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CHP Packaged Systems: A Growing Trend

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Presentation Objectives:

Presentation Focus:

- Highlight trend, opportunities, and considerations of packaged CHP systems

Topics Covered:

- Packaged CHP definition
- Market status and opportunity for growth
- Defining characteristics
- System cost and performance data
- When to consider packaged CHP
- Packaged CHP case study

Packaged CHP Defined

Packaged CHP systems include a prime mover (i.e., reciprocating engine, microturbine or fuel cell), a generator, heat recovery equipment, electrical switchgear, emissions control devices, and controls, packaged in a weather-resistant sound-attenuating enclosure.

2G Energy, Inc.

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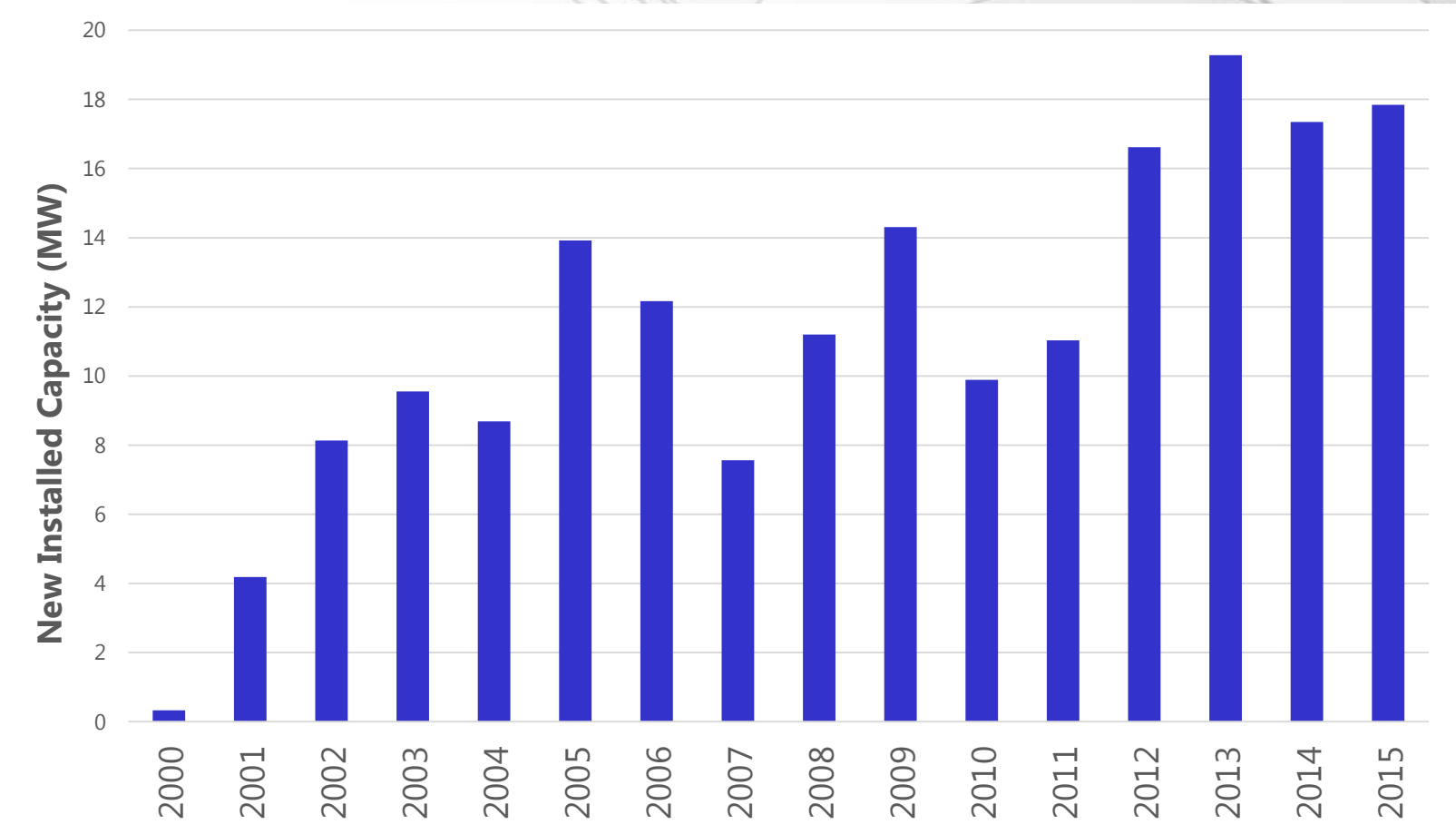
Growing Trend: Annual U.S. Capacity Additions



Source: ICF/U.S. DOE Combined Heat and Power Installation Database, February 2017, https://doe.icfwebservices.com/chpdb/.

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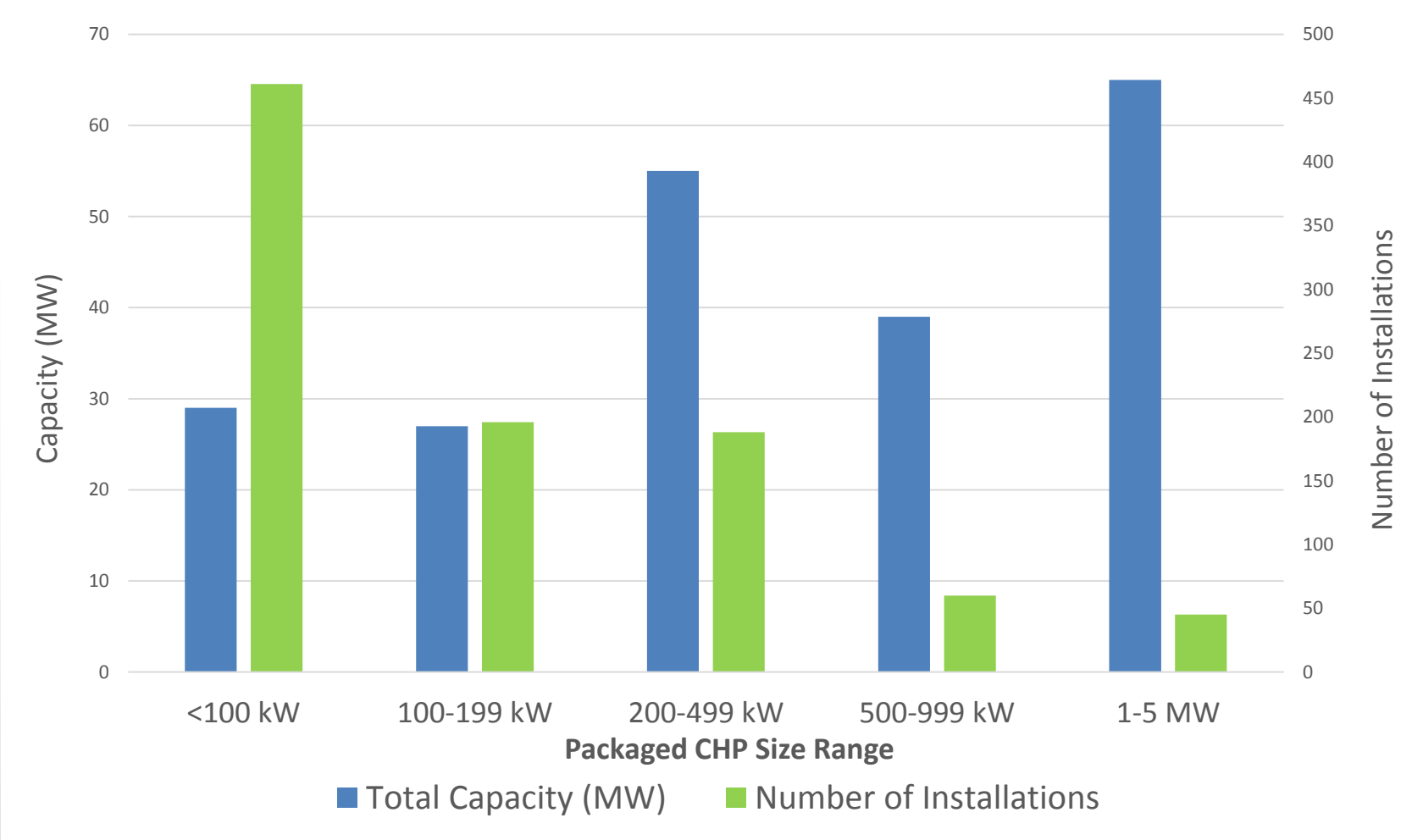
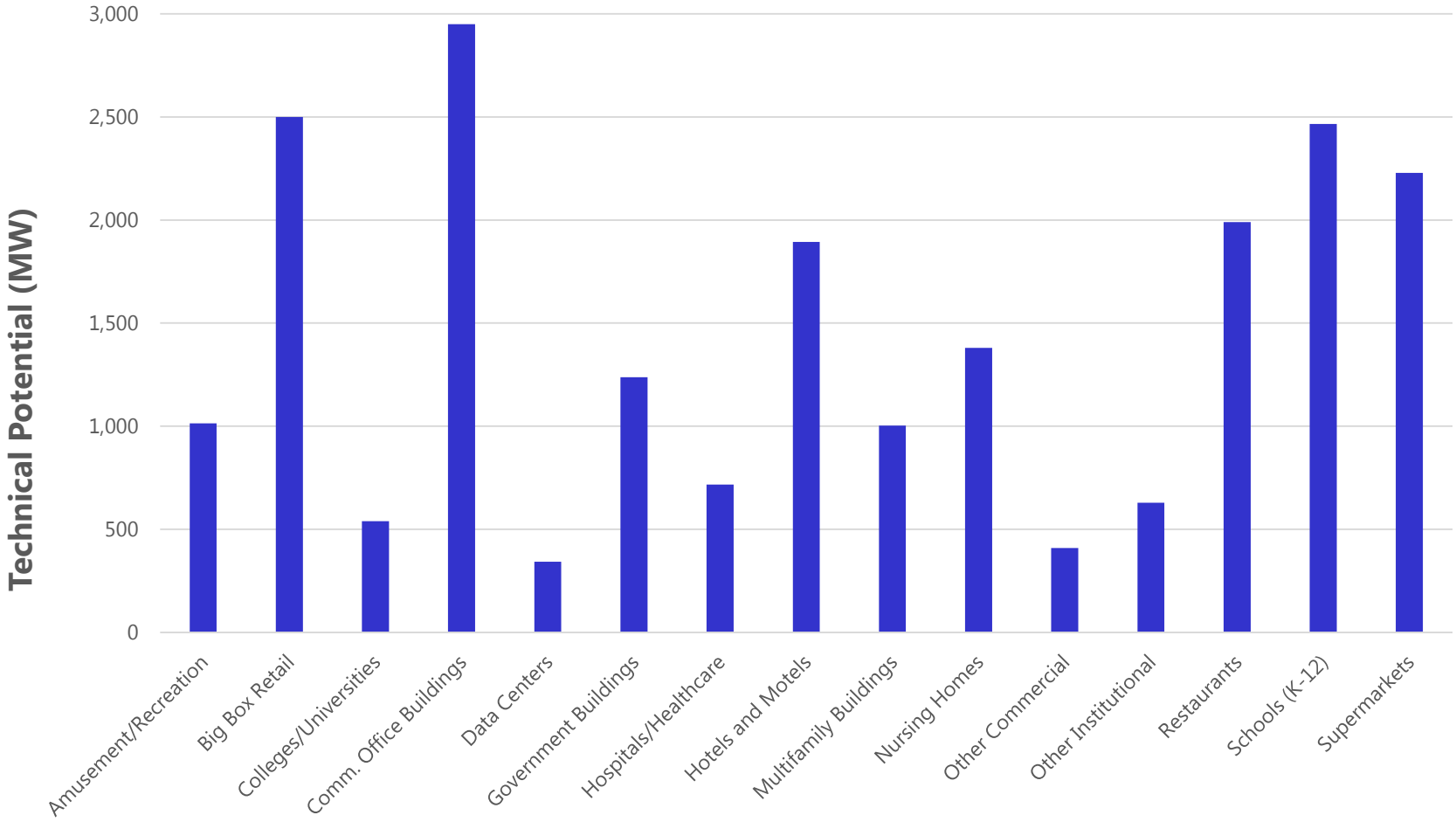
Packaged CHP Installations and Capacity by Size Range



Source: ICF/U.S. DOE Combined Heat and Power Installation Database, February 2017 https://doe.icfwebservices.com/chpdb/.

Technical Potential for Systems <500 kW



Source: ICF, CHP Technical Potential Database, 2016.

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Defining Characteristics

- Standardization
- Black start/islanding capability
- Acoustic enclosure for noise attenuation
- Modularity
- Well-suited for 3rd party own/operate business models
- Replicability
- Cost certainty

Performance Data

Cost and Performance Characteristics	Size Range (kW)				
	30-99	100-199	200-499	500-1,000	>1,000
Electrical Heat Rate (Btu/kWh), HHV	11,000 - 15,200	9,700 - 12,600	9,250 - 11,000	9,050 - 10,500	8,600 - 10,300
Electrical Efficiency (%), HHV	23-31%	27-35%	29-37%	32-38%	33-40%
Total Heat Recovered (Btu/kWh)	5,300 - 7,300	5,100 - 6,100	3,600 - 5,400	3,600 - 4,800	3,400 - 5,600
Typical form of Recovered Heat	H_2O	H_2O	H_2O	H_2O	H_2O, Steam
Total CHP Efficiency (%), HHV	72-82%	77-82%	67-82%	75-83%	78-87%
Power/Heat Ratio	0.46-0.64	0.52-0.7	0.64-0.95	0.72-0.96	0.61-1.01

Source: Vendor-supplied Data

Equipment Costs

Packaged CHP Costs	Size Range (kW)				
	30-99	100-199	200-499	500-1,000	>1,000
Equipment Cost ($/kW)	$1,000 - $2,900	$1,500 - $2,500	$1,300 - $2,000	$1,100 - $1,600	$700 - $1,200

Source: Vendor-supplied Data

When to Consider Packaged CHP

- **Space constraints**
  - Many facilities have constraints on the physical size of units that can be installed, and packaged systems tend to have a relatively small footprint.
- **Ease of installation and operation**
  - Many facilities may not have experience owning and operating complex equipment and value ease of installation and operation.
- **Potential for replicability**
  - If a packaged CHP system is a good fit for one facility, it becomes a known quantity that can be replicated at other facilities with similar load requirements and layouts.

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When to Consider Packaged CHP

- **Third-party financing options**
  - CHP projects are capital-intensive, which can be a problem for some market sectors. Many packaged CHP offerings include own/operate business models with flexible financing options.
- **Electrical load profiles match packaged system outputs**
  - Most packaged CHP systems are under 500 kW in size, which are good for the electrical loads of commercial, institutional, multifamily buildings

Maine Army National Guard Bangor CHP

- 2016 ENERGY STAR CHP Awardee
- The Maine Army National Guard Aviation Support Facility (AASF) in Bangor, Maine.
- Army anticipates the system could serve as a model for the approximately 500 Army aviation and ground vehicle support facilities across the U.S. with energy characteristics similar to AASF's.

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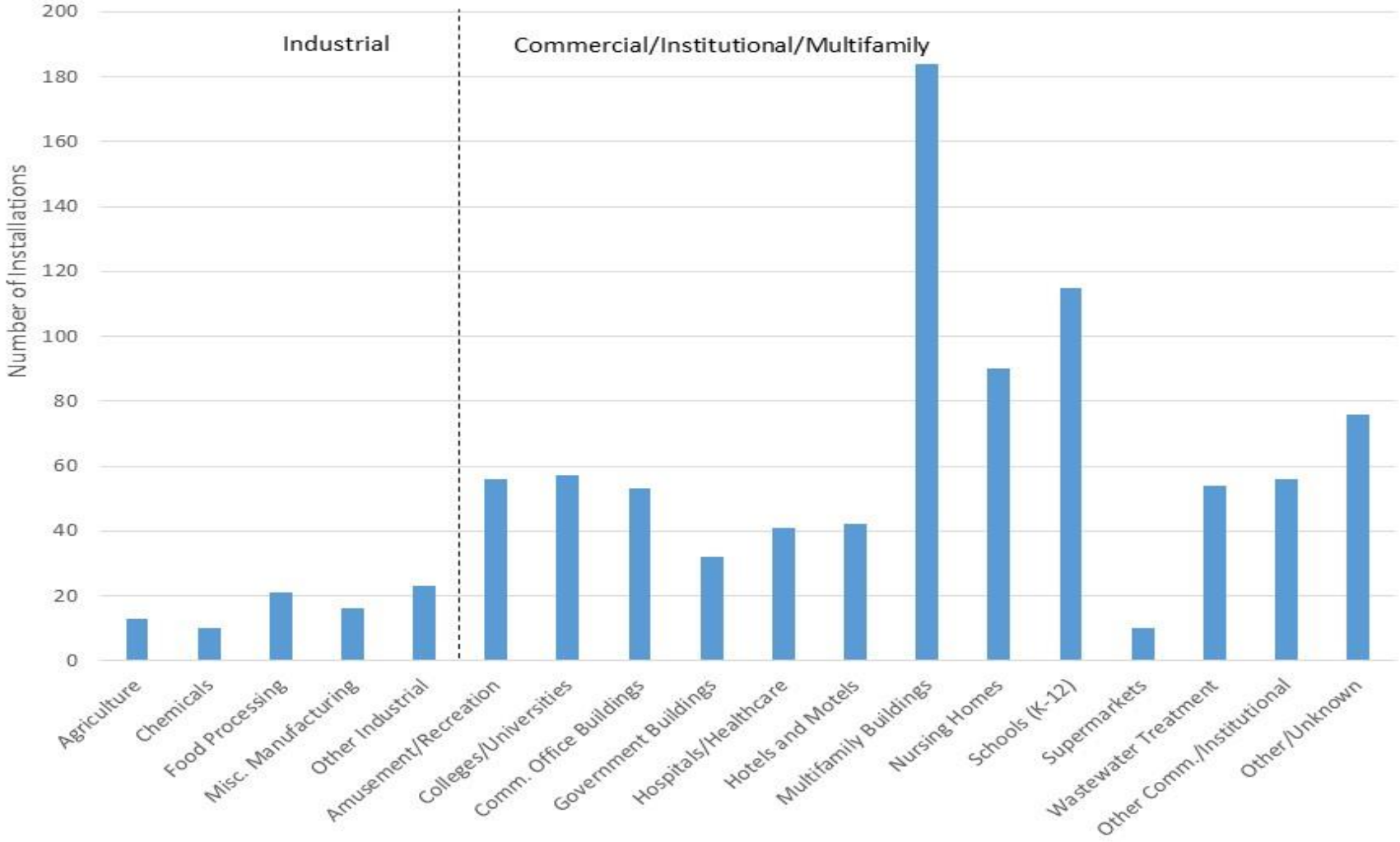
Maine Army National Guard Bangor CHP

- 75 kW Aegis Energy Services packaged CHP system (natural gas) designed by Innovative Construction and Design
- Commissioned in March 2015
- Primary drivers to meet energy goals. Determine if a small CHP system would work in a facility with an average 5,000 heating degree days.
- Recovered heat is used to produce hot water to radiantly heat the facility's hangar, maintaining the operational readiness of the aircraft in a region with over 5,000 heating degree days.
- CHP electricity output meets ~65% of facility load.
- System efficiency of 73 percent; system requires approximately 32 percent less fuel compared to conventional production of electricity and hot water.
- Annual energy cost savings = $60,000

Packaged CHP ENERGY STAR CHP Awardees

Award Winner	Award Year	State	CHP Size	Manufacturer
Maine Army National Guard	2016	ME	75 kW	Aegis
Rego Park Nursing Home	2005	NY	75 kW	Tecogen
Westfield YMCA	2008	NJ	75 kW	Tecogen
Sea Rise I & II	2005	NY	120 kW	Coast Intelligen
Atlantis Rehab - Greenpark Care Center	2005	NY	150 kW	Tecogen
The National Archives - Washington	2013	DC	150 kW	Aegis
Dominion-Crayne Station	2011	PA	195 kW	Capstone
Hermany Farms, Inc.	2005	NY	225 kW	Tecogen
Arrow Linen	2005	NY	300 kW	Coast Intelligen
St. Francis Hospital and Medical Center	2005	CT	400 kW	Doosan
Clinton Hills Apartments	2008	NY	600 kW	Capstone
Montvale Data Center - KPMG	2011	NJ	720 kW	UTC Power
Red Hook Fairway	2008	NY	950 kW	Coast Intelligen
Verizon – Garden City Office	2008	NY	1.4 MW	UTC Power
Mohegan Sun #4 - Resorts	2005	NJ	2 MW	UTC Power

Packaged CHP Installations by Market Segment



Source: ICF/U.S. DOE Combined Heat and Power Installation Database, February 2017 https://doe.icfwebservices.com/chpdb/.

Installed Capacity and Median Size by Market Segment

Sector	Market Segment	Installed Capacity (MW)	Median Size (kW)
Industrial	Agriculture	4.5	100
	Chemicals	5.0	180
	Food Processing	10.9	300
	Misc. Manufacturing	8.0	390
	Other Industrial	9.8	180
Commercial/Institutional	Amusement/Recreation	7.6	75
	Colleges/Universities	14.5	180
	Commercial Office Buildings	21.4	75
	Government Buildings	6.4	90
	Hospitals/Healthcare	15.7	220
	Hotels and Motels	7.8	100
	Multifamily Buildings	22.3	75
	Nursing Homes	10.8	75
	Schools (K-12)	17.7	75
	Supermarkets	4.2	320
	Wastewater Treatment	14.1	130
	Other Comm./Institutional	16.3	170
	Other/Unknown	18.6	140

Source: ICF/U.S. DOE Combined Heat and Power Installation Database, February 2017 https://doe.icfwebservices.com/chpdb/.

Questions and Contact Information

Packaged CHP Chapter – Catalog of CHP Technologies

Will be available at:

https://www.epa.gov/chp/catalog-chp-technologies

Contact:

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