Combined Heat and Power (CHP) and Higher Education

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Henry Johnstone, an IDEA Subcontractor
May 4, 2016

Webinar Instructions

- The webinar will **start promptly at 1:00 pm EDT (Boston time) and is scheduled to last one (1) hour.**
- Please **mute your phone** during the webinar. All lines are muted.
- If you are having problems with video or audio, please send a note via the Chat Box function on the right side. Click the Chat box and choose – **"Chat privately to Cheryl Jacques (host)". Or call to IDEA at 508-366-9339.**
- **Questions to Presenters**: Please enter your **Questions** in the **Q&A** box at the lower right of the screen. These questions will be moderated and addressed as time allows. We plan to handle Q&A at the conclusion of the presentation.
- **Survey**: Please complete the brief on-line survey following the webinar.
- **Webinar Download or Streaming**: Webinar will be recorded and will be made available via download or streaming. Slides will be made available in pdf format. Please visit **www.southwestchptap.org** or **www.districtenergy.org.**

Webinar Leaders

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Questions ?

- **Please type your question in the Q&A box on the lower right hand side of the webinar page.**

- **We will try to address as many questions as time allows; based on submittal sequence and relevance.**

- **Additional questions can be sent to gdillingham@harcresearch.org**

CHP Technical Assistance Partnerships

- ## 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.

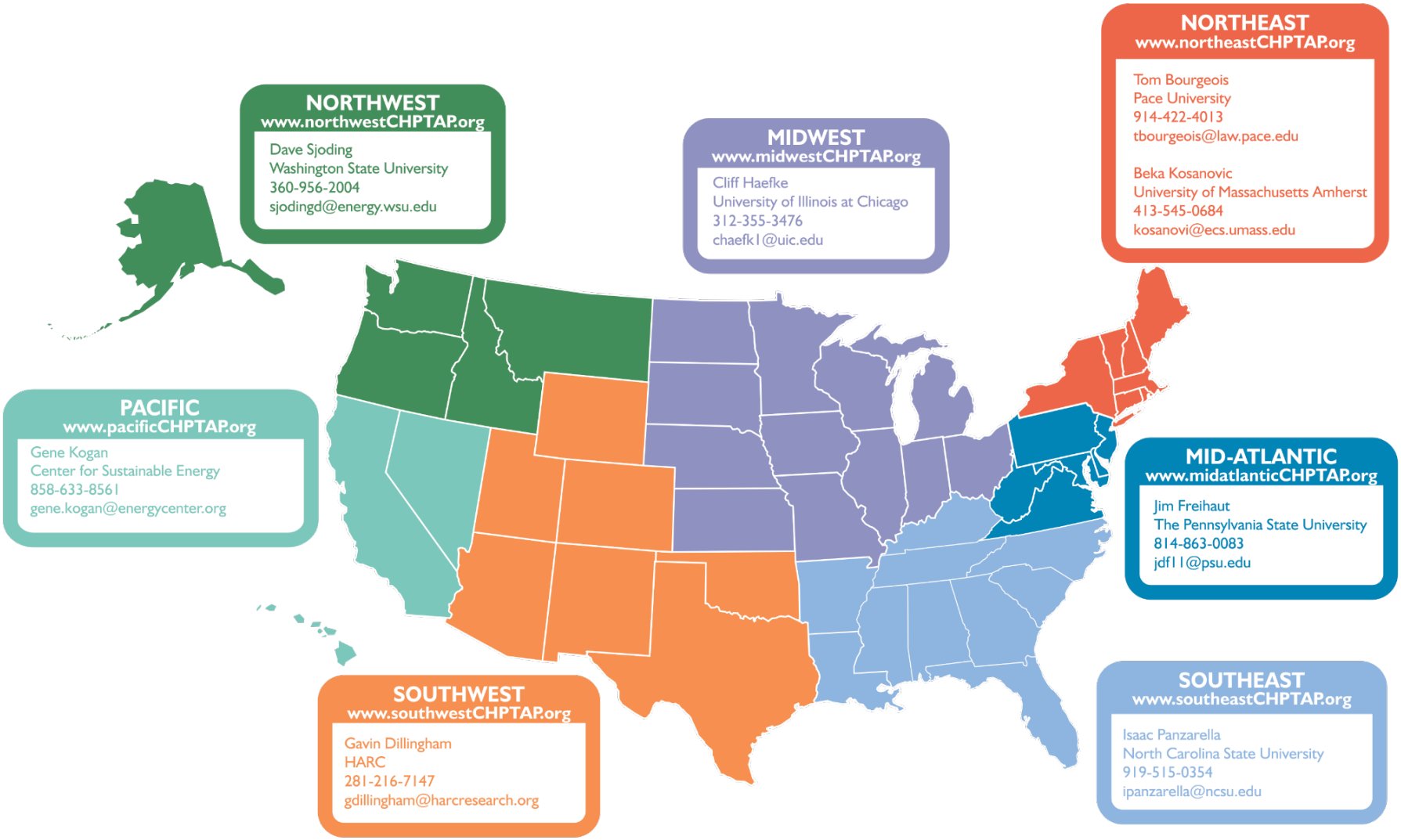
- ## Technical Assistance

  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.

- ## Market Opportunity Analysis

  Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors

DOE CHP Technical Assistance Partnerships (CHP TAPs)



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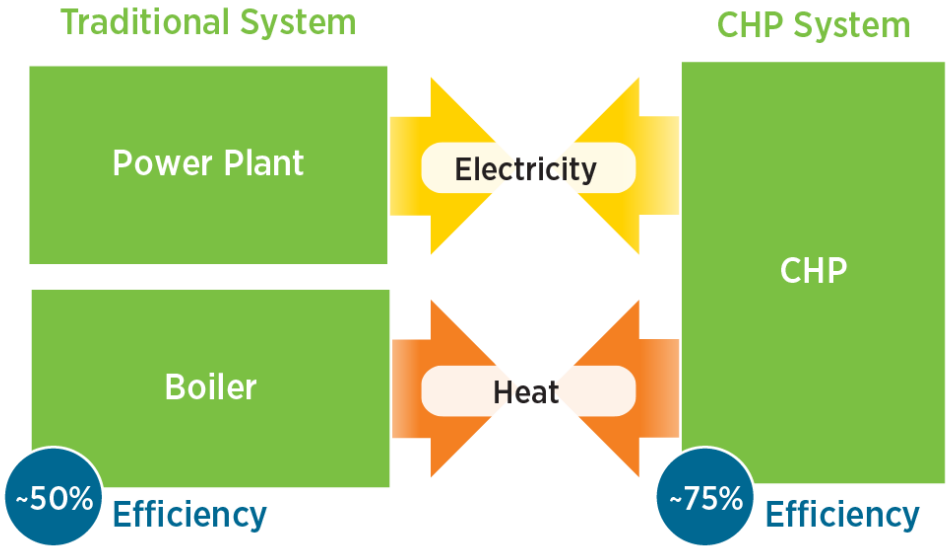
Outline

- CHP Overview
- CHP in Higher Education
- CHP Project Resources from the DOE SW CHP TAP
- Q&A

CHP Overview

CHP: A Key Part of Our Energy Future

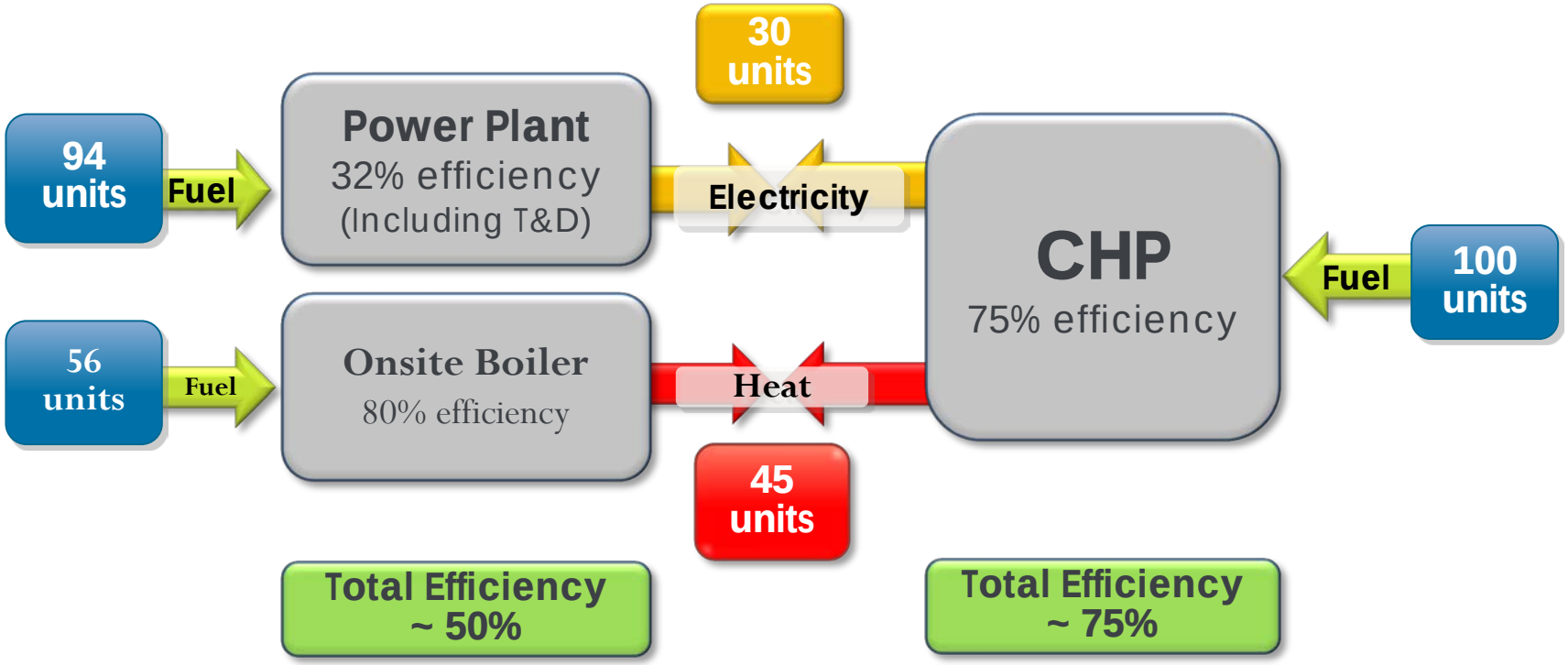
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



CHP provides efficient, clean, reliable, affordable energy – today and for the future.

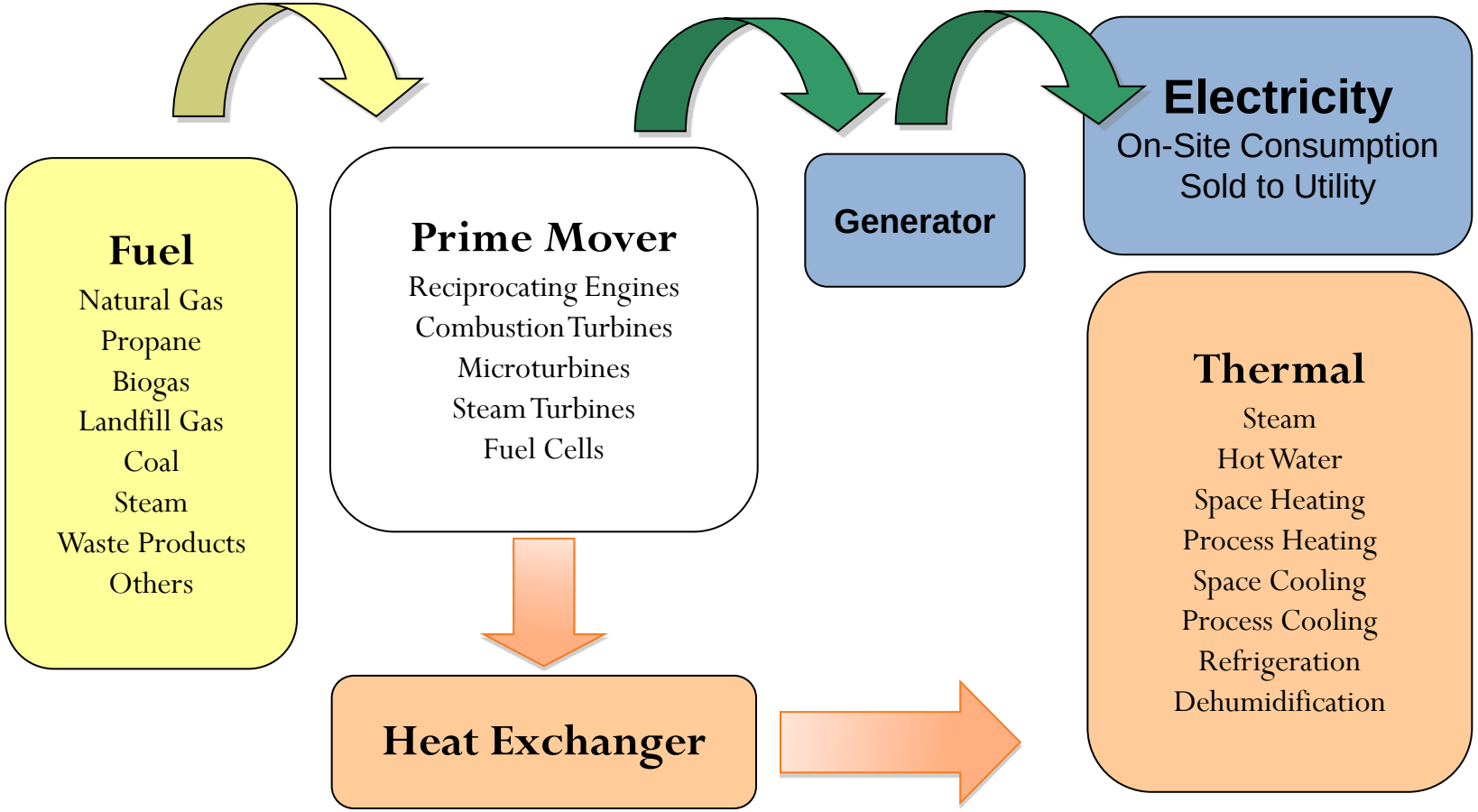
Source: www.energy.gov/chp

CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing GHGs



30 to 55% less greenhouse gas emissions

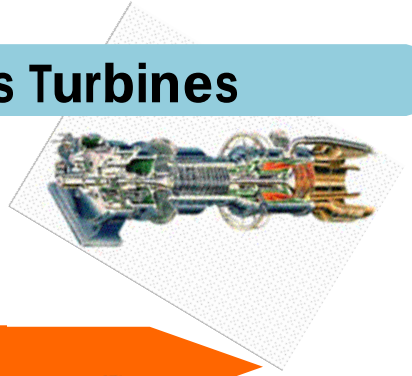
CHP System Schematic



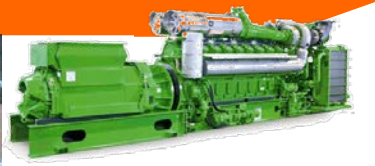
Common CHP Technologies

Microturbines

Gas Turbines



Reciprocating Engines



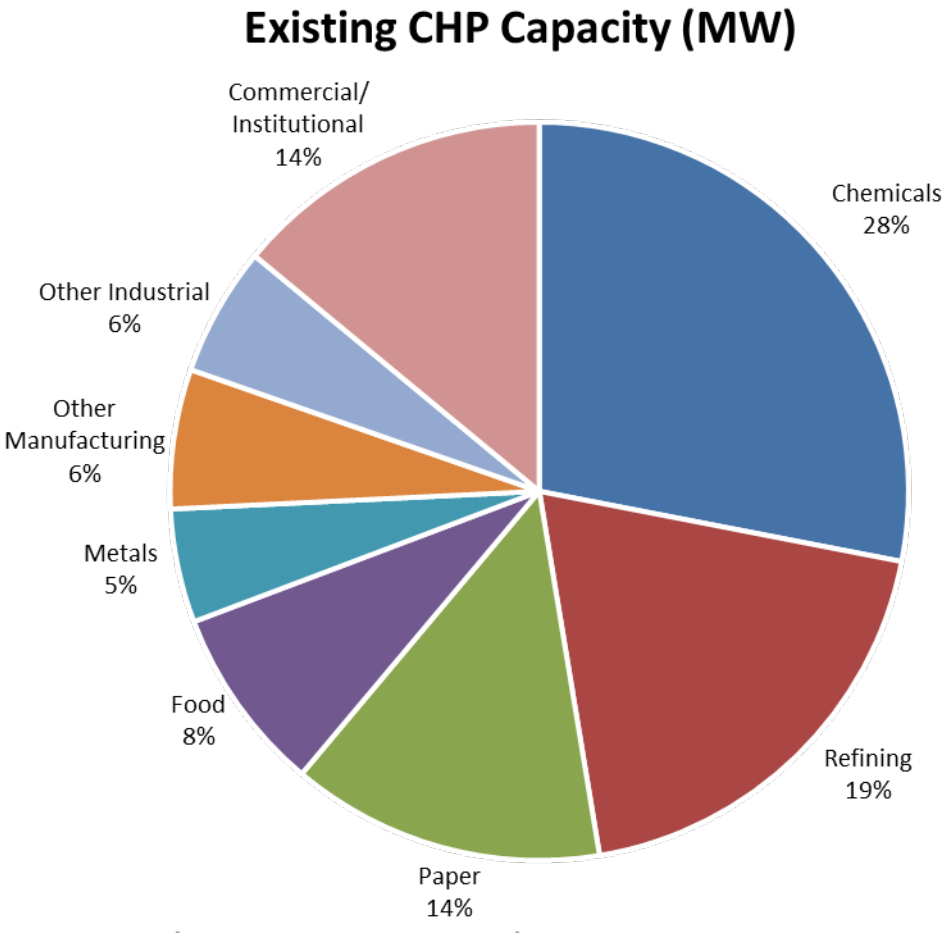
Fuel Cells

50 kW | 100 kW | 1 MW | 10 MW | 20 MW

What Are the Benefits of CHP?

- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs** (but requires capital investment)
- Higher efficiency **reduces emissions** of pollutants
- CHP can also increase **energy reliability** and enhance power quality

CHP Today in the United States



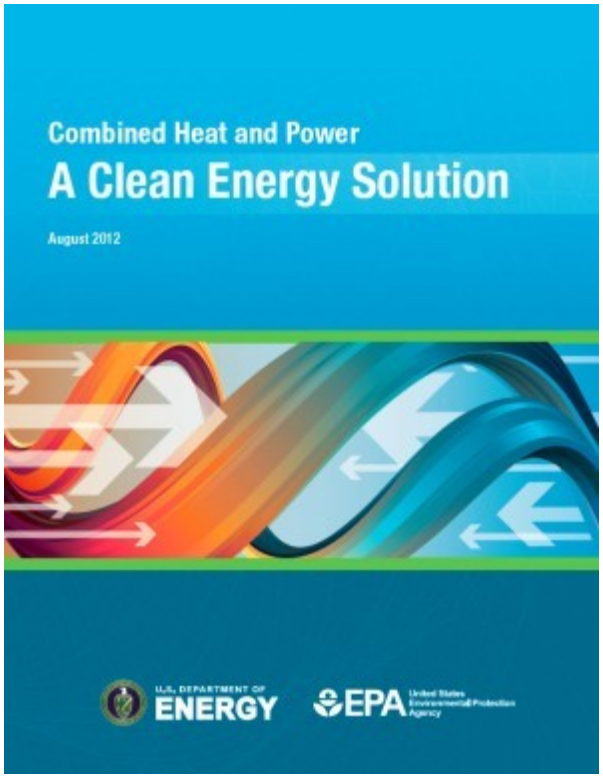
Source: DOE CHP Installation Database (U.S. installations as of December 31, 2014)

- **82.7 GW** of installed CHP at over 4,400 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO_2** compared to separate production

Emerging National Drivers for CHP

- Benefits of CHP recognized by policymakers
  - President Obama signed an Executive Order to accelerate investments in industrial EE and CHP on 8/30/12 that sets national goal of 40 GW of new CHP installation over the next decade
  - State Portfolio Standards (RPS, EEPS), Tax Incentives, Grants, standby rates, etc.
- Favorable outlook for natural gas supply and price in North America
- Opportunities created by environmental drivers
- Utilities finding economic value
- Energy resiliency and critical infrastructure

DOE / EPA CHP Report (8/2012)



http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf

Finding the Best Candidates:
Some or All of These Characteristics

- High and constant thermal load
- Favorable spark spread
- Need for high reliability
- Concern over future electricity prices
- Interest in reducing environmental impact
- Existing central plant
- Planned facility expansion or new construction; or equipment replacement within the next 3-5 years

Energy & Sustainability Trends in Higher Education

Energy efficiency and sustainability is moving well beyond the LEED building to systems and institution-wide strategies, driven by both environmental and financial stewardship.

- Campuses approach energy efficiency and sustainability planning holistically
- New tone to energy efficiency and sustainability conversations: it's no longer to do the right thing or to be a leader, it's institutional survival; resource consumption on campus, reduction of energy costs, etc.
- Greater focus on energy efficiency and sustainability as part of financial sustainability
- On the campus level, there's a gathering storm to move off the grid and aim toward zero impact
- Building efficiency and energy management are emerging as the key sustainability initiatives

Sources: "Report on Trends in Higher Education Planning 2014", SCUP Academy Council
http://www.scup.org/asset/75087/ReportOnTrendsInHigherEducationPlanning2014

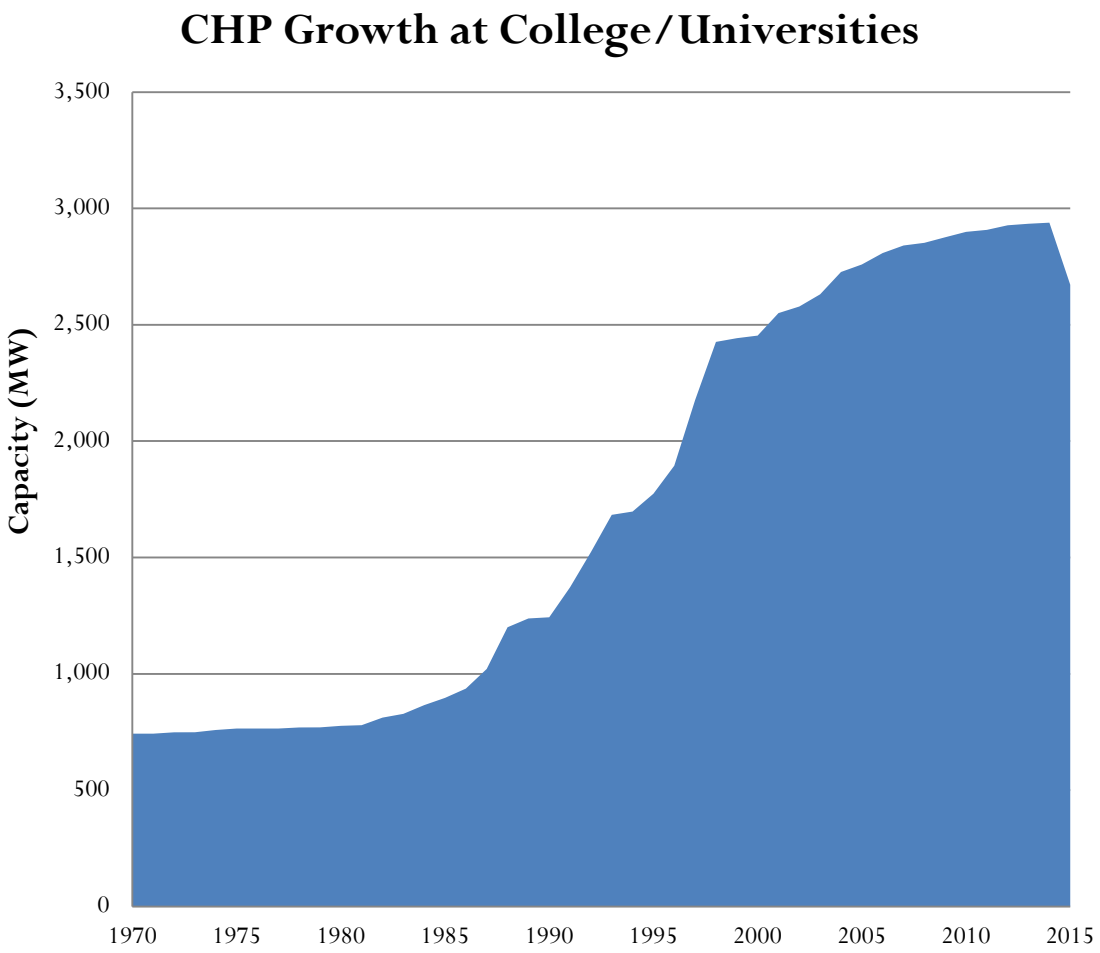
Resilient University Microgrids in Superstorm Sandy

- **The College of New Jersey (NJ) – 5.2 MW CHP**
  - "Combined heat and power allowed our central plant to operate in island mode without compromising our power supply." - *Lori Winyard, Director, Energy and Central Facilities at TCNJ*
- **Fairfield, University (CT) – 4.6 MW CHP**
  - 98% of the Town of Fairfield lost power, university only lost power for a brief period at the storm's peak
  - University buildings served as area of refuge for off-campus students
- **Stony Brook University (LI, NY) – 45 MW CHP**
  - < 1 hour power interruption to campus of 24,000 students (7,000 residents)
- **NYU Washington Square Campus (NY, NY) – 13.4 MW CHP**
- **Princeton University (NJ) – 15 MW CHP**
  - CHP/district energy plant supplies all heat and hot water and half of the electricity to campus of 12,000 students/faculty
  - "We designed it so the electrical system for the campus could become its own island in an emergency. It cost more to do that. But I'm sure glad we did." – *Ted Borer, Energy Manager at Princeton University [see Wednesday am Ted Talk]*

http://www.districtenergy.org/26th-annual-campus-energy-conference/

CHP in Higher Education

- 270 colleges and universities have CHP, totaling 2,670 MW of capacity.
- Represents 3.5% of total installed CHP capacity in the U.S. (82.7 GW)
- Further technical potential totaling 13,932 MW of capacity



Source: DOE/ICF CHP Installation Database (as of April 20, 2016) and DOE CHP Technical Potential Study (2016)

CHP Installation Status in U.S. Higher Education

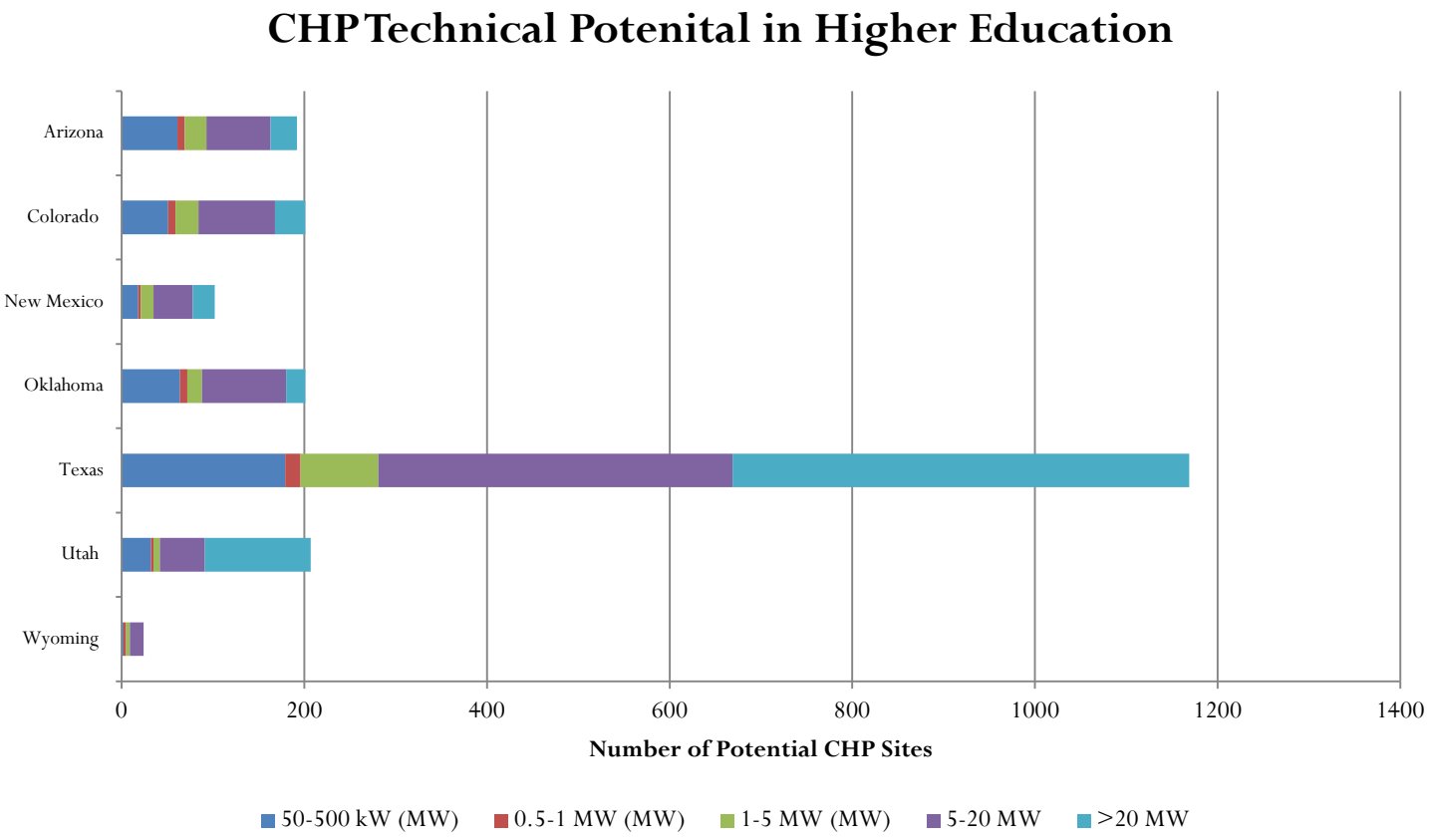
Prime Mover Type in Higher Education

Prime Mover Type	# of CHP Systems	CHP Gen. Capacity (MW)
Combustion Turbine	58	843
Reciprocating Engine	93	162
Boiler/Steam Turbine	58	951
Microturbine	23	5
Fuel Cell	18	8
Combined Cycle	18	701
Total	**264**	**2,670**

Source: U.S. DOE CHP Installation Database https://doe.icfwebservices.com/chpdb/

Where are the Southwest opportunities for CHP in Higher Ed?

(2,052 MW of CHP Potential at 731 Sites)



Source: DOE CHP Technical Potential Study (2016)

Project Snapshot:

University of Texas - Austin

Austin, TX

Application/Industry: University

Capacity (MW): 137 MW

Prime Mover: Combined Cycle Gas Turbine; Steam Turbine

Fuel Type: Natural Gas

Thermal Use: Space heating, cooling and water heating

Installation Year: 1929

Emissions Savings: Reduces CO_2 emissions by 82,000 tons/year

Testimonial: "We've been able to produce twice the amount of energy, for twice the amount of square footage, with the same amount of fuel, for a 10-year period. Everyone could do that— I'm not the only one. These are all proven technologies that you can implement right now." **—Juan Ontiveras, Associate VP, Utilities, Energy & Facilities Management**

Project Snapshot:

Washtenaw Community College

Ann Arbor, MI

Application/Industry: College
Capacity (MW): 130 kW
Prime Mover: Microturbine
Fuel Type: Natural Gas
Thermal Use: Hot Water, Cooling
Installation Year: 2014
Energy Savings: >$60,000/year

Testimonial: The microturbine CHP system at Washtenaw Community College is equipped with a FlexSet control system. The control system is web-based, allowing the facility mangers to monitor the system on computers or cell phones. The system's designer, GEM Energy, also donated an additional microturbine to the school for the training of future energy professionals.

Source: http://www.gemenergy.com/wp-content/uploads/2014/10/CHP-Washtenaw-102814.pdf

Project Snapshot:

Arizona State University

Tempe, AZ

Application/Industry: University

Capacity (MW): 9 MW

Prime Mover: Gas Turbine; Steam Turbine

Fuel Type: Natural Gas

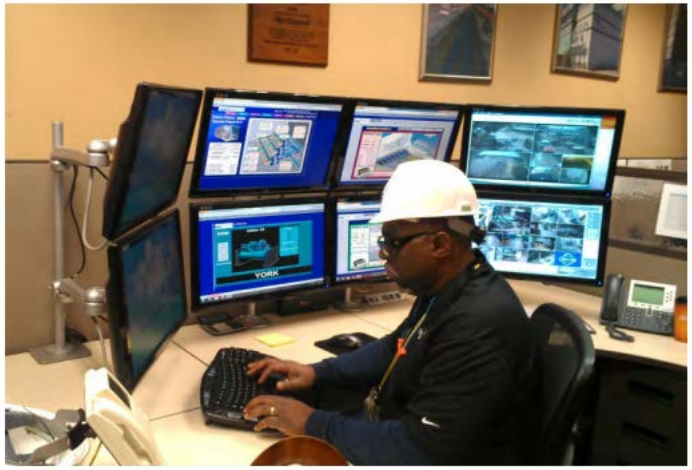
Thermal Use: Steam Distribution across campus heating and humidification

Installation Year: 2006

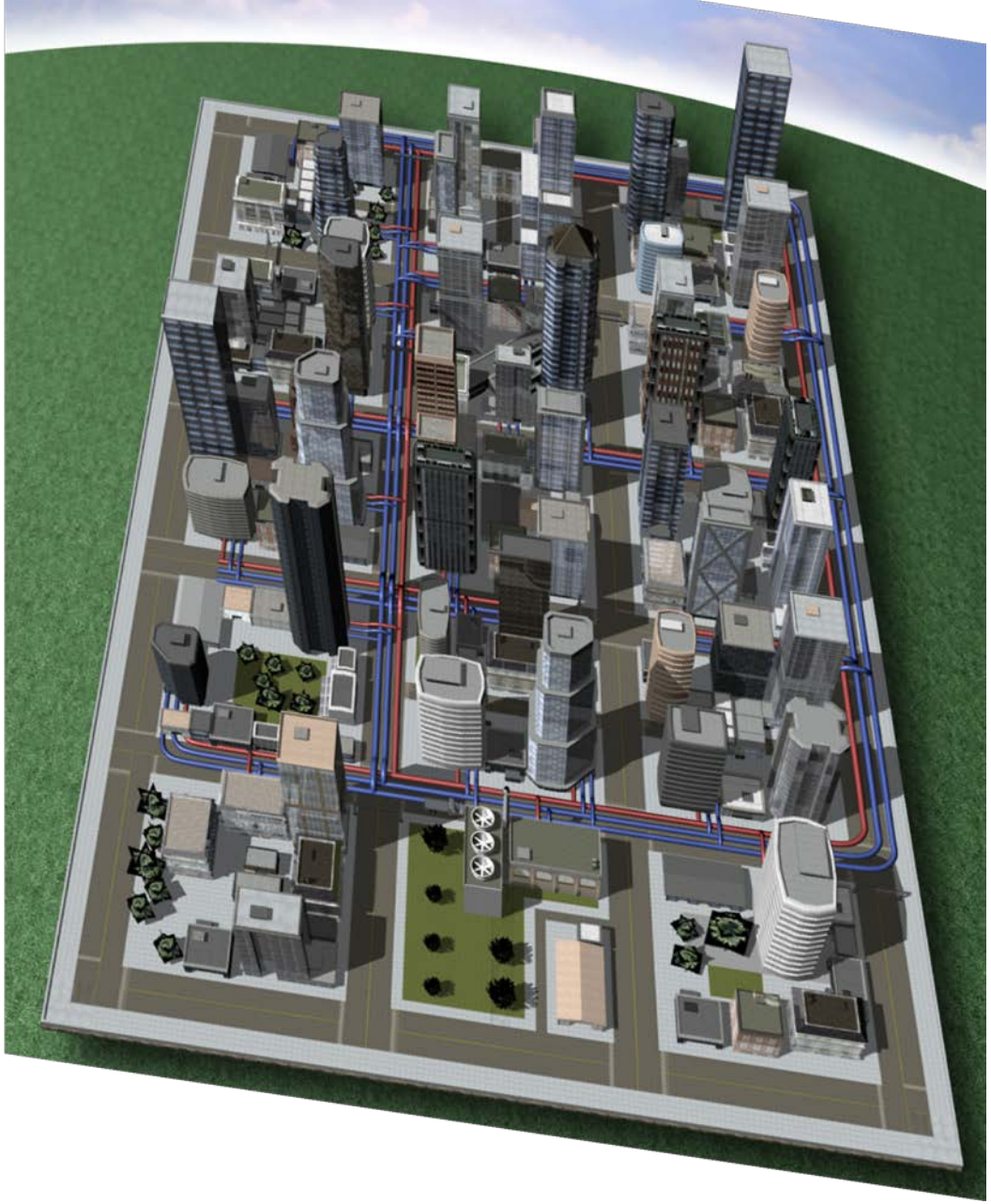
Emissions Savings: Reduces CO_2 emissions by 64,000 tons/year

Testimonial: "CHP is integral to how we operate the campus, and we enjoy the benefits of it: reliable and efficient operation." **— Rick Pretzman, Assistant Facilities Manager, Arizona State University**

CHP is a cornerstone of Arizona State University's sustainability, efficiency, and reliability



Source: https://mysolar.cat.com/cda/files/2111485/7/dschp-ksu.pdf



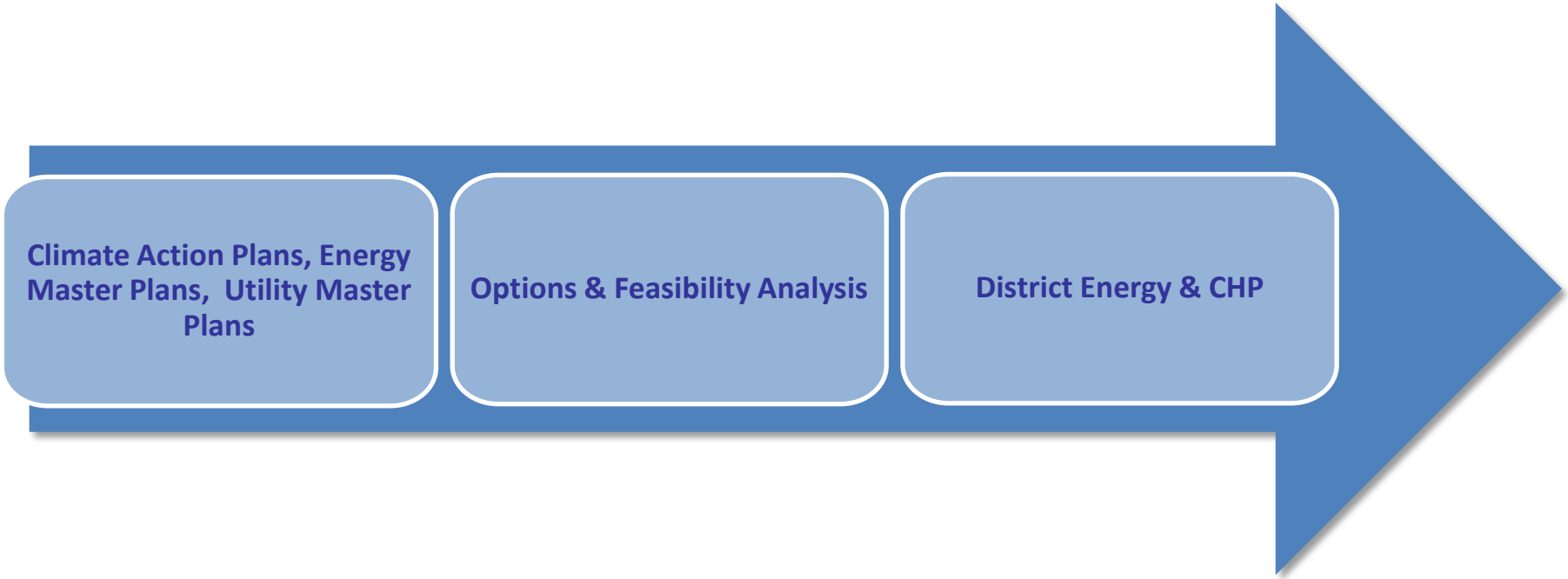
WANTED:
RELIABLE
RESILIENT
CLEAN
ECONOMICAL
ENERGY

CHP for Higher Education
Webinar
May 4, 2016

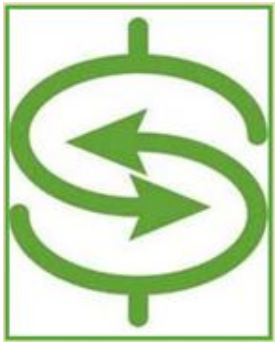
Laxmi Rao
Director

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Energy Planning in Higher Education



- Reliable on-site electrical and thermal energy source
- Ability to supply campus during power interruptions
- Higher efficiency reduces energy consumption, cost and emissions
- Flexibility to generate or purchase power



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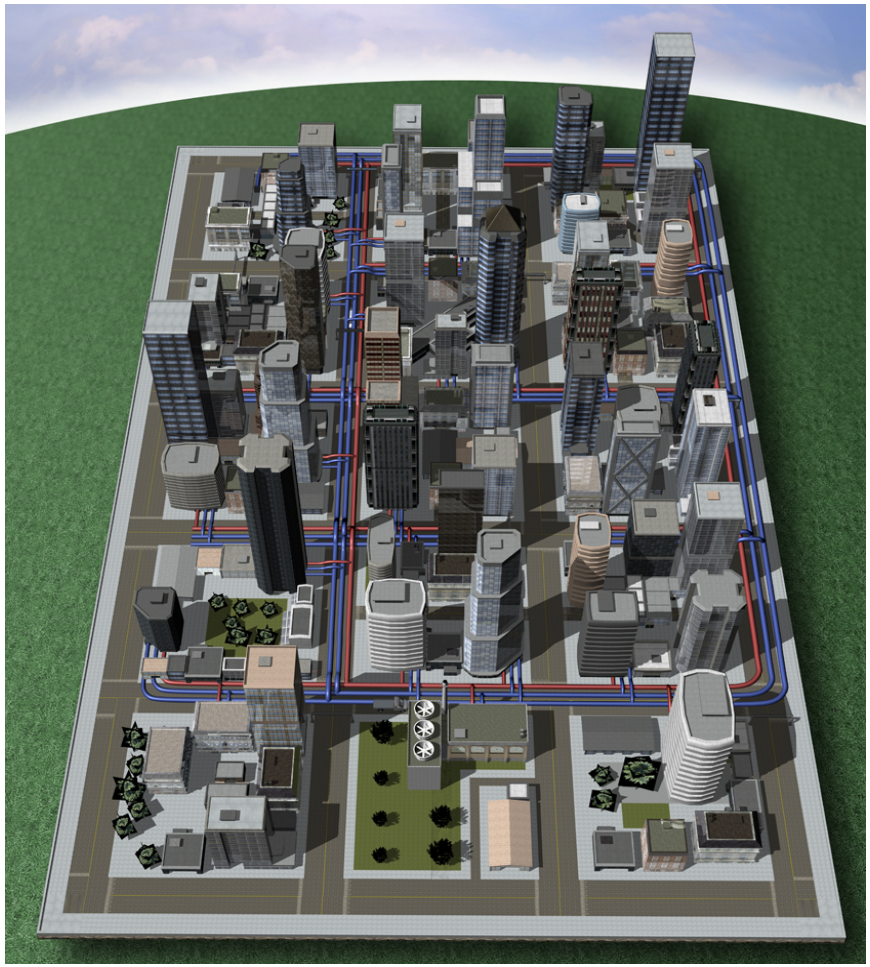
District Energy/CHP
Community Scale Energy Solution

- Underground network of pipes "combines" heating and cooling requirements of multiple buildings
- Creates a "market" for valuable thermal energy
- Aggregated thermal loads create scale to apply fuels and technologies not feasible on single-building basis
- Higher Ed energy demand profiles align well with CHP
- Fuel flexibility & distributed generation improves energy security, strengthens local economy



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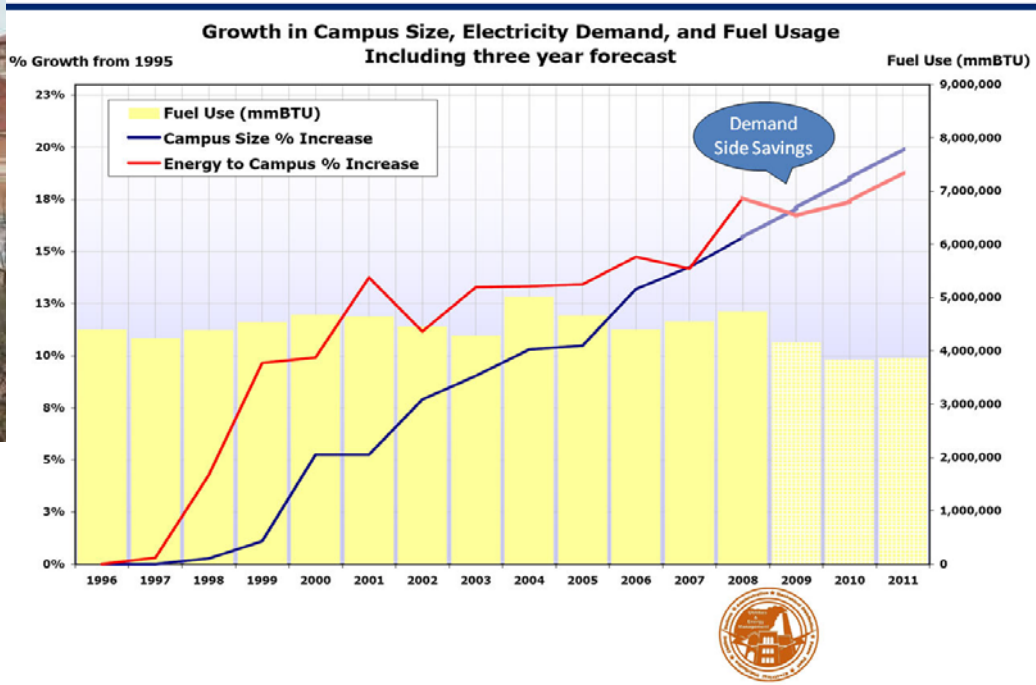
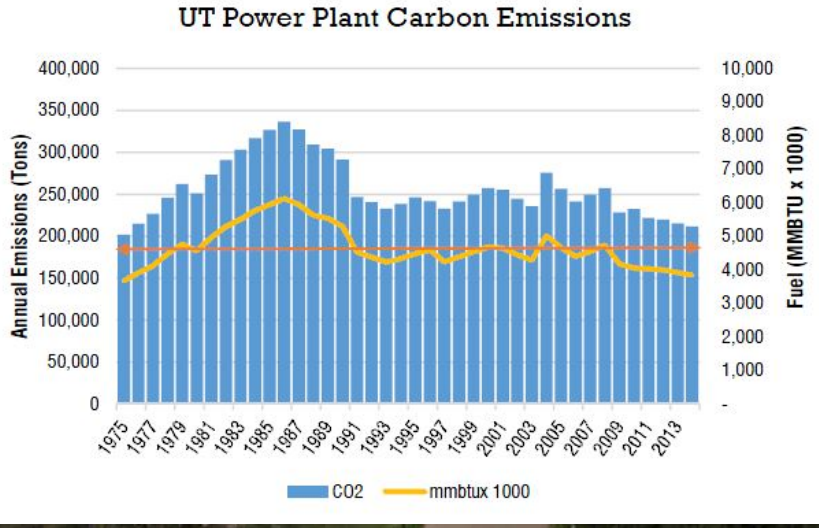
CHP & Fuel Savings
UT Austin

Campus Growth vs. Gas Consumption





Texas A&M
45-MW

- CHP has played a key role in reducing the University's energy consumption by more than 40 % per sq. foot over the last 10 years, resulting in nearly $150 million in savings.
- Fuel savings prevent an estimated 99,600 tons per year of carbon dioxide emissions
- Ability to operate independently from the grid ensures power reliability for university facilities, including numerous research facilities, dormitories, and a veterinary hospital.

"Projected efficiency-related cost avoidance from CHP will offset all debt incurred for the project, and allows the university to maximize institutional funding to support research, teaching , improvement of facilities and other programs "

- James Riley, Texas A&M Executive Director of Utilities & Energy Services

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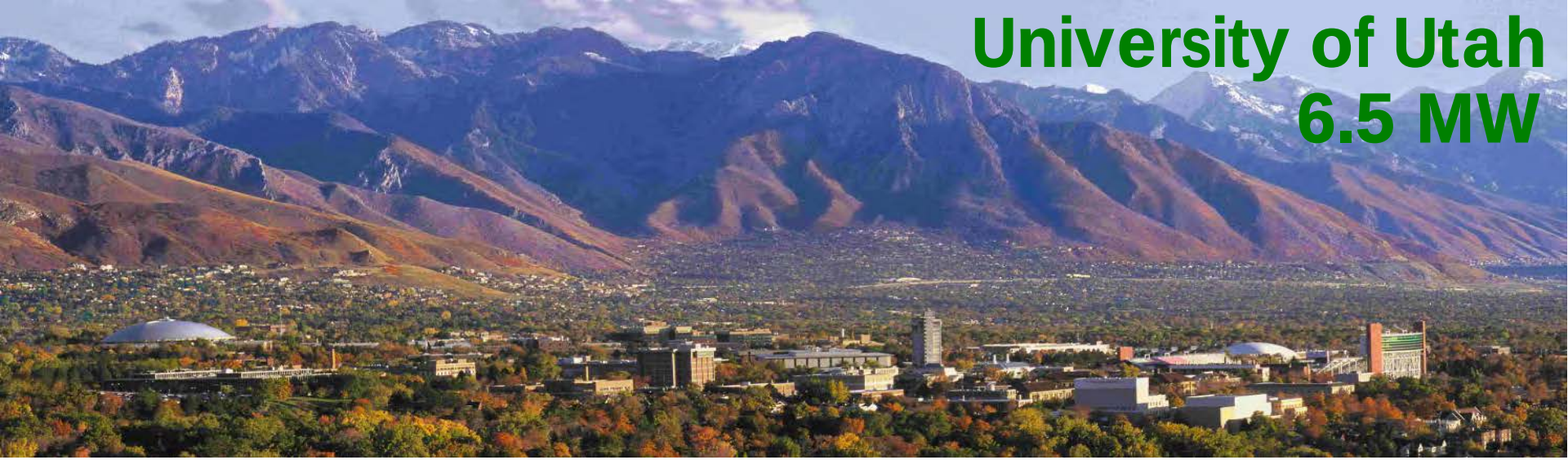

University of Utah
6.5 MW

- 28,000 Students on 1,500 acres
- 100% thermal needs and 10% electric load (lower campus)
- Total Efficiency 90%
- Fuel - Natural Gas
- Equipment- Solar Taurus Gas Turbine, Rentech HRSG
- Cost - $18,000,000
- Annual Energy Savings $735,00
- Simple Payback – 12 years

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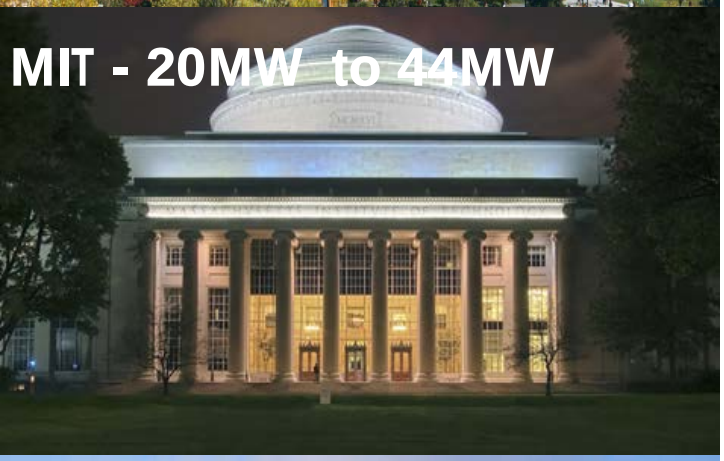

More CHP & District Energy In the Higher Education Sector

CHP in Higher Education

Data and approach to assessing CHP potential

Henry Johnstone

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Reasons a Campus Performs a CHP Evaluation

- Reduce Operating Cost
- Improve Efficiency & Reduce Campus Carbon Footprint
- Prepare for Campus Load Growth
- Address Infrastructure Renewal/Reliability
- Respond to Changes in Utility Purchase Markets

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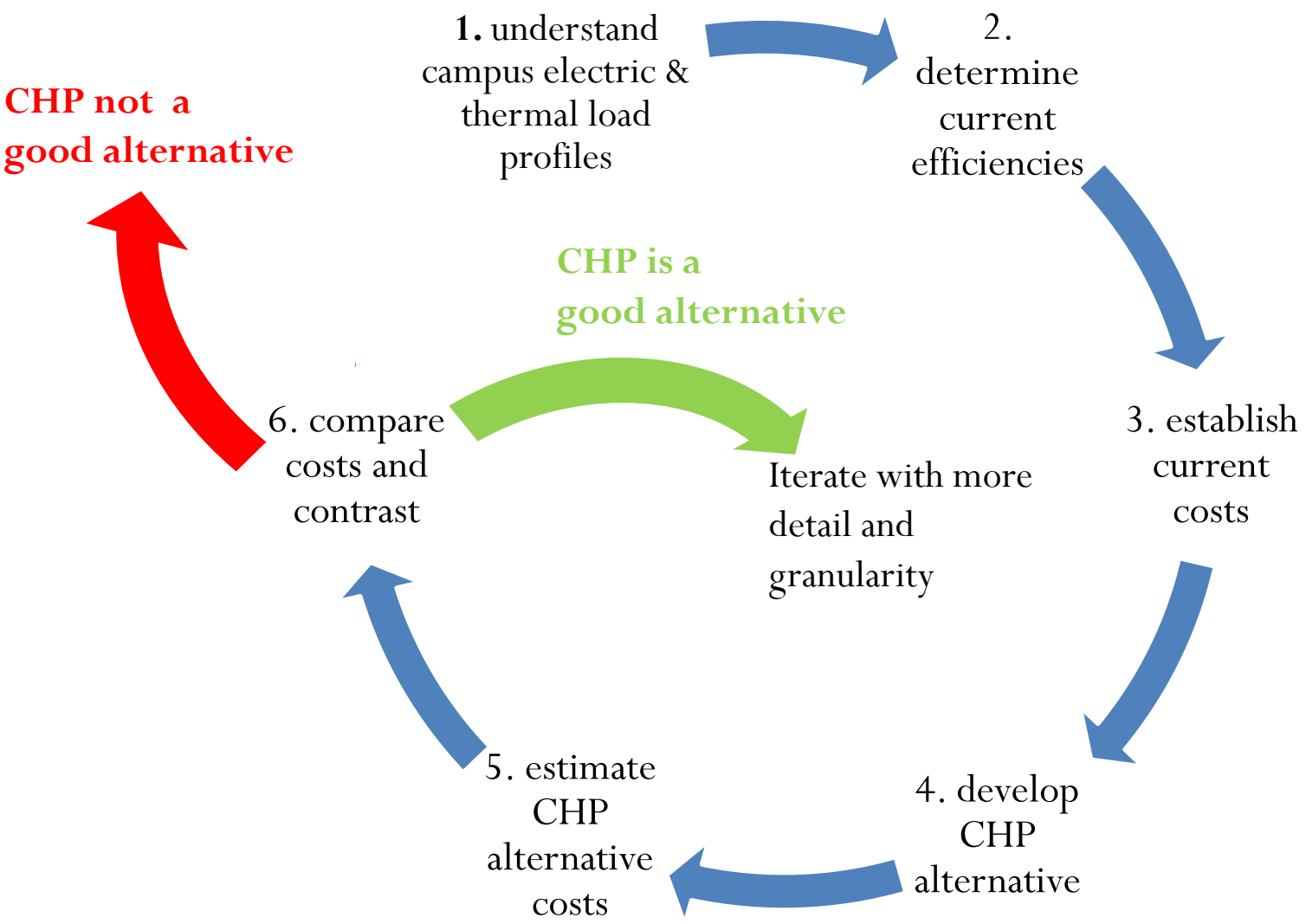
Approach



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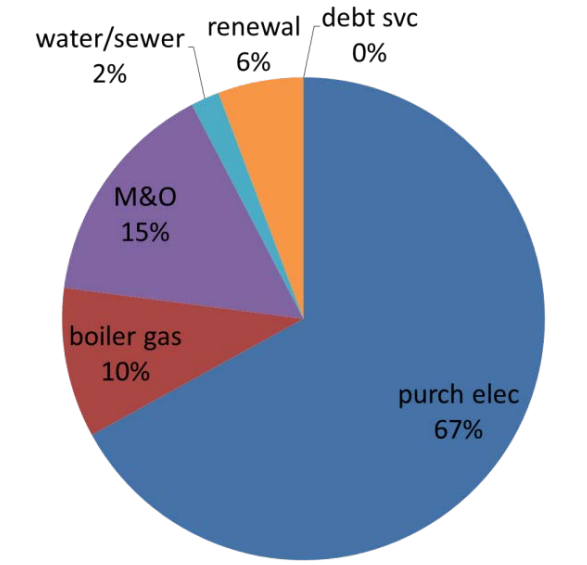
Operating Cost Factors

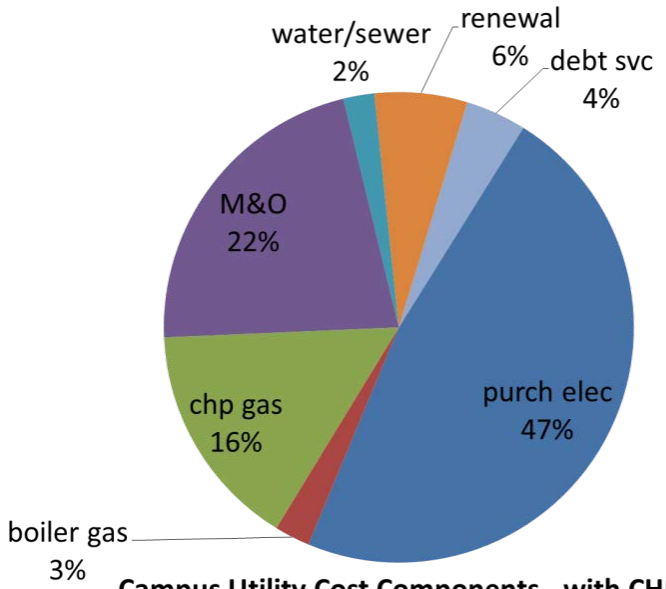
Conventional vs CHP

- Purchased electric
- Boiler Gas
- M&O
- Water/Sewer



Campus Utility Cost Components - Conventional

- Purchased electric
- Boiler Gas + CHP Gas
- M&O
- Water Sewer



Campus Utility Cost Components - with CHP

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Data

Heating and Electric Power Load

- Climate, Elevation
- Size and composition of Campus District:
  - Occupancy and Energy Use Intensity
  - Summer Thermal Demand

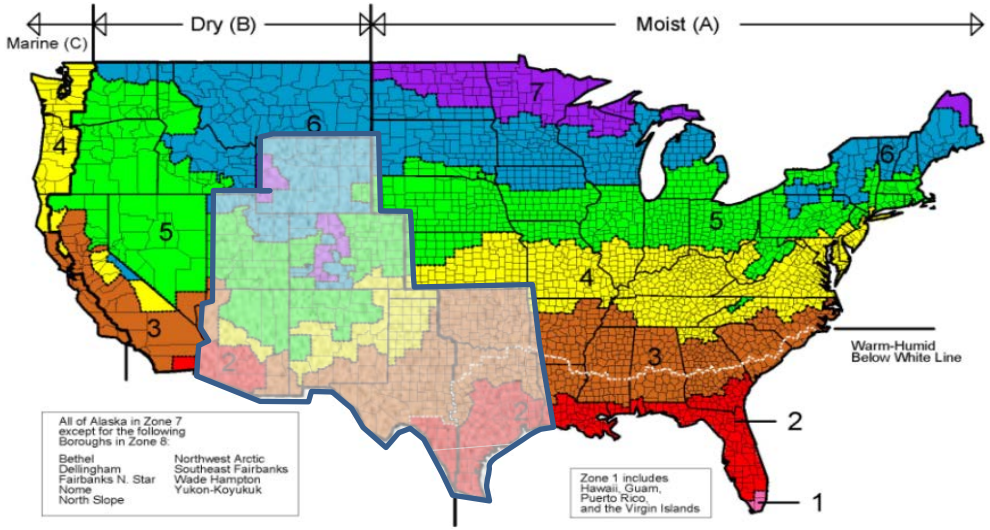
Utility Cost Data

- Billing Data
- Rates and Rate Structures
- Opportunities/ Incentives/ Trends

Time Scales

- Annual KWh, MMBTU
- Monthly (average day)
- Hourly
- Life Cycle Cost

Load Type	GSF	# Bldgs
Classroom/Office	1,250,000	7
Large Lecture Hall	175,000	2
Administrative Office	475,000	3
Library/Learning Center	350,000	1
Theater/Music Hall	300,000	2
Residence Hall	2,250,000	5
Student Activity Center	300,000	2
Teaching Laboratory	750,000	5
Wet Research Laboratory	1,500,000	6
Viviarium	125,000	1
Dry Reseach Laboratory	1,125,000	7
Data Center	100,000	1
Recreation Center	175,000	1
Athletic Venues	750,000	3
Hospital	1,000,000	3
Total	***10,725,000***	**51**



Data

Data Sources

Monthly Electric Billings

Monthly Boiler Gas Billings

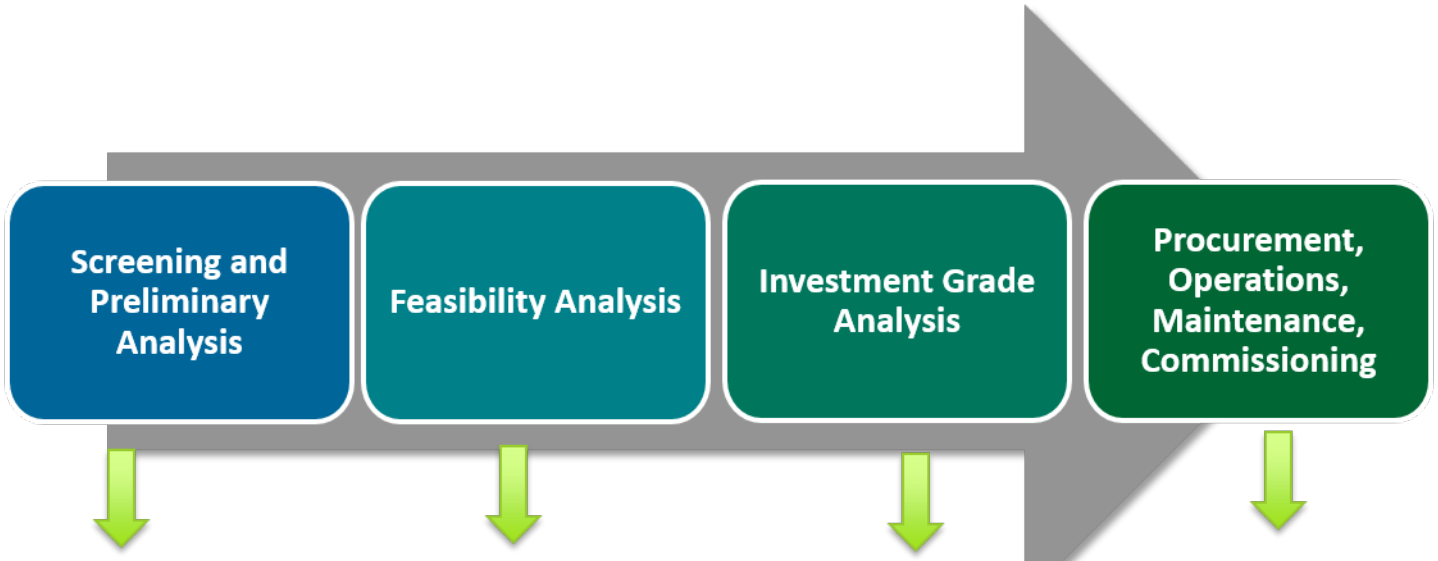
Campus Metering

Energy Modelling Data

How to Implement a CHP Project with the Help of the CHP TAP

Gavin Dillingham

CHP TAP Technical Assistance



US DOE CHP TAP Services:

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 selection.	Review specifications and bids. Limited operational analysis

Screening Questions

- **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.)**

Screening Questions (cont.)

- 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.)

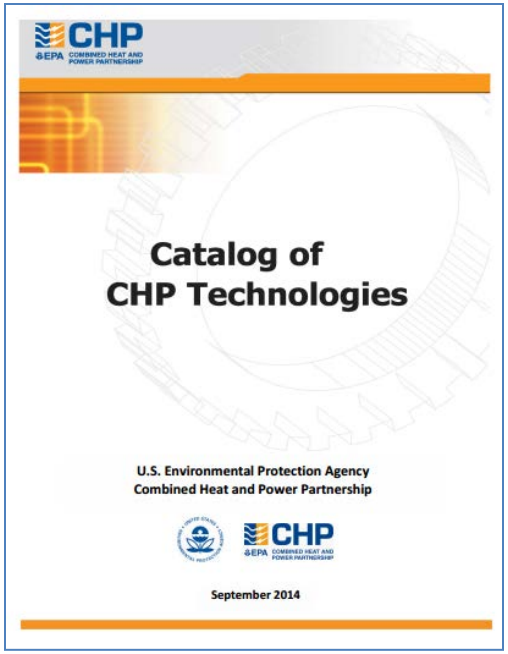
DOE TAP CHP Screening Analysis

- **High level assessment to determine if site shows potential for a CHP project**
  - **Qualitative Analysis**
    - **Energy Consumption & Costs**
    - **Estimated Energy Savings & Payback**
    - **CHP System Sizing**
  - **Quantitative Analysis**
    - **Understanding project drivers**
    - **Understanding site peculiarities**

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
Standby Power, $	$0	$0
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		$12,990,000
Simple Payback, Years		**5.3**
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**

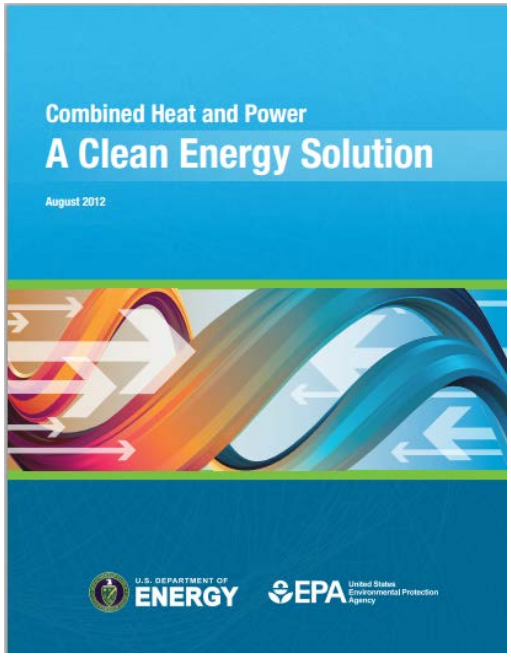
CHP Project Resources

DOE/EPA Catalog of CHP Technologies (updated 2014)



http://www.epa.gov/chp/technologies.html

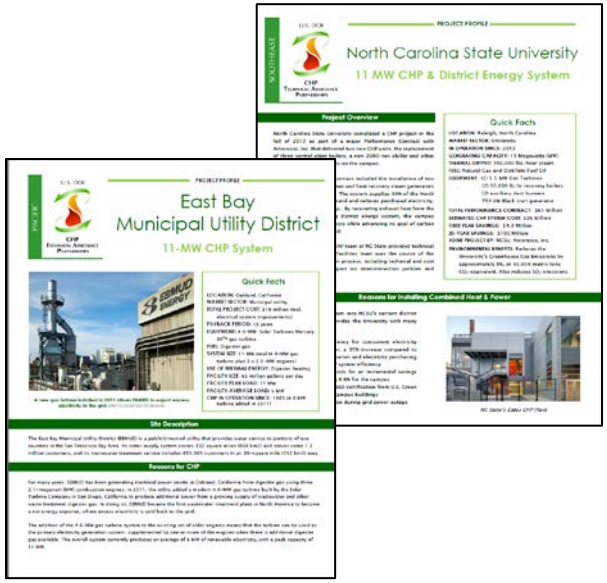
Good Primer Report



www.eere.energy.gov/chp

CHP Project Resources

DOE Project Profile Database (150+ case studies)



www.eere.energy.gov/chp-profiles

DOE Database of Incentives & Policies (DSIRE)

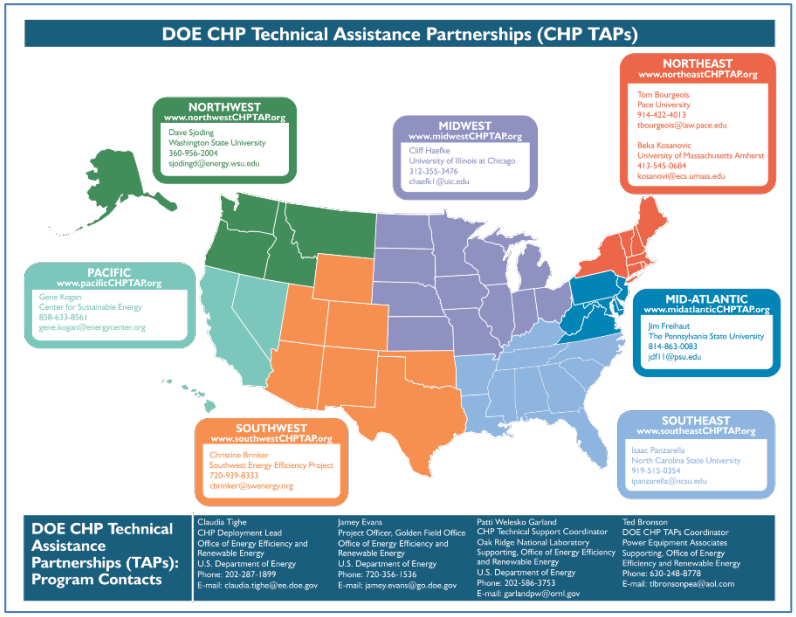
www.dsireusa.org

CHP Project Resources

DOE CHP Installation Database (List of all known CHP systems in U.S.)

www.eere.energy.gov/chp-installs

No-Cost CHP Screening and Other Technical Assistance from the CHP TAP



www.eere.energy.gov/chp-contacts

Next Steps

Resources are available to assist in developing CHP Projects.

Contact the Southwest CHP TAP to:

- Perform CHP Qualification Screening for a particular facility
- Identify existing CHP sites for Project Profiles
- Additional Technical Assistance

Summary

- CHP plays a key role in higher education providing energy savings, reduced emissions, and opportunities for resiliency
- Emerging drivers are creating new opportunities to evaluate CHP and numerous example exist to learn more how higher education has incorporated CHP
- Engage with the US DOE Southwest CHP TAP to learn more about the technical assistance offerings in evaluating CHP in your facility

Thank you for attending.

- Upon completion, you will receive an email. Please complete the survey.
- You will also receive an email with link to the presentation and webinar recording.
- If you have additional questions, please forward to gdillingham@harcresearch.org .
- Slides will be made available in pdf format.

Thank You!

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