



# GAS TURBINES IN SUPPORT OF GRID MODERNIZATION

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Presented by:  
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Solar Turbines Incorporated

**A CULTURE OF CUSTOMER CARE**

**Solar Turbines**

*A Caterpillar Company*

Caterpillar: Non-Confidential

# SOLAR TURBINES INCORPORATED

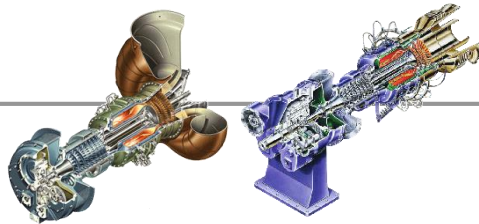
- World's Largest Manufacturer of Industrial Gas Turbines (1 to 22 MW)
- Over 15,000 Gas Turbines Sold
- Over 6,000 Gas Compressors Sold
- Installations in over 100 Countries
- Direct End-to-End Sales & Service
- More than 2 Billion Fleet Operating Hours
- Global Workforce ~ 8,000 Employees
- 48 Sales & Service Locations
- 70% of Products are Exported
- Based in San Diego, California, U.S.A.
- Subsidiary of Caterpillar Inc. Since 1981



# SOLAR GAS TURBINE FAMILIES

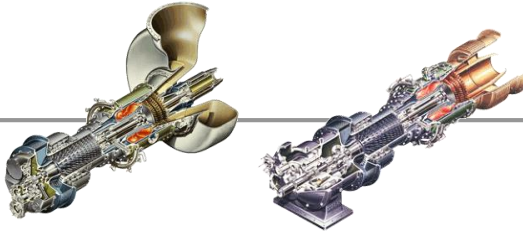
## Saturn 20

1590 hp/1210 kWe  
(Over 5040 Units)



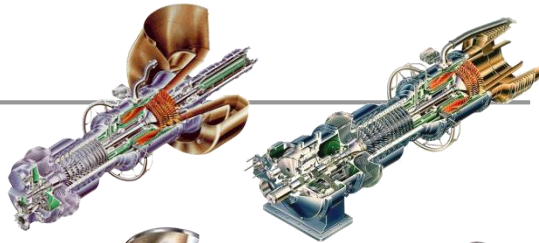
## Centaur 40 & 50

4700-6130 hp  
3515-4600 kWe  
(Over 3660 Units)



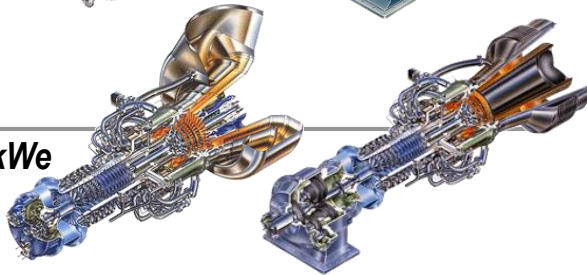
## Taurus 60

7700 hp/5670 kWe  
(Over 1960 Units)



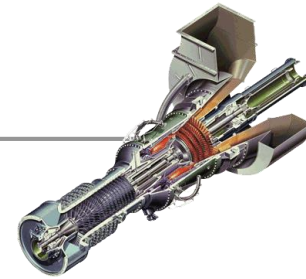
## Taurus 70

10,915 hp / 7965 kWe  
(Over 800 Units)



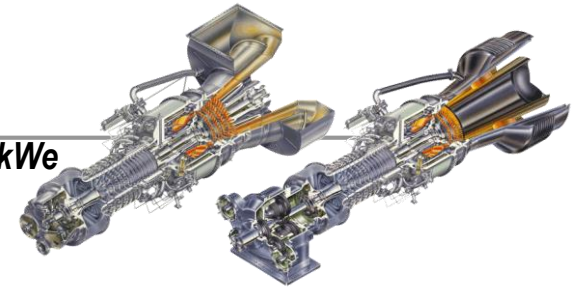
## Mars 90 & 100

13,220 – 15,900 hp  
9450 – 11,350 kWe  
(Over 1300 Units)



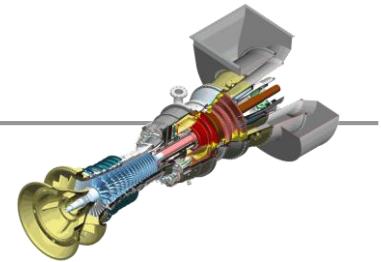
## Titan 130

20,500 hp / 15,000 kWe  
(Over 820 Units)

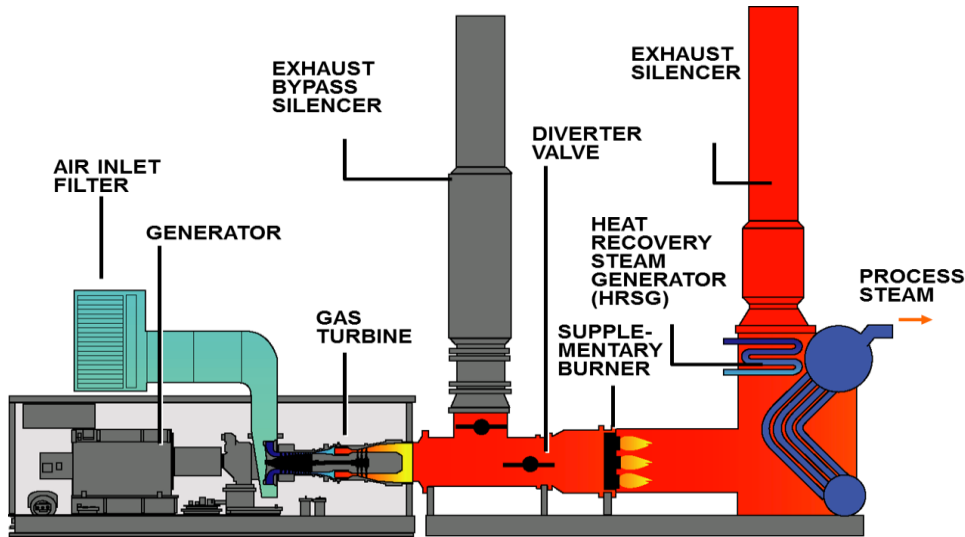


## Titan 250

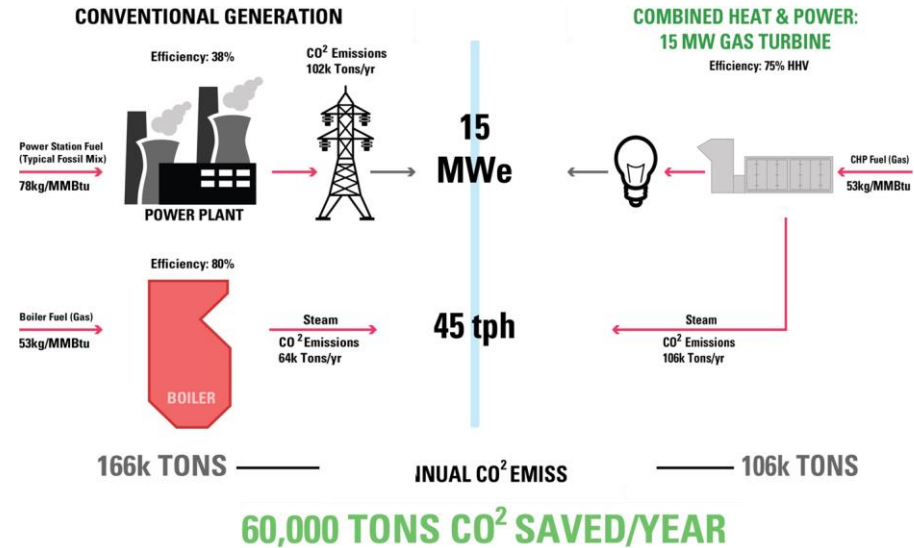
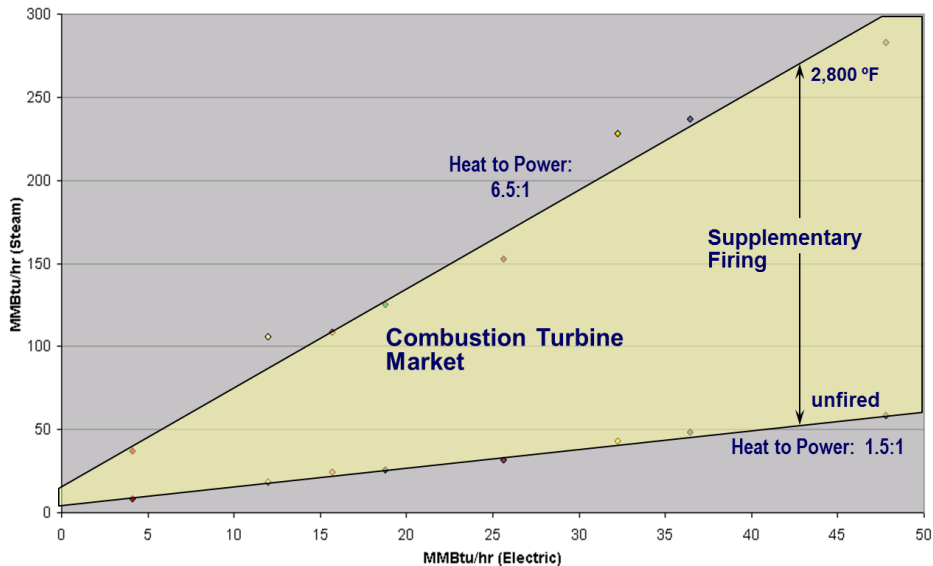
30,000 hp / 21,745 kWe  
(Over 40 Units and Growing)



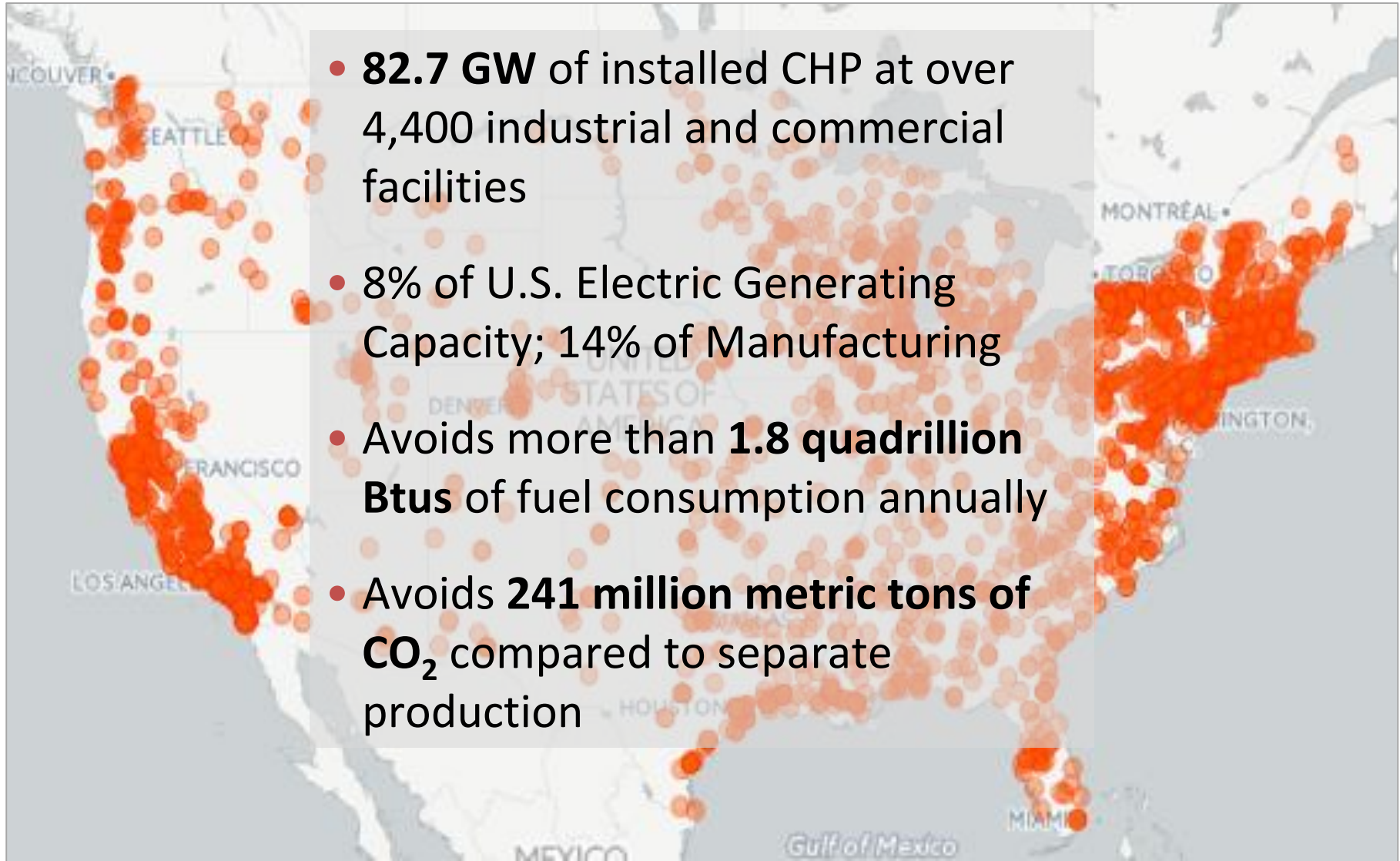
# GAS TURBINE FOR CHP APPLICATION



- Gas Turbines are ideal suited for CHP due to:
  - High Mass flow
  - High Exhaust temperature
- Small Footprint
- Low Maintenance
- Low Emissions due to DLE combustion



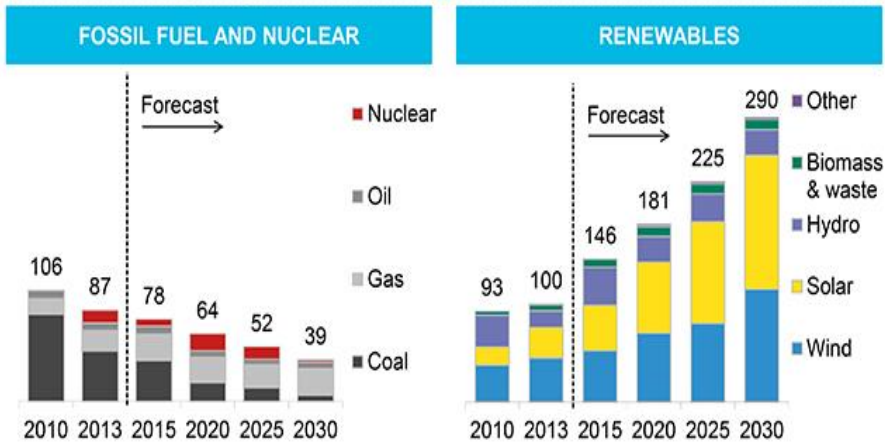
# CHP IS LOCATED IN EVERY STATE



Source: CHP Association

# CURRENT GENERATION TRENDS

## GLOBAL POWER GENERATION CAPACITY ADDITIONS 2010 – 2030 (GW)

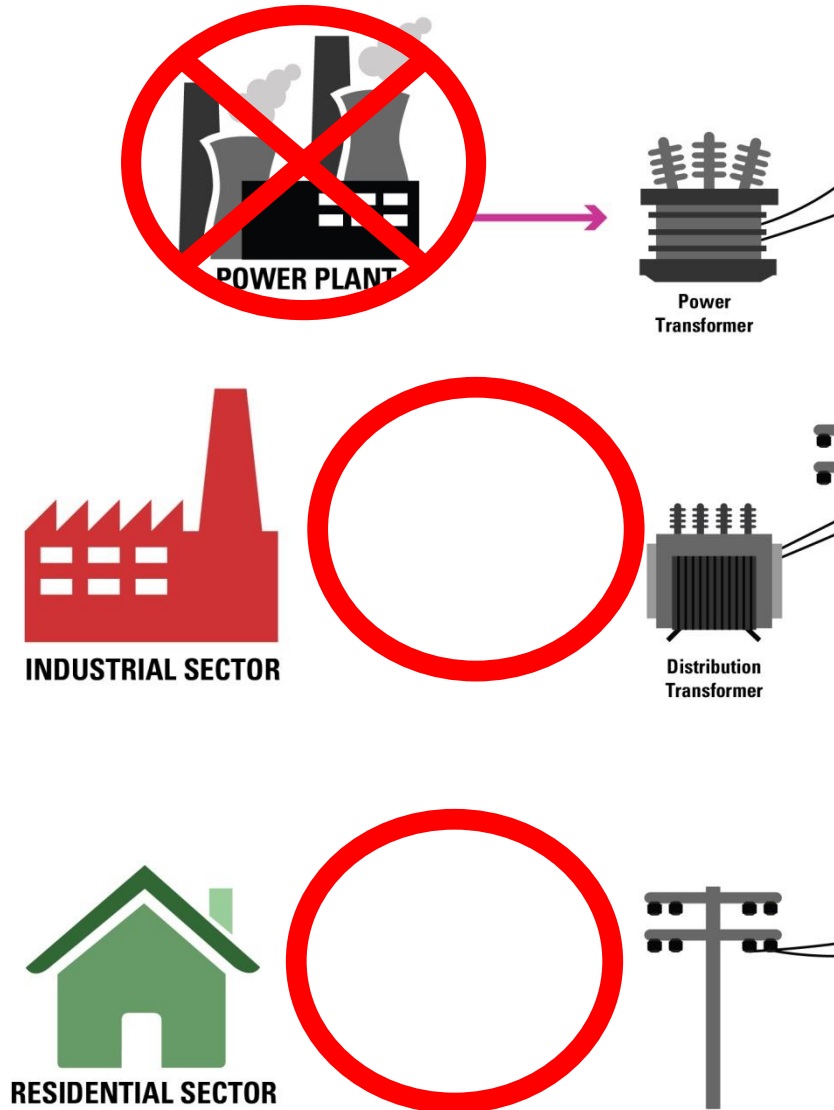


Source: Michael Liebreich/BNEFSummit 2014



- Increase in Renewable Energy – Intermittent power
- Current distribution system operates at capacity limits
- New transmission lines needed - cost intensive and long approval process
- Centralized power generation network is jeopardized by natural disasters e.g super storm Sandy

# HOW SMALL GAS TURBINES CAN SUPPORT THE GRID



- ✓ Support Grid Stability
- ✓ Allows decentralized PG
  - ✓ Island Mode / Parallel Operation
  - ✓ Increase Reliability
  - ✓ Increase Resiliency
- ✓ Minimize Investment compared to centralized power generation
- ✓ Reduce transmission losses – placed closer to consumer
- ✓ Quick start-up
- ✓ Flexible load following
- ✓ Low Emissions
- ✓ High Efficient when CHP is used

# UTILITY OWNED CHP

## Project: Eight Flags in Florida

Plant size: 22 MW CHP

Usage:

- Power for local utility
- Sell steam to industrial company

## Advantages:

- Benefits the Customer with Lower Rates
- Grows Natural Gas Usage
- Reduces Carbon Emissions
- Can Be Used Productively By Electric Utilities
- Provides Returns to Stockholders

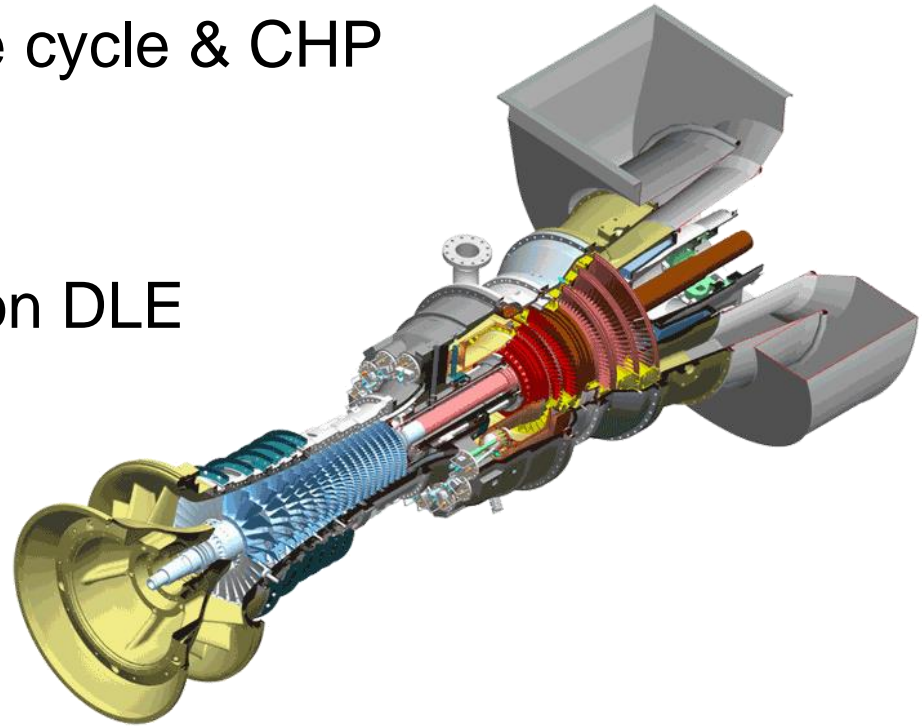




# TECHNOLOGY IMPROVEMENTS

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- Improved Start-up time
- Reduced Emissions
- Higher Efficiency – Simple cycle & CHP
- Increase in power density
- Increase in fuel flexibility on DLE



# SUMMARY

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- ✓ Turbines are ideally suited for CHP applications
- ✓ Turbines below 25 MW are ideally suited for behind the fence power / decentralized power / peaking
- ✓ Able of operating in parallel to the grid or island mode
- ✓ Low Emissions
- ✓ Gas is the cleanest fossil fuel
- ✓ Gas will have strong availability at relatively low cost for quite some time

# Solar<sup>®</sup> Turbines

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# CHP VALUE PROPOSITION

Category	10 MW CHP	10 MW PV	10 MW Wind	Combined Cycle (10 MW Portion)
Annual Capacity Factor	85%	22%	34%	70%
Annual Electricity	74,446 MWh	19,272 MWh	29,784 MWh	61,320 MWh
Annual Useful Heat	103,417 MWh <sub>t</sub>	None	None	None
Footprint Required	6,000 sq ft	1,740,000 sq ft	76,000 sq ft	N/A
Capital Cost	\$20 million	\$60.5 million	\$24.4 million	\$10 million
Annual Energy Savings	308,100 MMBtu	196,462 MMBtu	303,623 MMBtu	154,649 MMBtu
Annual CO <sub>2</sub> Savings	42,751 Tons	17,887 Tons	27,644 Tons	28,172 Tons
Annual NO <sub>x</sub> Savings	59.4 Tons	16.2 Tons	24.9 Tons	39.3 Tons

- 10 MW Gas Turbine CHP — 28% electric efficiency, 68% total CHP efficiency, 15 ppm NO<sub>x</sub> emissions
- Capacity factors and capital costs for PV and Wind based on utility systems in DOE's Advanced Energy Outlook 2011
- Capital cost and efficiency for natural gas combined cycle system based on Advanced Energy Outlook 2011 (540 MW system proportioned to 10 MW of output), NGCC 48% electric efficiency, NO<sub>x</sub> emissions 9 ppm
- CHP, PV, Wind and NGCC electricity displaces National All Fossil Average Generation resources (eGRID 2012) — 9,572 Btu/kWh, 1,743 lbs CO<sub>2</sub>/MWh, 1.5708 lbs NO<sub>x</sub>/MWh, 6.5% T&D losses; CHP thermal output displaces 80% efficient on-site natural gas boiler with 0.1 lb/MMBtu NO<sub>x</sub> emissions

Source: DOE/EE-0079 August 2012