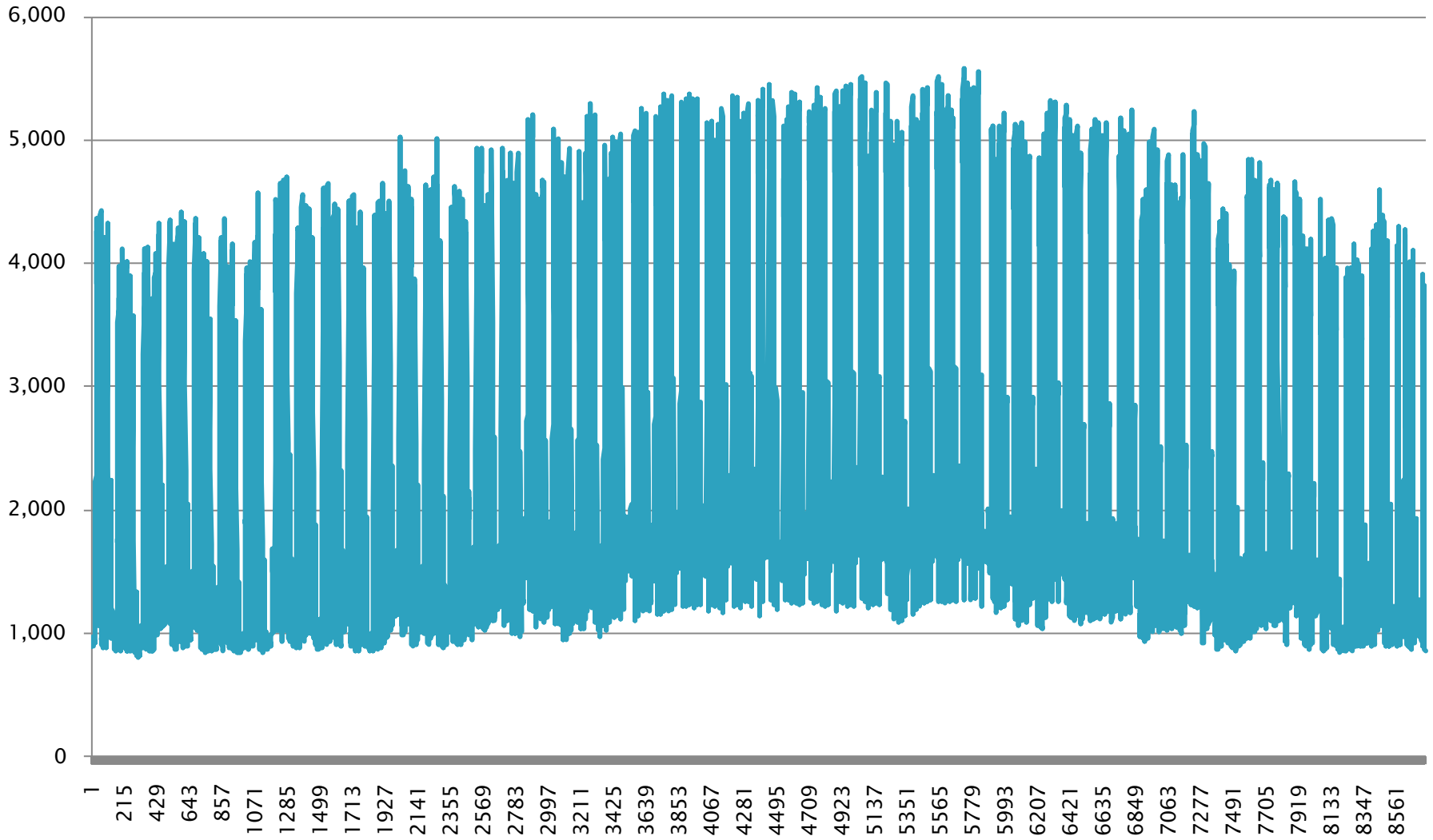
- ▶ 1.3 Million square feet Office Building
- ▶ Located in downtown Houston
- ▶ Operation – Monday thru Friday 7 AM – 7 PM
- ▶ HVAC Systems
 - Lighting Power Density – 1 W/sf
 - Centrifugal Chillers
 - Variable Air Volume Systems
- ▶ Rates
 - Electricity : \$0.068/kWh & \$8.3/kW
 - Gas : \$6.00 /MMBtu



Methodology

- ▶ Used DOE 2.1 – Building Energy Analyzer^{Pro}
- ▶ Obtained hourly
 - electric,
 - chilled water,
 - domestic hot water
 - space heating loads
- ▶ Calibrated Model using Actual Utility Bills
- ▶ Analyzed different CHP configurations

Hourly Electricity Profile (kW)



Electric & Thermal Loads

Summer

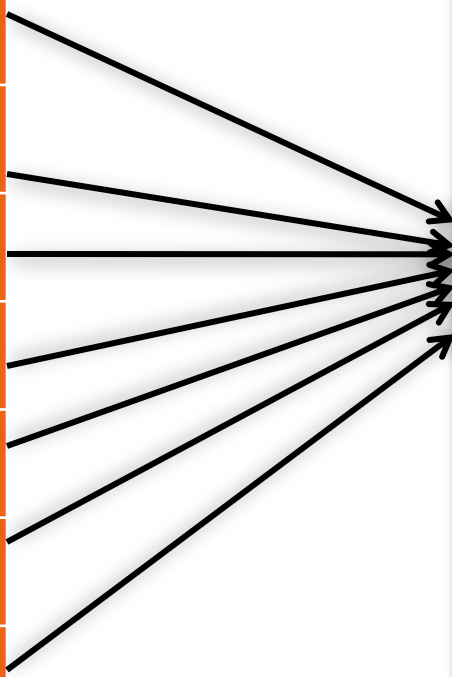
- ▶ Weekday
 - Peak Electric demand
 - 5,584 kW
 - Peak Cooling Load
 - 3,228 tons
- ▶ Night/ Weekend
 - Electric demand
 - 1,093 kW
 - Cooling Load
 - 800 tons

Winter

- ▶ Weekday
 - Peak Electric demand
 - 4,700 kW
 - Peak Cooling Load
 - 2,395 tons
- ▶ Night/ Weekend
 - Electric demand
 - 845 kW
 - Cooling Load
 - 138 tons

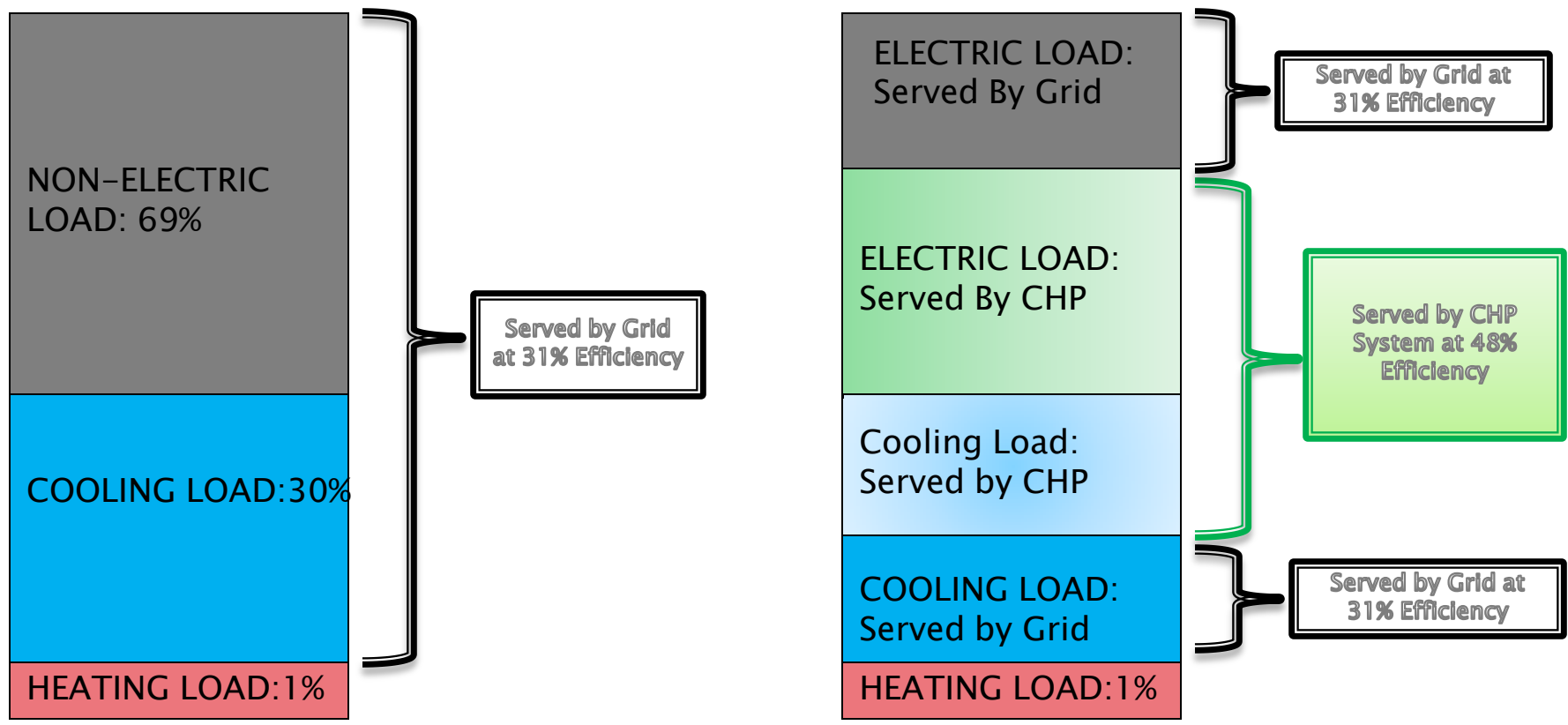
CHP Analysis Matrix: 112 Combinations

Absorption Chiller (Tons)	Matching Engine Capacity (kW)	Matching Turbine Size (kW)
200	667	500
400	1,333	1,000
600	2,000	1,500
800	2,667	2,000
1,000	3,333	2,500
1,200	4,000	3,000
1,400	4,667	3,500



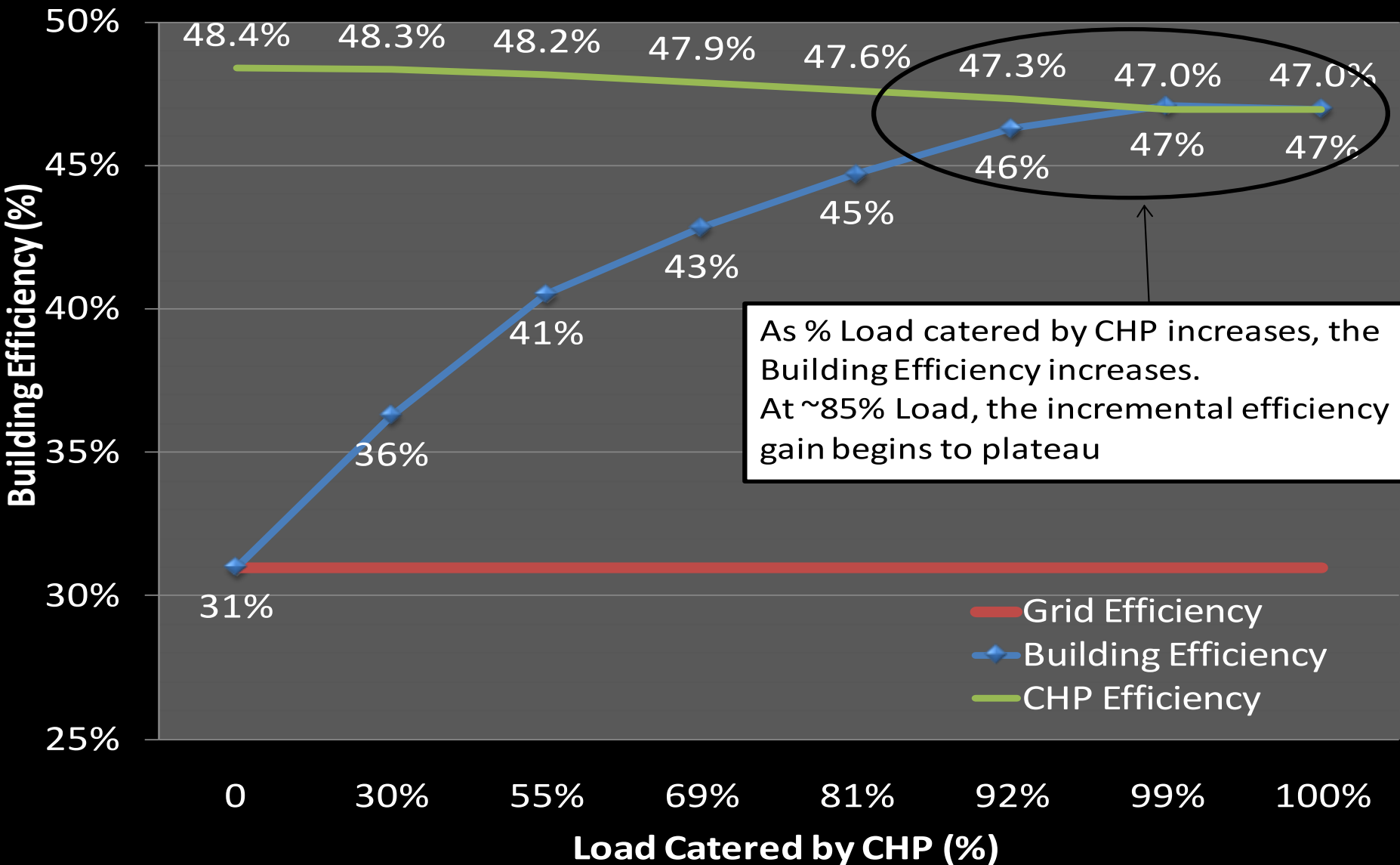
- Thermal Energy Storage (ton-hrs)**
- 0
 - 3,000
 - 6,000
 - 9,000
 - 12,000
 - 15,000
 - 18,000
 - 21,000

Building Efficiency



$$\text{Building Efficiency} = \text{Load Catered by Grid (\%)} * \text{Grid Efficiency} + \text{Load Catered by CHP (\%)} * \text{CHP Efficiency}$$

Building Efficiency vs. CHP system size



As % Load catered by CHP increases, the Building Efficiency increases.
At ~85% Load, the incremental efficiency gain begins to plateau

Impacts of Sample Configurations

CHP Plant caters to 55% of the Building's Electricity Consumption

- ▶ CHP Configuration A
 - 1.3 MW Engine
 - 400 ton Absorption Chiller
- ▶ Impacts
 - Building Efficiency: 41%
 - Efficiency Increase: 31%
 - Annual Savings: \$406,136
 - CO₂ reduction: 5,070 tons

CHP Plant caters to 77% of the Building's Electricity Consumption

- ▶ CHP Configuration B
 - 2 MW Engine
 - 600 ton Absorption Chiller & 9,000 ton-hrs TES
- ▶ Impacts
 - Building Efficiency: 44%
 - Efficiency Increase: 43%
 - Annual Savings: \$528,097
 - CO₂ reduction: 8,114 tons

CHP & other EEM'S

Baseline Electricity Consumption (kWh)			20,426,466	
	Reduction in Electricity Consumption (kWh)	Increase in Building Efficiency (%)	Annual Savings (\$)	Simple Payback
Lighting – 30% reduction in Lighting Power Density	980,470	11%	\$67,144	~ 4 years
Chillers – 30% more Efficient Chillers	1,838,382	20%	\$125,896	~ 12 years
CHP Config A – 400 ton Absorption Chiller	2,433,146	31%	\$406,136	~ 6 years
CHP Config B – 600 ton Absorption Chiller & 9,000 ton-hr tank	3,695,988	43%	\$528,097	~ 10 years

Analysis Summary

- ▶ System Efficiencies range: 36% –48%
- ▶ Energy Efficiency Increase: 16% – 55%
- ▶ Simple Paybacks: 5 – 14 years
- ▶ TES contributes to EE increase: Waste heat utilization during off-peak

- ▶ CHP is technically and economically viable in Office Applications
- ▶ Significant environmental impacts due to “energy recycling”

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