IDEA's
27th Annual Campus Energy Conference

Technical Assistance
from DOE CHP
Technical Assistance Partnerships

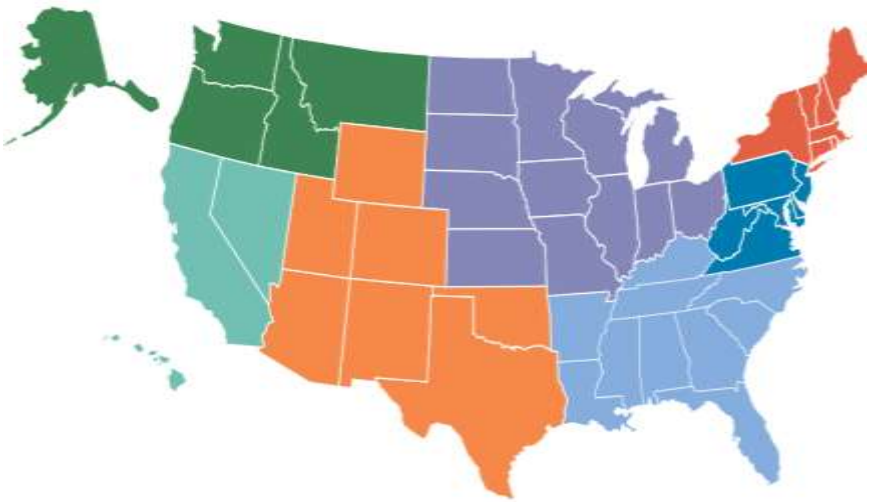
Isaac Panzarella, Director
U.S. DOE Southeast
Combined Heat and Power
Technical Assistance Partnership

U.S. Department of Energy
CHP Technical Assistance Partnerships

CHP Technical Assistance Partnerships

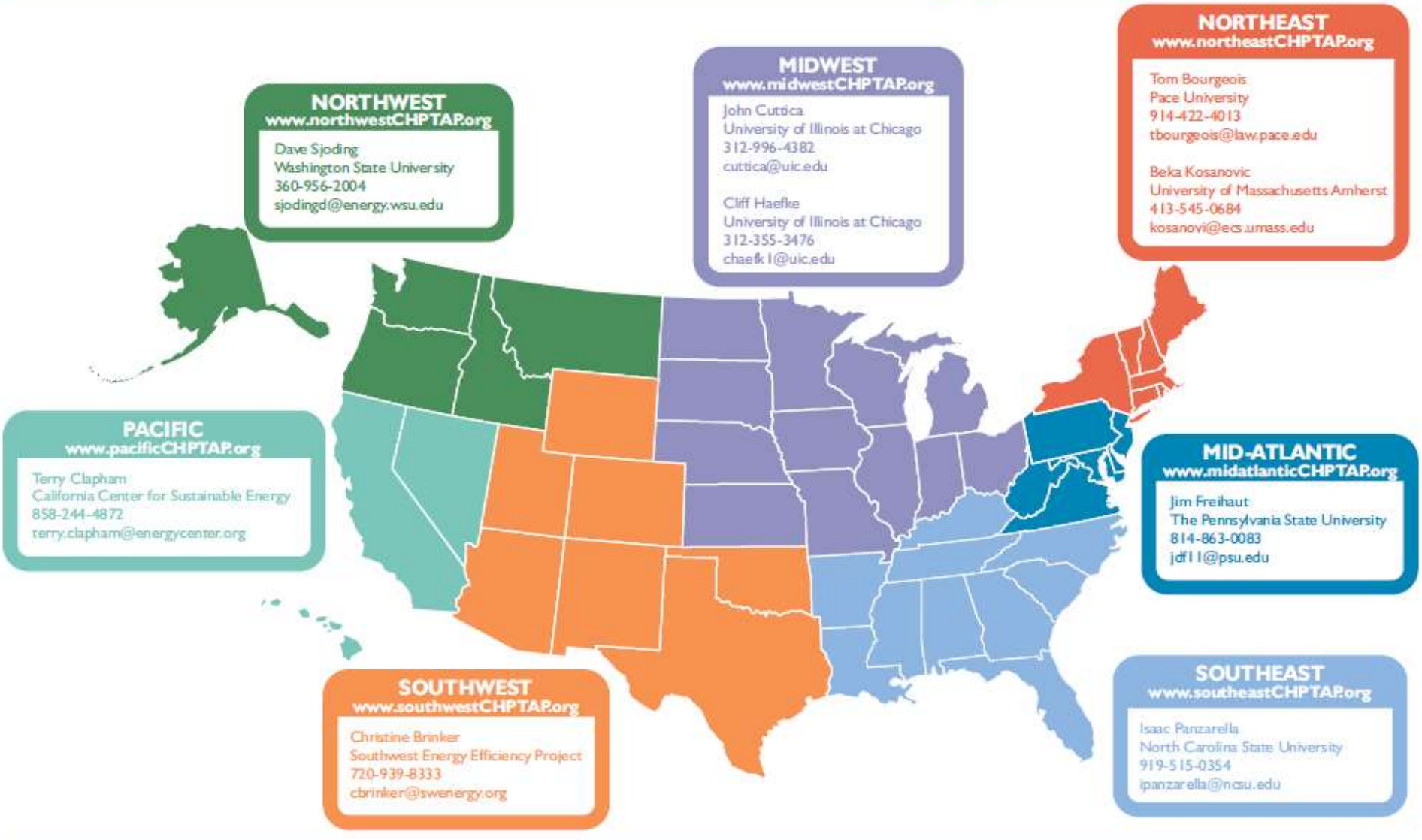
DOE's CHP TAPs promote and assist in transforming the market for CHP, waste heat to power, and district energy with CHP throughout the United States. Key services include:

- **Market Opportunity Analysis.**
  Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors
- **Education and Outreach.**
  Providing information on the energy and non-energy benefits and applications of CHP to state and local policy makers, regulators, end users, trade associations, and others.
- **Technical Assistance.**
  Providing technical assistance to end-users and stakeholders to help them consider CHP, waste heat to power, and/or district energy with CHP in their facility and to help them through the development process from initial CHP screening to installation.



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

DOE CHP Technical Assistance Partnerships (CHP TAPs)



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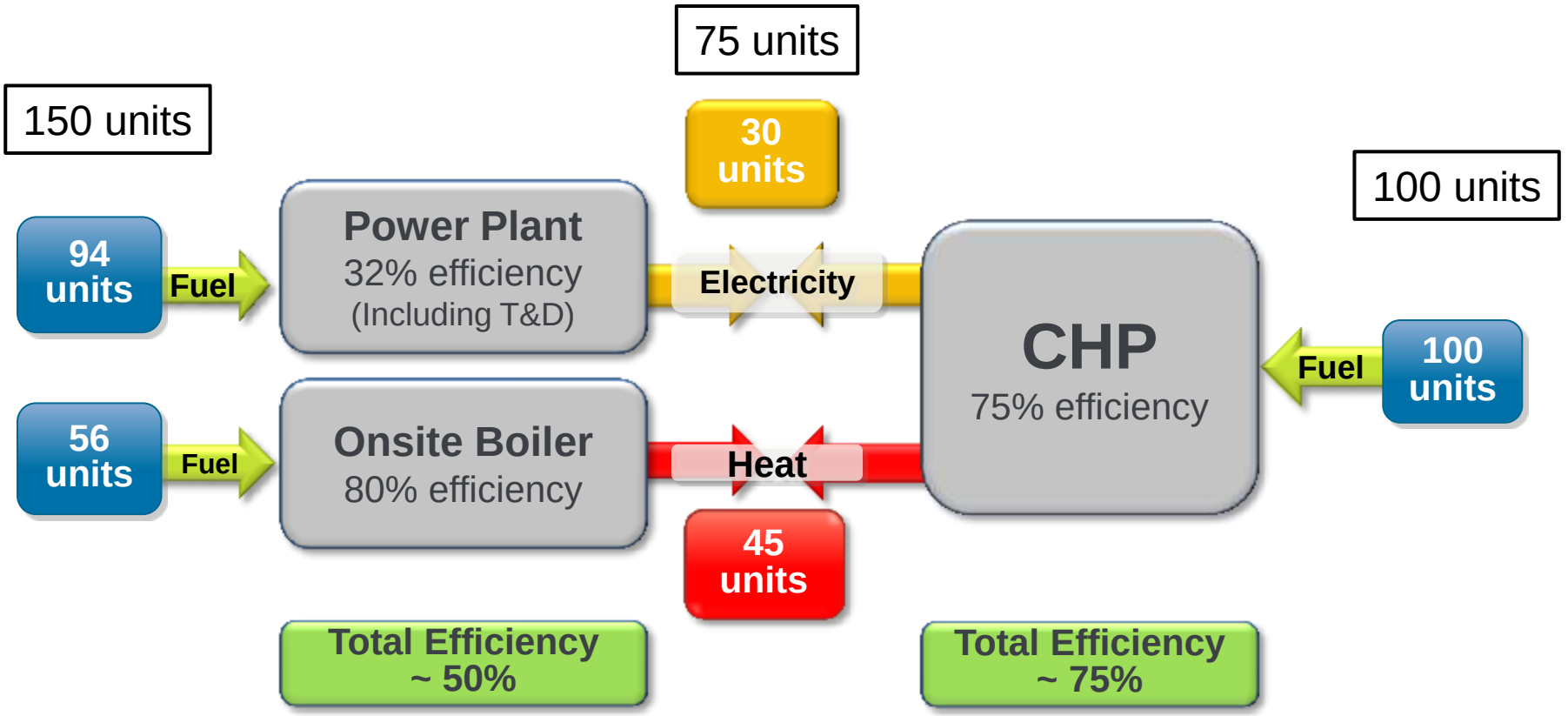
What Is Combined Heat and Power?

CHP is an *integrated energy system* that:

- Is located at or near a factory or building(s)
- Generates electrical and/or mechanical power
- Recovers waste heat for
  - heating,
  - cooling or
  - dehumidification
- Can utilize a variety of technologies and fuels

CHP Recaptures Much of that Heat, Increasing Overall Efficiency of Energy Services and Reducing Emissions

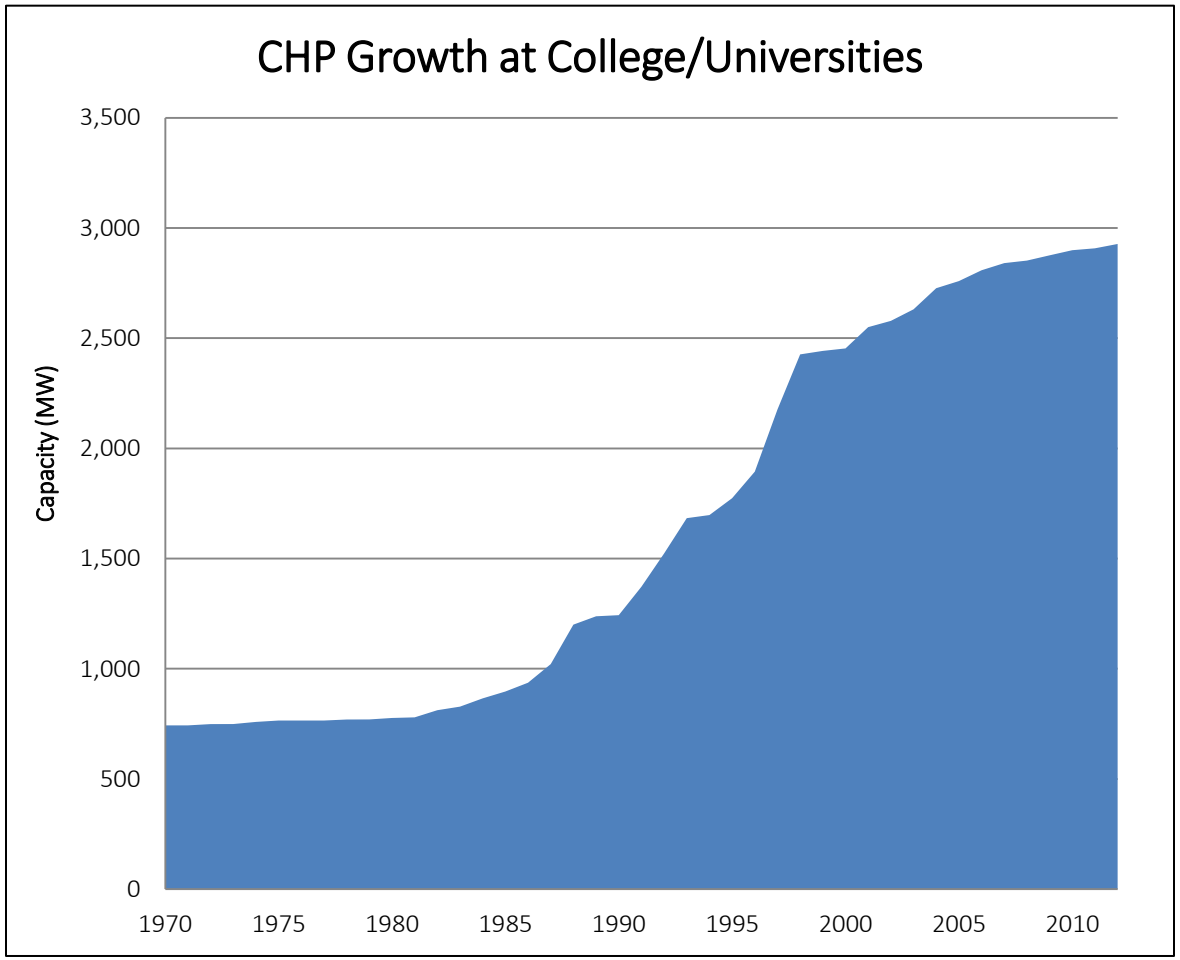


Why are CHP investments typically made?
(> 4,200 installations & ~ 82 GW installed capacity)

- Reduces energy costs for the end-user
- Increases energy efficiency, helps manage costs, maintain jobs
- Provides stability in the face of uncertain electricity prices
- Reduces risk of electric grid disruptions & enhances energy reliability (Hurricanes Katrina & Sandy; 2004 Blackout)
- Environmental Stewardship
  - Used as compliance strategy for reducing air emissions
  - Contributes to reducing Carbon Footprint

CHP in Colleges & Universities

- 285 colleges and universities have CHP, totaling 2,714 MW of capacity.
- Represents 3.3% of total installed CHP capacity in the U.S. (82 GW)
- Further technical potential totaling 8,403.9 MW of capacity

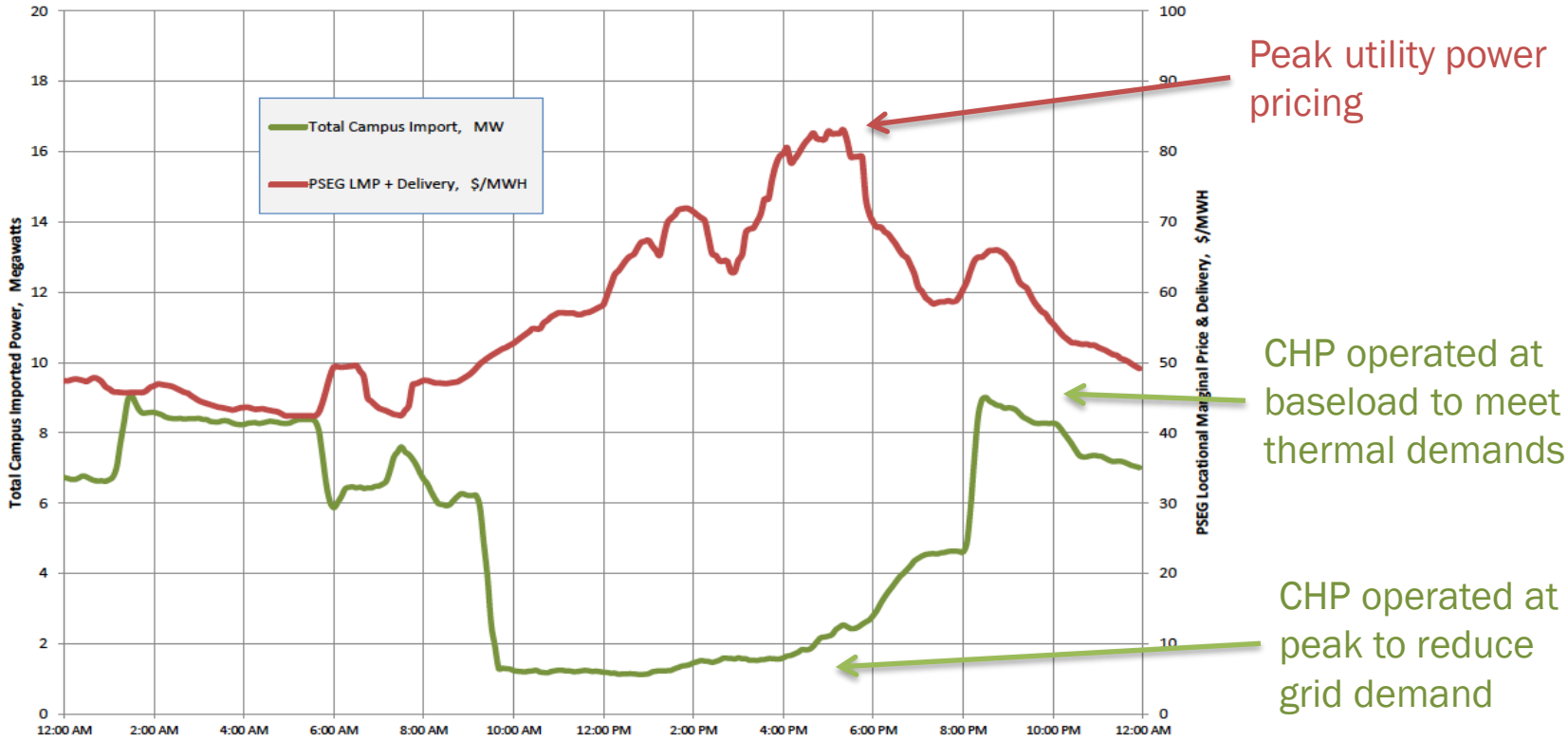


Source: ICF CHP Installation Database 2012

U.S. Department of Energy
CHP Technical Assistance Partnerships

Real time pricing strategy

- Princeton University has a 15 MW gas turbine CHP system, operated to maximize savings by reducing demand on grid during peak pricing times.



Borer, "Ted Talk on CHP & Campus Sustainability" for International District Energy Association. February 2013; http://www.districtenergy.org/26th-annual-campus-energy-conference

CHP and Critical Infrastructure

"Critical infrastructure" refers to those assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, national economic security, or national public health and safety."

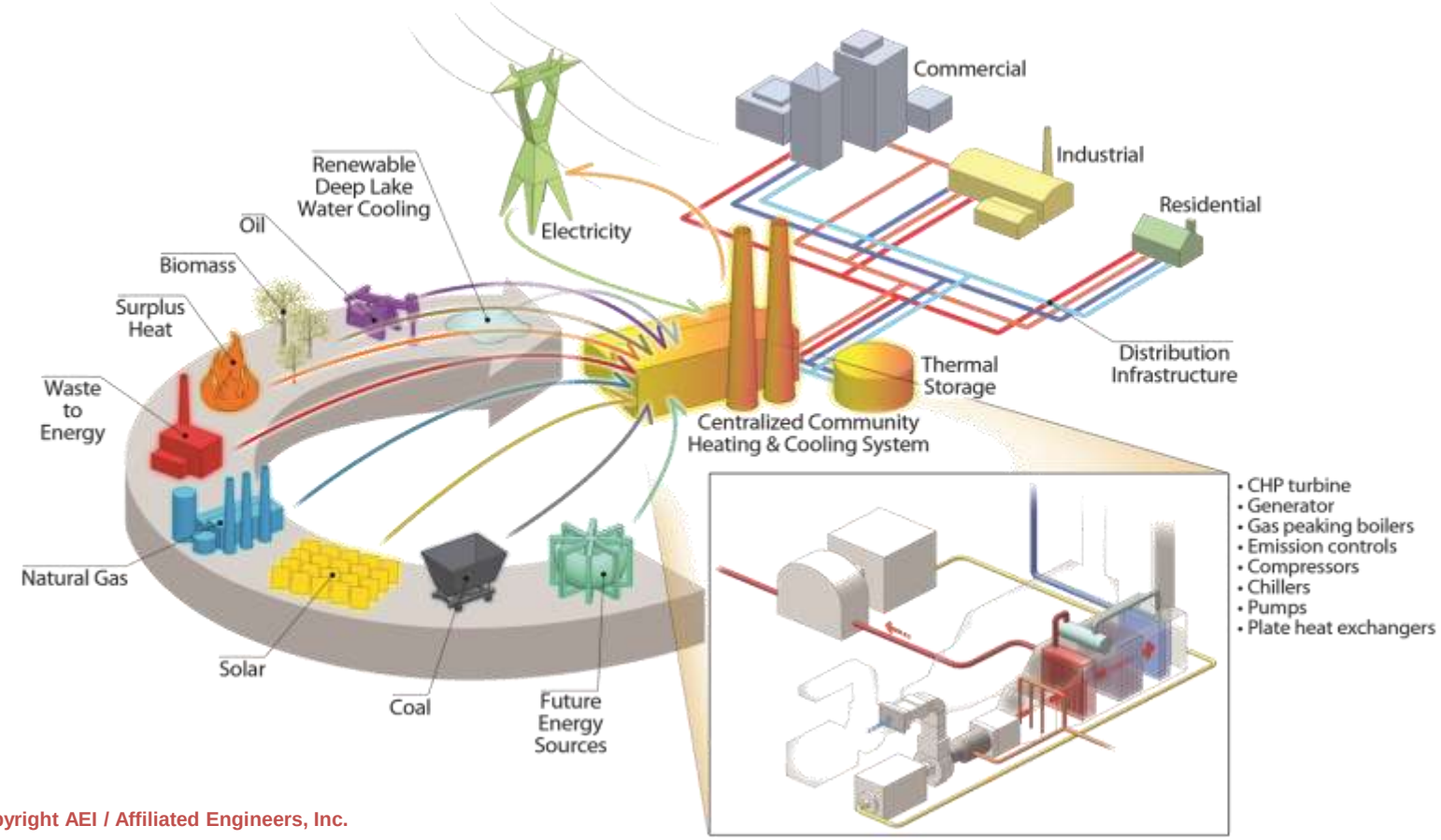
Patriot Act of 2001 Section 1016 (e)

Applications:

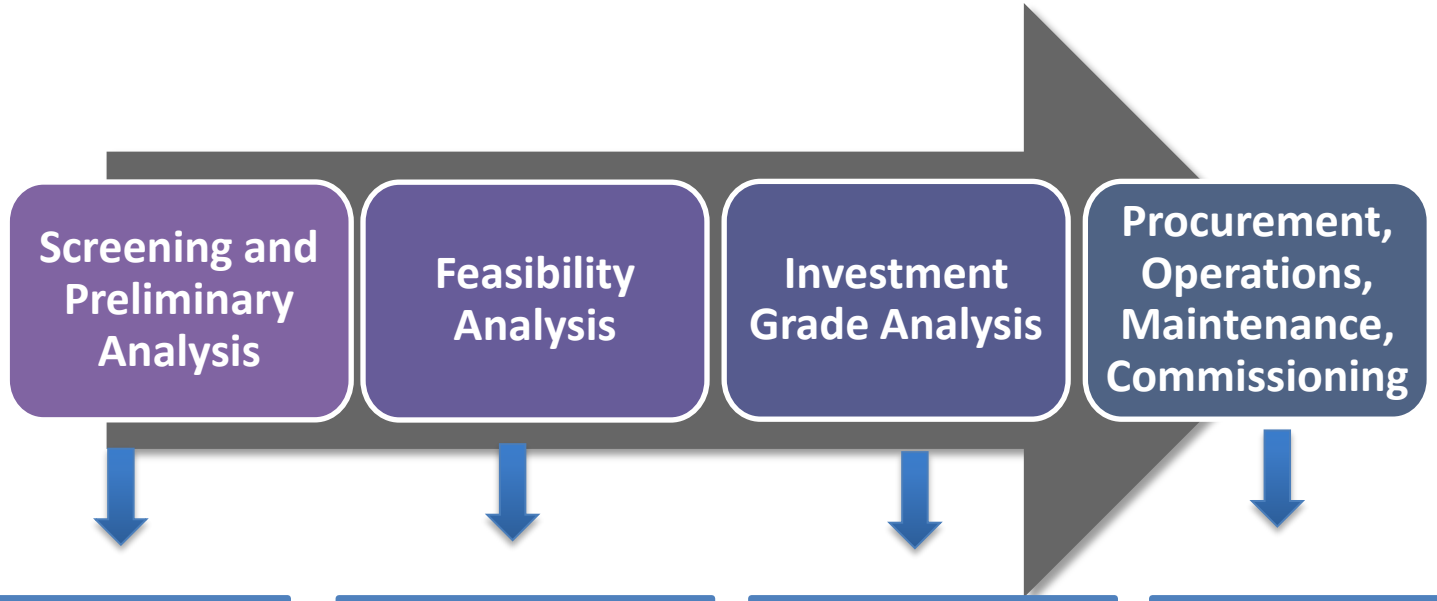
- Hospitals and healthcare centers
- Water / wastewater treatment plants
- Police, fire, and public safety
- Centers of refuge (often schools or universities)
- Military/National Security
- Food distribution facilities
- Telecom and data centers

CHP with District Energy & Microgrids

- Local “distributed” generation integrating CHP; thermal energy; electricity generation; thermal storage and renewables
- Able to “island” in the event of a grid failure



CHP Project Development Process and CHP TAP Technical Assistance



Screening and Preliminary Analysis	Feasibility Analysis	Investment Grade Analysis	Procurement, Operations, Maintenance, Commissioning
Quick screening questions with spreadsheet payback calculator.	Uses available site information. Estimate: savings, Installation costs, simple paybacks, equipment sizing and type.	3rd Party review of Engineering Analysis. Review equipment sizing and choices.	Review specifications and bids, Limited operational analysis

What makes a good CHP candidate?

- **Do you pay more than $.06/kWh on average for electricity (including generation, transmission and distribution)?**
- **Are you concerned about the impact of current or future energy costs on your operations?**
- **Are you concerned about power reliability?**
  What if the power goes out for 5 minutes… for 1 hour?
- **Does your facility operate for more than 3,000 hours per year?**
- **Do you have thermal loads throughout the year?**
  (including steam, hot water, chilled water, hot air, etc.)

What makes a good CHP candidate?

- Does your facility have an existing central plant?
- Do you expect to replace, upgrade, or retrofit central plant equipment within the next 3-5 years?
- Do you anticipate a facility expansion or new construction project within the next 3-5 years?
- Have you already implemented energy efficiency measures and still have high energy costs?
- Are you interested in reducing your facility's impact on the environment?
- Do you have access to on-site or nearby biomass resources? (i.e., landfill gas, farm manure, food processing waste, etc.)

CHP TAP CHP Qualification Screening Example

CHP TAP CHP Qualification Screen

Gas Fueled CHP - Recip Engine, Microturbine, Fuel Cell or Gas Turbine Systems / natural gas, LFG, biogas

Facility Information		
Facility Name	ABC Health Care	
Location (City, State)	Anywhere, USA	
Application	Hospital	
Annual Hours of Operation	8520	Annual operating hours with loads conducive to CHP
Average Power Demand, MW	10.4	
Annual Electricity Consumption, kWh	88,250,160	
Average Thermal Demand, MMBtu/hr	50	
Annual Thermal Demand, MMBtu	426,000	
Thermal Fuel Costs, $/MMBtu	$6.00	
CHP Fuel Costs, $MM/Btu	$6.00	
Average Electricity Costs, $/kWh	$0.080	
Percent Electric Price Avoided	90%	Typically 70 to 95%
CHP System		
Net CHP Power, MW	10.2	Based on thermal match but capped at average power demand
CHP Electric Efficiency, % (HHV)	29.1%	CHP system specs
CHP Thermal Output, Btu/kWh	4,922	CHP system specs
CHP Power to Heat Ratio	0.69	Calculated based on CHP power output and thermal output
CHP Availability, %	96%	90 to 98%
Incremental O&M Costs, $/kWh	$0.009	CHP system specs
Displaced Thermal Efficiency, %	80.0%	Displaced onsite thermal (boiler, heater, etc) efficiency
Thermal Utilization, %	100.0%	Amount of available thermal captured and used - typically 80 to 100%

CHP Qualification Screening Example, Continued

Annual Energy Consumption	Base Case	CHP Case
Purchased Electricty, kWh	88,250,160	5,534,150
Generated Electricity, kWh	0	82,716,010
On-site Thermal, MMBtu	426,000	18,872
CHP Thermal, MMBtu	0	407,128
Boiler Fuel, MMBtu	532,500	23,590
CHP Fuel, MMBtu	0	969,845
Total Fuel, MMBtu	532,500	993,435
Annual Operating Costs		
Purchased Electricity, $	$7,060,013	$1,104,460
On-site Thermal Fuel, $	$3,195,000	$141,539
CHP Fuel, $	$0	$5,819,071
Incremental O&M, $	$0	$744,444
Total Operating Costs, $	$10,255,013	$7,809,514
Simple Payback		
Annual Operating Savings, $		$2,445,499
Total Installed Costs, $/kW		$1,400
Total Installed Costs, $/k		$14,221,861
Simple Payback, Years		**5.8**
Operating Costs to Generate		
Fuel Costs, $/kWh		$0.070
Thermal Credit, $/kWh		($0.037)
Incremental O&M, $/kWh		$0.009
Total Operating Costs to Generate, $/kWh		**$0.042**

District Energy Screening Tool Parameters

Operating Expense	Capital Expense	Economic Considerations

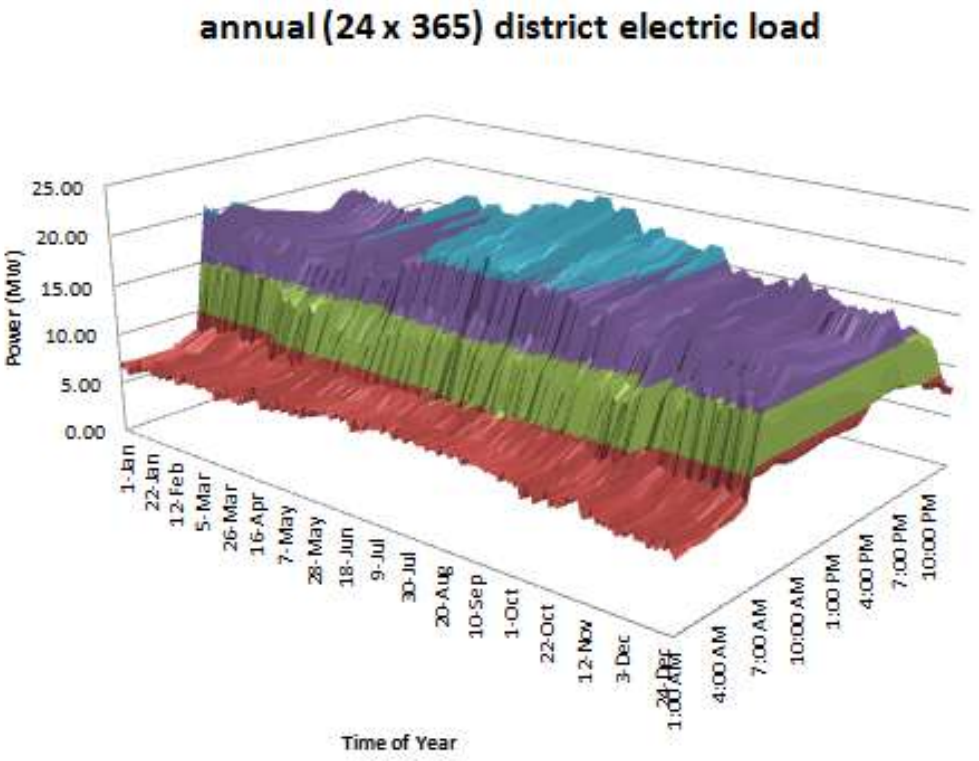
• Energy Costs
• Labor Costs
• Maintenance Costs (LTSA)
• Consumables
	• Unit Cost estimates by system type
	  • Boilers
	  • Chillers
	  • Electric gear
	  • CHP equipment
	  • Distribution Piping
	  • Building SF Costs
	• Debt Service
		• Discount Rate
		• Escalation Rates
		  • Electricity
		  • Natural Gas
		  • General Inflation
		• Loan Terms

IDEA District Energy/CHP Screening Tool

- Excel Spreadsheet
- Inputs
  - Primary
  - Secondary
  - CHP
  - Phasing
- Derive composite energy load profiles
- Calculate annual operating costs of alternatives
- Develop cash flow projections, compute NPV of alternatives
- Estimate MTCO2eq of alternatives

District Energy / CHP Screening Tool

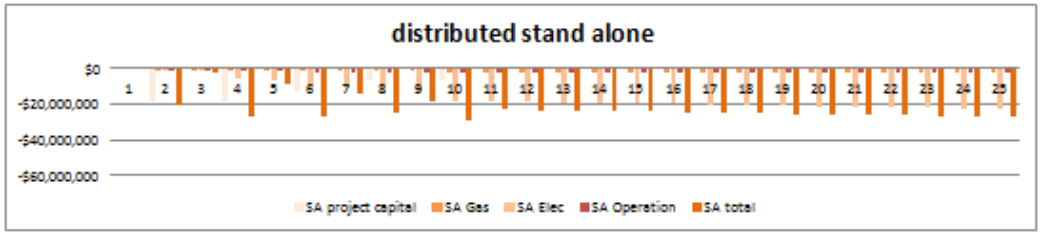
Occupancy Type	*input values here*	*input values here*	
	SF	# Bldg	
Large Office	1,000,000	*3*	
Medium Office	1,500,000	*10*	
Small Office	300,000	*20*	
Warehouse	-	-	
Stand Alone Retail	500,000	*4*	
Strip Mall	-	-	
Primary School	-	-	
Secondary School	-	-	
Supermarket	-	-	
Quick Service Restaurant	30,000	*4*	
Full Service Restaurant	30,000	*4*	
Hospital	1,200,000	*1*	
Outpatient Health Clinic	-	-	
Small Hotel	250,000	*2*	
Large Hotel	500,000	*1*	
Midrise Apt	1,000,000	*10*	
Total	*6,310,000*	*59*	

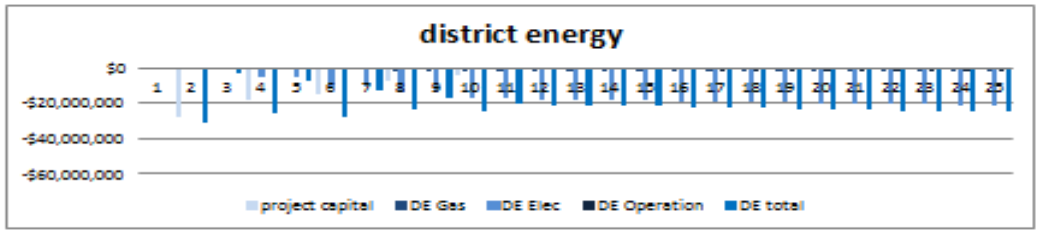


District Energy / CHP Screening Tool

Stand Alone

year	total	%	Plant	SA project capital	SA Gas	SA Elec	SA Operation	SA total
1	0%	0%		$ -	$ -	$ -	$ -	$ -
2	30%	30%		$ (18,048,560)	$ (186,040)	$ (1,451,284)	$ (708,000)	$ (20,393,884)
3	30%	30%		$ -	$ (186,970)	$ (1,473,054)	$ (708,000)	$ (2,368,023)
4	60%	60%		$ (18,411,336)	$ (751,619)	$ (5,980,597)	$ (1,416,000)	$ (26,559,553)
5	60%	60%		$ -	$ (755,377)	$ (6,070,306)	$ (1,416,000)	$ (8,241,684)
6	80%	80%		$ (12,520,936)	$ (1,349,607)	$ (10,953,531)	$ (1,888,000)	$ (26,712,074)
7	80%	80%		$ -	$ (1,356,355)	$ (11,117,834)	$ (1,888,000)	$ (14,362,189)
8	90%	90%		$ (6,386,303)	$ (1,725,220)	$ (14,282,073)	$ (2,124,000)	$ (24,517,597)
9	90%	90%		$ -	$ (1,733,846)	$ (14,496,304)	$ (2,124,000)	$ (18,354,151)
10	100%	100%		$ (6,514,668)	$ (2,151,254)	$ (18,165,122)	$ (2,360,000)	$ (29,191,044)
11	100%	100%		$ -	$ (2,162,010)	$ (18,437,599)	$ (2,360,000)	$ (22,959,609)
12	100%	100%		$ -	$ (2,172,820)	$ (18,714,163)	$ (2,360,000)	$ (23,246,983)
13	100%	100%		$ -	$ (2,183,684)	$ (18,994,876)	$ (2,360,000)	$ (23,538,560)
14	100%	100%		$ -	$ (2,194,603)	$ (19,279,799)	$ (2,360,000)	$ (23,834,401)
15	100%	100%		$ -	$ (2,205,576)	$ (19,568,996)	$ (2,360,000)	$ (24,134,571)
16	100%	100%		$ -	$ (2,216,604)	$ (19,862,531)	$ (2,360,000)	$ (24,439,134)
17	100%	100%		$ -	$ (2,227,687)	$ (20,160,469)	$ (2,360,000)	$ (24,748,155)
18	100%	100%		$ -	$ (2,238,825)	$ (20,462,876)	$ (2,360,000)	$ (25,061,701)
19	100%	100%		$ -	$ (2,250,019)	$ (20,769,819)	$ (2,360,000)	$ (25,379,838)
20	100%	100%		$ -	$ (2,261,269)	$ (21,081,366)	$ (2,360,000)	$ (25,702,635)
21	100%	100%		$ -	$ (2,272,576)	$ (21,397,586)	$ (2,360,000)	$ (26,030,162)
22	100%	100%		$ -	$ (2,283,938)	$ (21,718,550)	$ (2,360,000)	$ (26,362,489)
23	100%	100%		$ -	$ (2,295,358)	$ (22,044,329)	$ (2,360,000)	$ (26,699,687)
24	100%	100%		$ -	$ (2,306,835)	$ (22,374,993)	$ (2,360,000)	$ (27,041,828)
25	100%	100%		$ -	$ (2,318,369)	$ (22,710,618)	$ (2,360,000)	$ (27,388,987)
				$ (61,881,804)	$ (43,786,461)	$ (391,568,675)	$ (50,032,000)	
remaining principal owed								$ *(8,243,62)*
system and equipment value								$ *(3,509,282)*
				$ (61,881,804)				$ (547,268,941)
				$ (9.81)			NPV	($283,495,551)





Feasibility Analysis

A DOE CHP TAP Feasibility Analysis Usually Involves

- **Baseline Energy Analysis**
  - Electrical load profiling
  - Thermal load profiling
- **CHP Equipment Selection and Sizing**
  - Matching technology to thermal needs, size, fuel availability, and unique requirements (duct firing, thermal, reliability considerations)
- **Analysis Assumptions**
  - Energy Costs – electric rates and fuel prices
  - CHP System Costs – installed equipment costs, O&M, interconnection

Feasibility Considerations, Continued

- **Feasibility Analysis**
  - Facility Energy Profiles on baseline and CHP Options
  - Economic Analysis – operating savings, simple payback
  - Sensitivity Analysis
  - Emissions Analysis
- **Recommended Next Steps**

Investment Grade Analysis

- Generally involves contracting with a design engineering firm
- Results in design specs that can become part of an RFP
- Consider best technologies
- May include a utility required "interconnect study"
- Consider balance-of-plant items such as piping, stack breaching, platforms, electrical switchgear, steam piping, pumps, etc.

Procurement, Operations & Maintenance

- Project financing
- Permits – number and complexity vary
- Emissions – site vs. source considerations
- Interconnection – varies from state to state
- Project Construction
- Operations and Maintenance: in-house, contractors, or both

Next Steps

Contact us to see if your facility is a good CHP candidate.

- Colleges & Universities
- Institutional campuses
- Commercial complexes
- Military installations
- Hospitals

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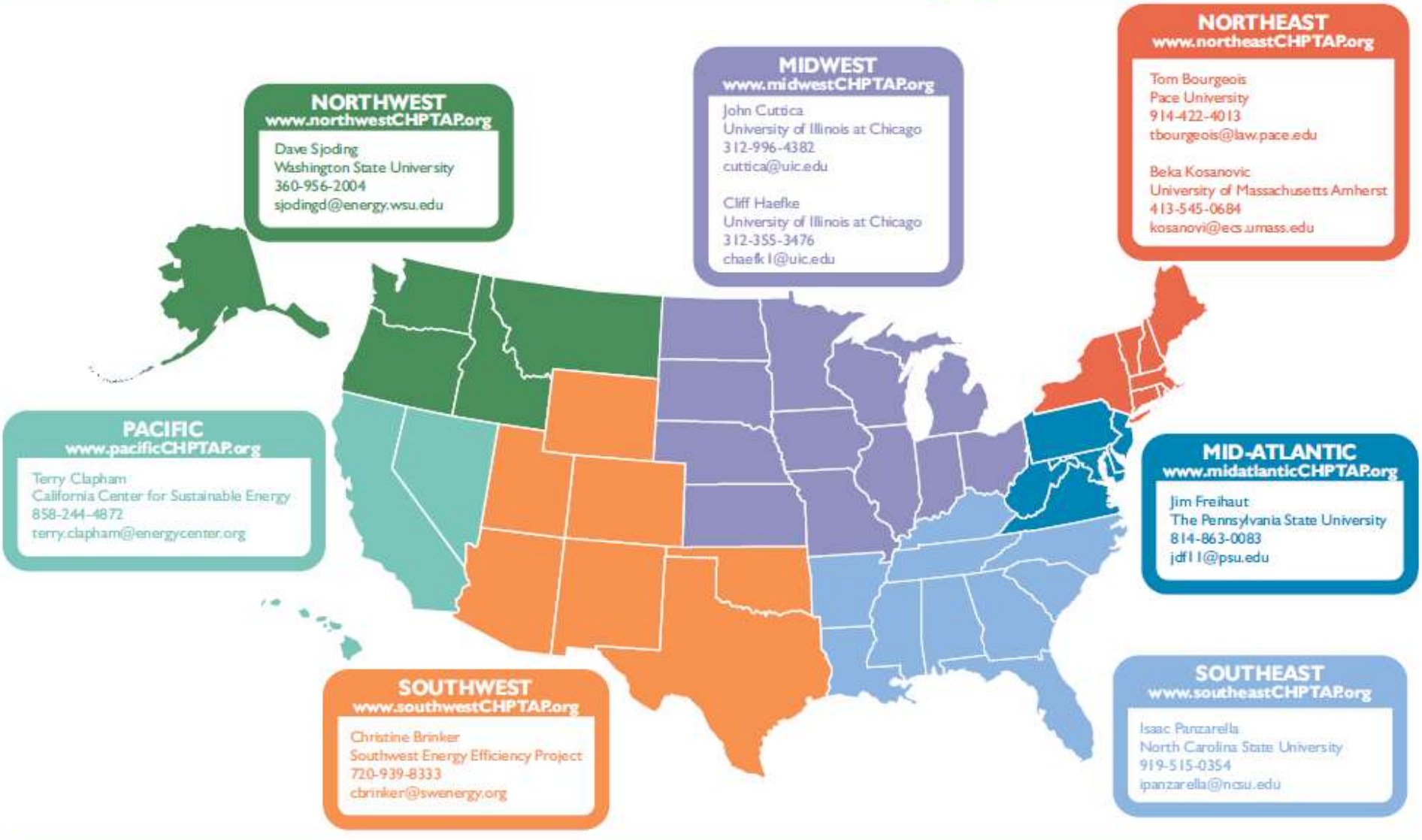

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