Implementing Combined Heat and Power: Resources & Tools Available From the U.S. DOE CHP TAP's

Tom Bourgeois, Co-Director

U.S. DOE Northeast Combined Heat and Power Technical Assistance Partnership (CHP TAP)

Presentation Outline

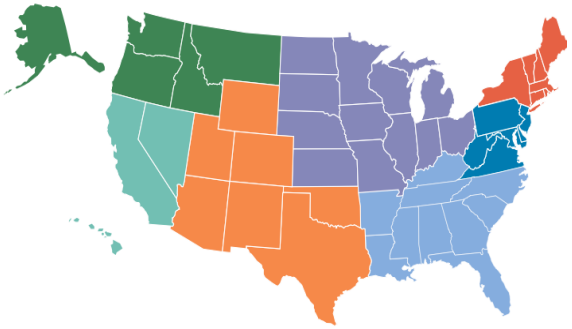
- CHP foundation of a microgrid
- Proven and Tested
- CHP Markets
- Resiliency and sustainability potential
- The US DOE CHP TAP's Tools & Resources
- Accelerator Program
- Summary
- Next Steps

U.S. DOE CHP Deployment Program

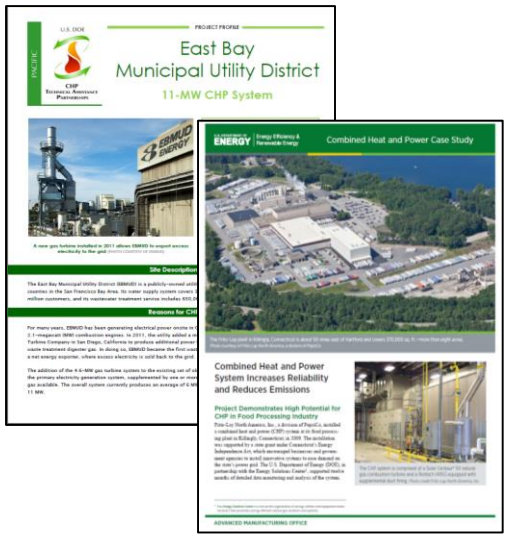
- Market Analysis and Tracking – Supporting analyses of CHP market opportunities in diverse markets including industrial, federal, institutional, and commercial sectors.
- Technical Assistance through DOE's CHP Technical Assistance Partnerships (CHP TAPs) – Promote and assist in transforming the market for CHP, waste heat to power, and district energy with CHP throughout the United States
- Just Launched Combined Heat and Power (CHP) for Resiliency Accelerator -

  Collaborating with Partners to support consideration of CHP and other distributed generation solutions for critical infrastructure resiliency planning at the state, local, and utility levels
- Packaged CHP System Challenge (under development) -

  Increase CHP deployment in underdeveloped markets with standardized, pre-approved and warrantied packaged CHP systems driven by strong end-user engagement via Market Mover Partners, such as cities, states, and utilities



www.energy.gov/chp



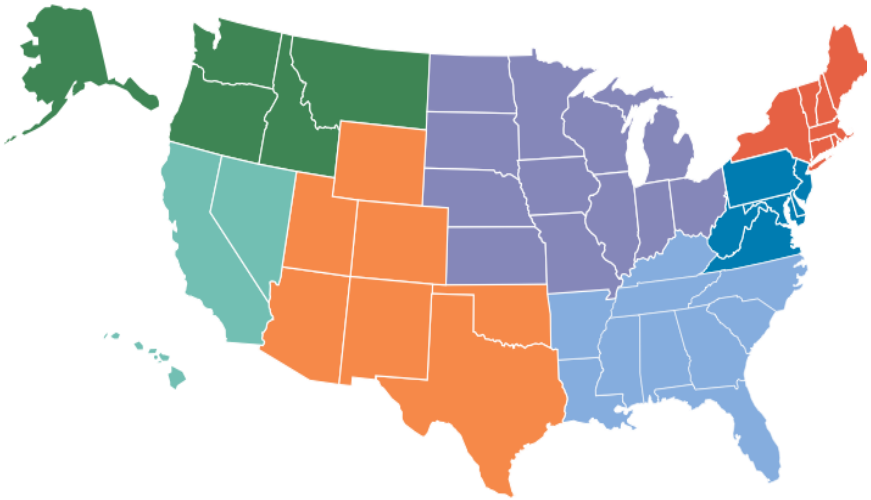
DOE CHP Technical Assistance Partnerships

DOE's CHP TAPs provide local, hands on assistance for the installation of CHP, waste heat to power, and district energy or microgrid with CHP. Key services include:

- Technical Assistance (Top priority!)
  Providing technical assistance to potential CHP host sites from initial CHP screening to installation.

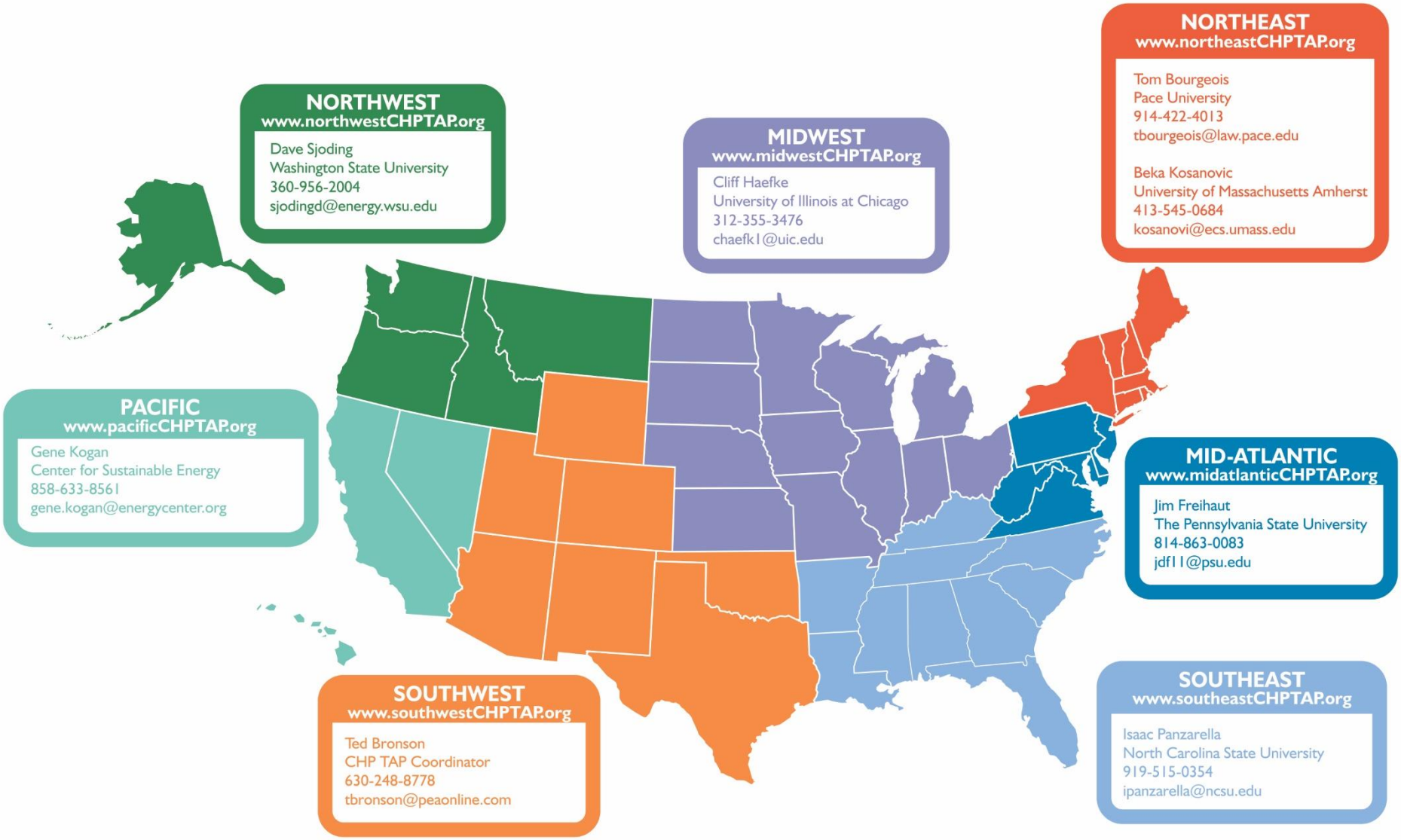
- Market Opportunity
  Supporting key end-user stakeholders (associations, utilities, commissions, etc) to further the installation of CHP.

- 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.



www.energy.gov/chp

DOE CHP Technical Assistance Partnerships (CHP TAPs)



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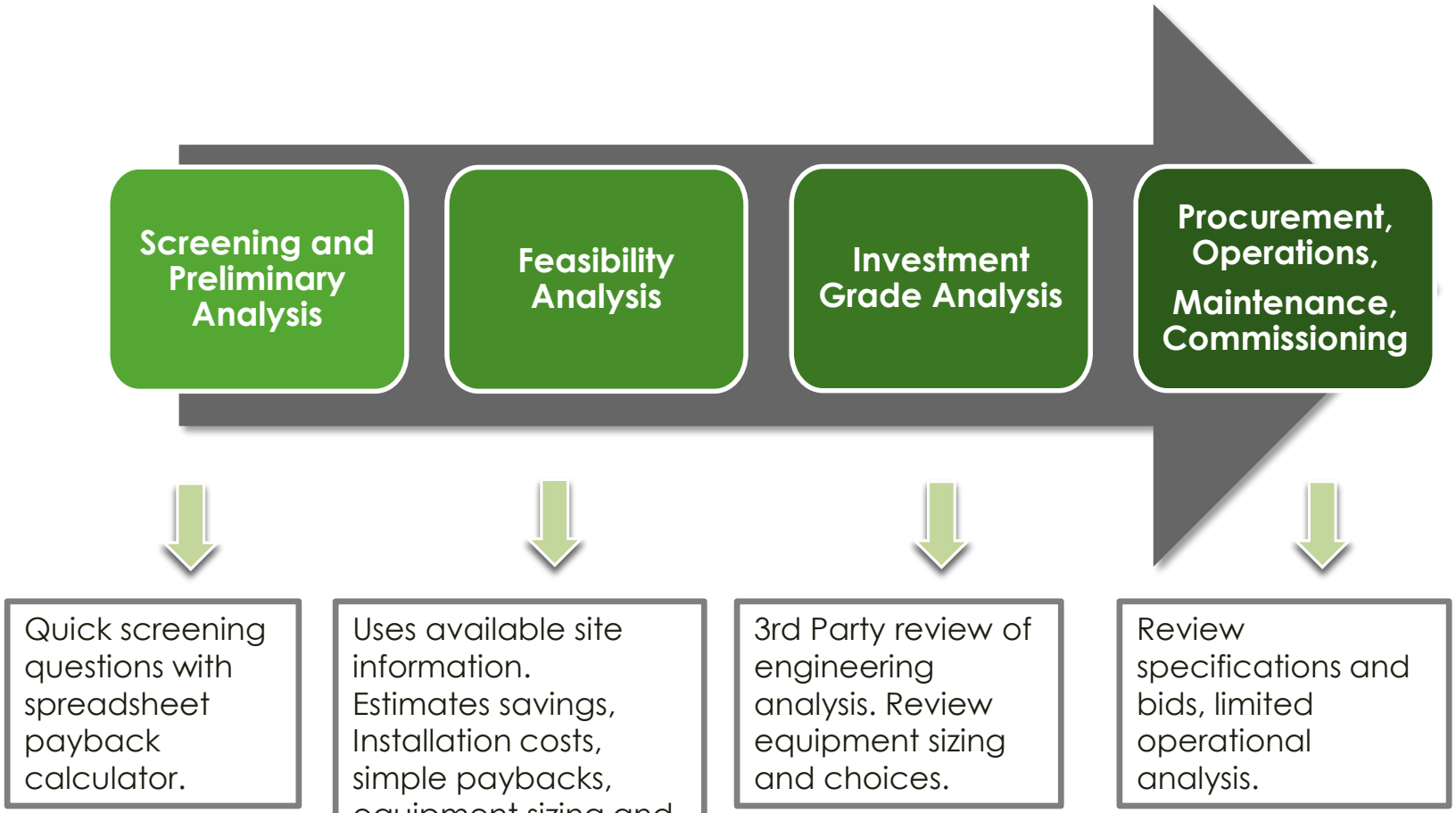
CHP Technical Assistance

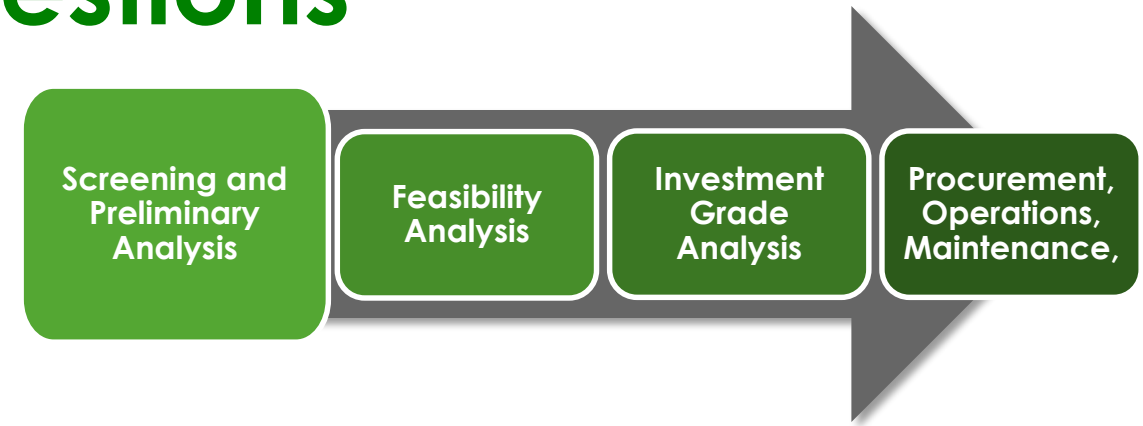


DOE TAP CHP Screening Analysis

- **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**

Screening Questions

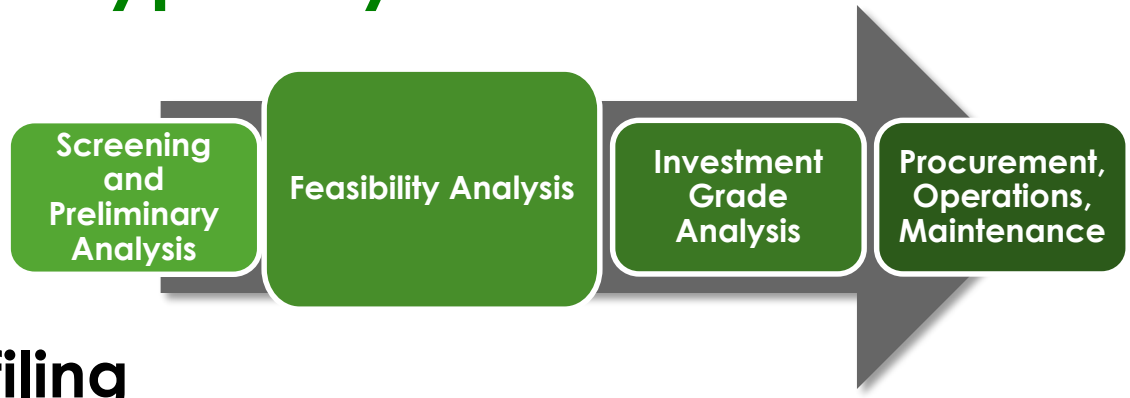


- Do you pay more than $.06/kWh on average for electricity (including generation, transmission and distribution)?
- Are you concerned about the impact of current or future energy costs on your operations?
- Are you concerned about power reliability? What if the power goes out for 5 minutes… for 1 hour?
- 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.)

A Feasibility Analysis Typically Involves:



- Electrical load profiling
- Thermal load profiling
- Unit sizing
- Thermal use determination (what to do with the heat)
- Installation cost estimations
- Financial calculations (simple payback, ROI, etc.)
- Cost/savings information compared to what your facility would pay if the CHP system were not installed

Providing A Source of Unbiased Advice To Assist Decision makers:

- 3rd Party reviews of Engineering Analysis.
- Review equipment sizing and choices.
- Review specifications and bids
- limited operational analysis.

These activities can advance the market for superior CHP, by better informing customers and instilling confidence

U.S. DOE's Continued Interest in CHP

DOE's AMO CHP Deployment Program

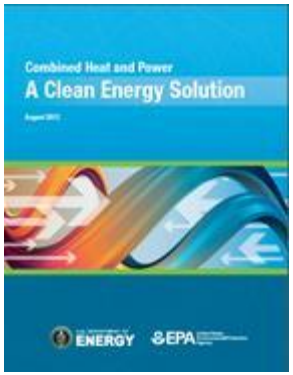
- Covers industrial, commercial, and institutional
- Support President's Executive Order 13624: 40GW of new CHP by 2020

Program activities include:

- Market Analysis and Tracking
  - CHP Market Study
  - DOE/ICF CHP Installation Database
- Publication of fact sheets, reports, project profiles:
  - Waste Heat to Power Market Assessment
  - CHP Project Profile Database

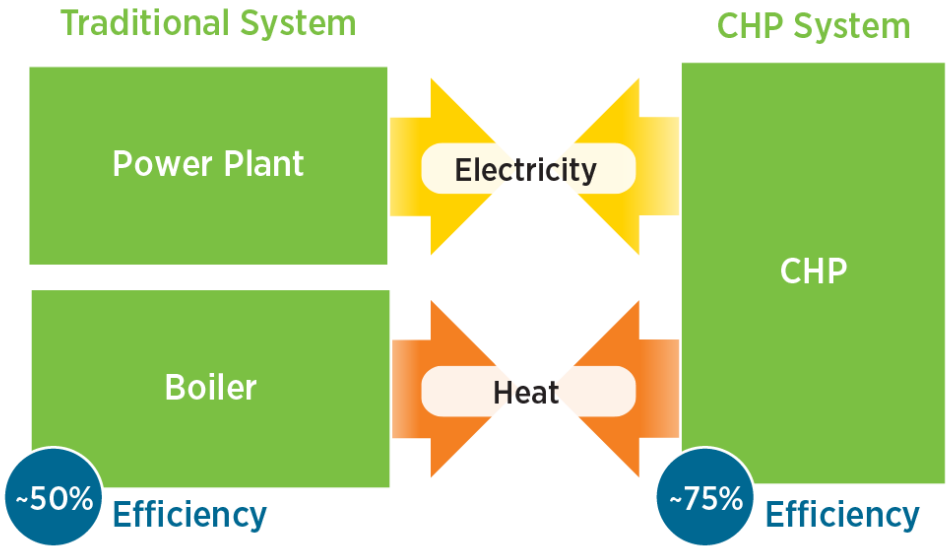
www.energy.gov/chp

- CHP Technical Assistance Partnerships (CHP TAPs).
- Packaged CHP Accelerator



CHP: The Foundation of a Microgrid

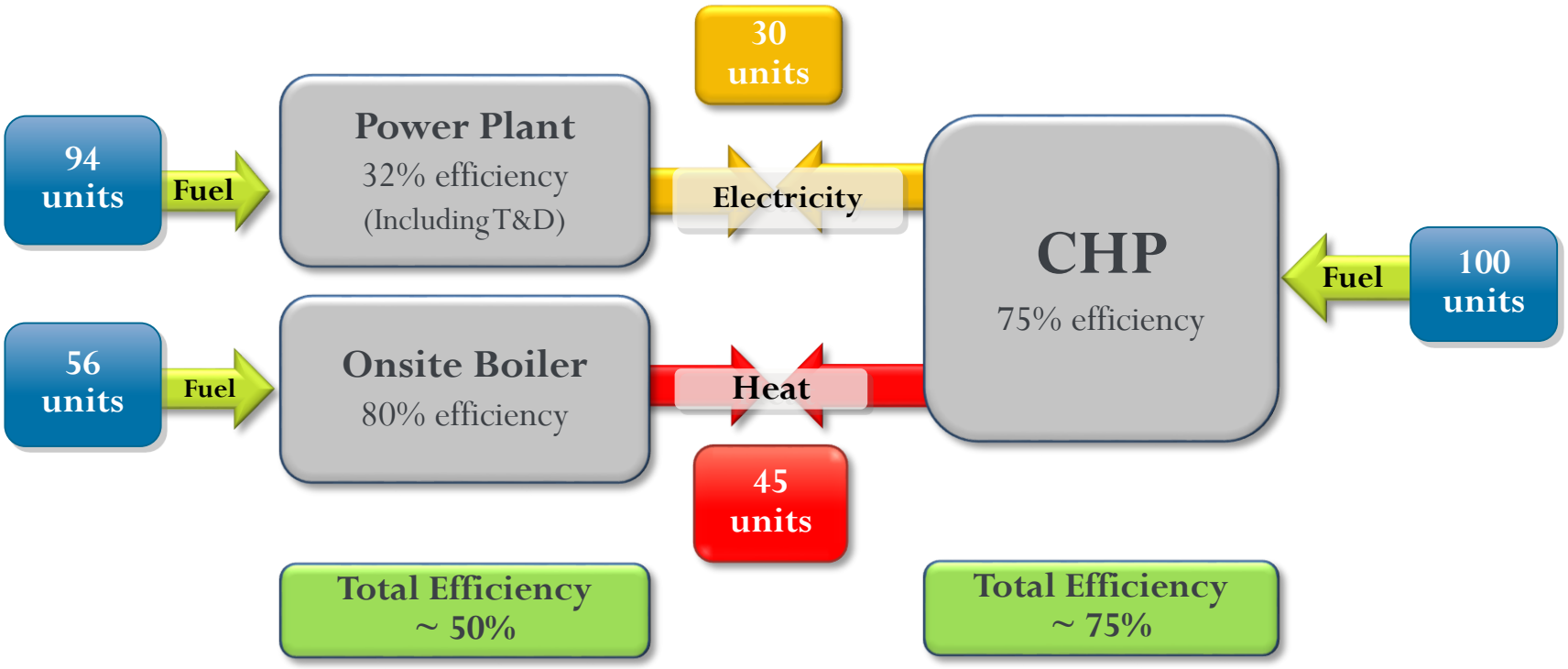
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



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

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

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



30 to 55% less greenhouse gas emissions

CHP is Tested and Proven in Applications and Sectors Across the Nation

CHP Is Used Nationwide

>4,300 CHP Sites (2013)

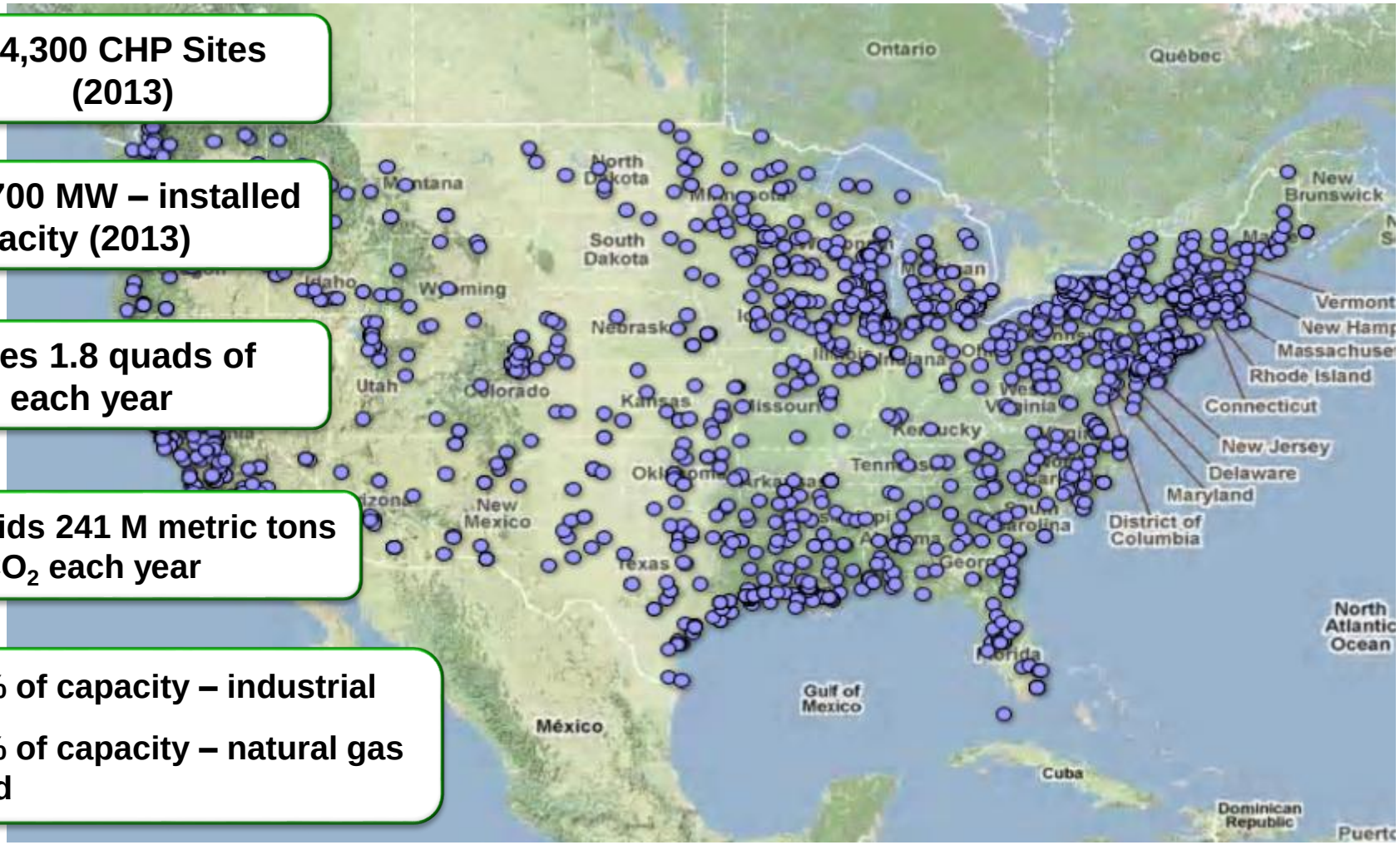
82,700 MW – installed capacity (2013)

Saves 1.8 quads of fuel each year

Avoids 241 M metric tons of CO_2 each year

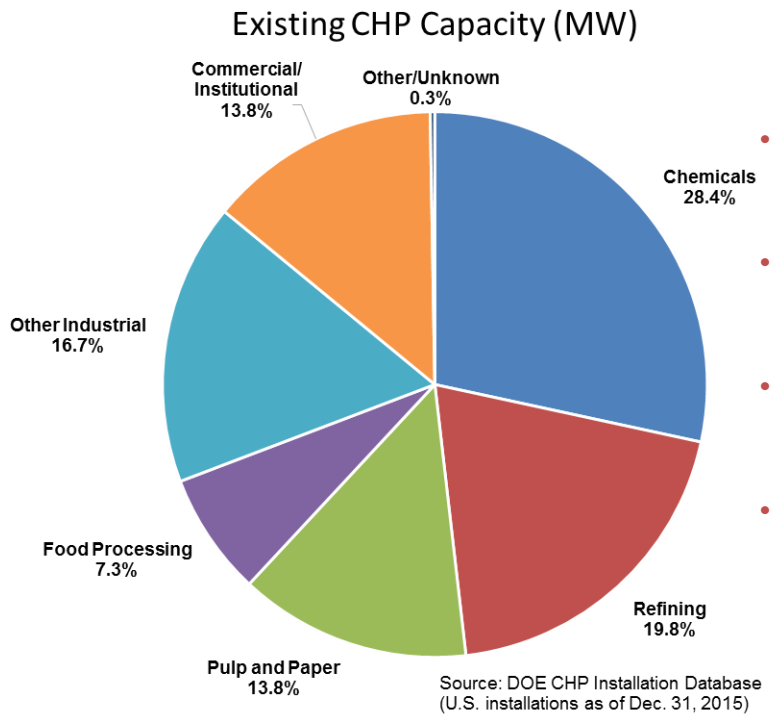
86% of capacity – industrial

69% of capacity – natural gas fired



Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2013)

CHP Today in the United States



- **81 GW** of installed CHP at over 4,300 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

Attractive CHP Markets

Industrial

- Chemical manufacturing
- Ethanol
- Food processing
- Natural gas pipelines
- Petrochemicals
- Pharmaceuticals
- Pulp and paper
- Refining
- Rubber and plastics

Commercial

- Data centers
- Hotels and casinos
- Multi-family housing
- Laundries
- Apartments
- Office buildings
- Refrigerated warehouses
- Restaurants
- Supermarkets
- Green buildings

Institutional

- Hospitals
- Schools (K – 12)
- Universities & colleges
- Wastewater treatment
- Residential confinement

Agricultural

- Concentrated animal feeding operations
- Dairies
- Wood waste (biomass)

What Are the Benefits of CHP?

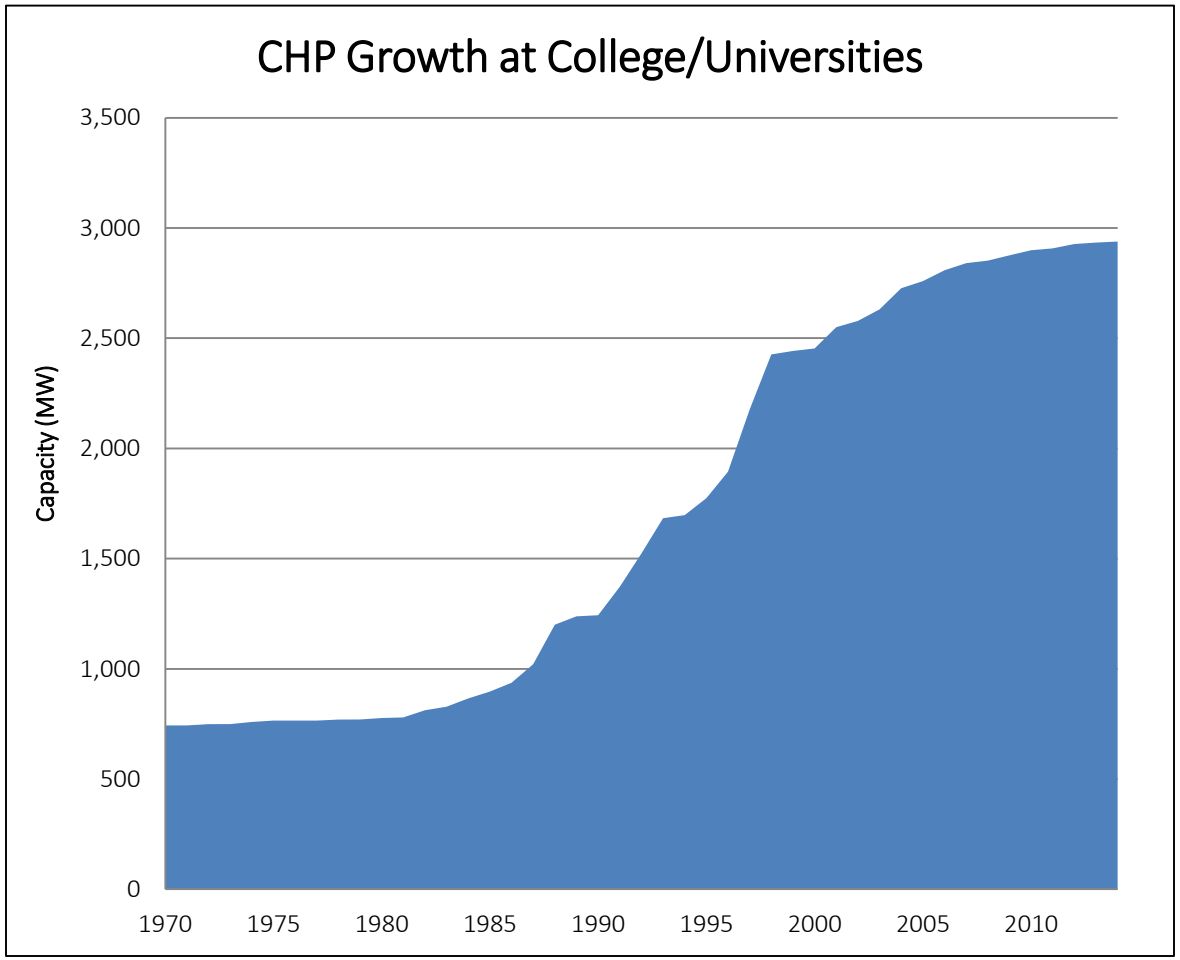
- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating cost**, (but requires capital investment)
- Higher efficiency **reduces emissions** of all pollutants
- CHP can also increase **energy reliability** and enhance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

Energy, Sustainability & Resiliency for Universities and Cities and Potential for CHP

Kendall Cogeneration Plant, Cambridge, Mass - photo courtesy of Veolia North America

CHP in Colleges & Universities

- 299 colleges and universities have CHP, totaling 2,939 MW of capacity.
- Represents 3.5% of total installed CHP capacity in the U.S. (82.7 GW)
- Further technical potential totaling 8,403.9 MW of capacity



Source: DOE/ICF CHP Installation Database (as of December 31, 2014) and ICF Internal Estimates (2013)

Energy & Sustainability Trends at Universities

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

Energy & Sustainability Trends in Cities

Cities increasingly compete for citizens, enterprises and investment. The bar is also being raised on the intrinsic capabilities, facilities and capacities to enable long-term, sustained development. Cities are starting to consider different ways to achieve their energy and emission reduction goals:

- Decentralized Energy and Microgrids
- Combined Heat & Power and District Heating
- Smart Grids and Smart Metering
- Renewable and Feed-in Tariffs
- High Efficiency Lamps and Smart Lighting
- Electric and Alternative Fuel Vehicles

Sources: "Building and Managing an Intelligent City", Accenture, 2011
"Current trends in Smart City initiatives: Some stylized facts", Paolo Neirotti et al, Elsevier, 2013
"Urban Sustainability Trends For Healthy Cities", Powerhouse Growers, 2014

Northeast is the Epicenter of Activity for Microgrids

MA Awarded $18.4M to Communities for Energy Resiliency Projects (December 29, 2014); $7.4 Mil. Announced 9/25/2014

Governor Cuomo Announced 83 NY Prize Stage 1 Winners (July 8, 2015)

NJ Launched $200M Energy Resilience Bank for Microgrids and Distributed Generation: Islanding critical facilities will be a priority

Governor Malloy: Microgrid Projects In Bridgeport and Milford Awarded $5 Million in State Funding to Harden Energy System
(October 8,2014)

Nine microgrid projects awarded a total of $18 million in funding through the CT DEEP Microgrid Pilot Program
(July 24, 2013)

Definitions – Microgrid

Microgrid Definition

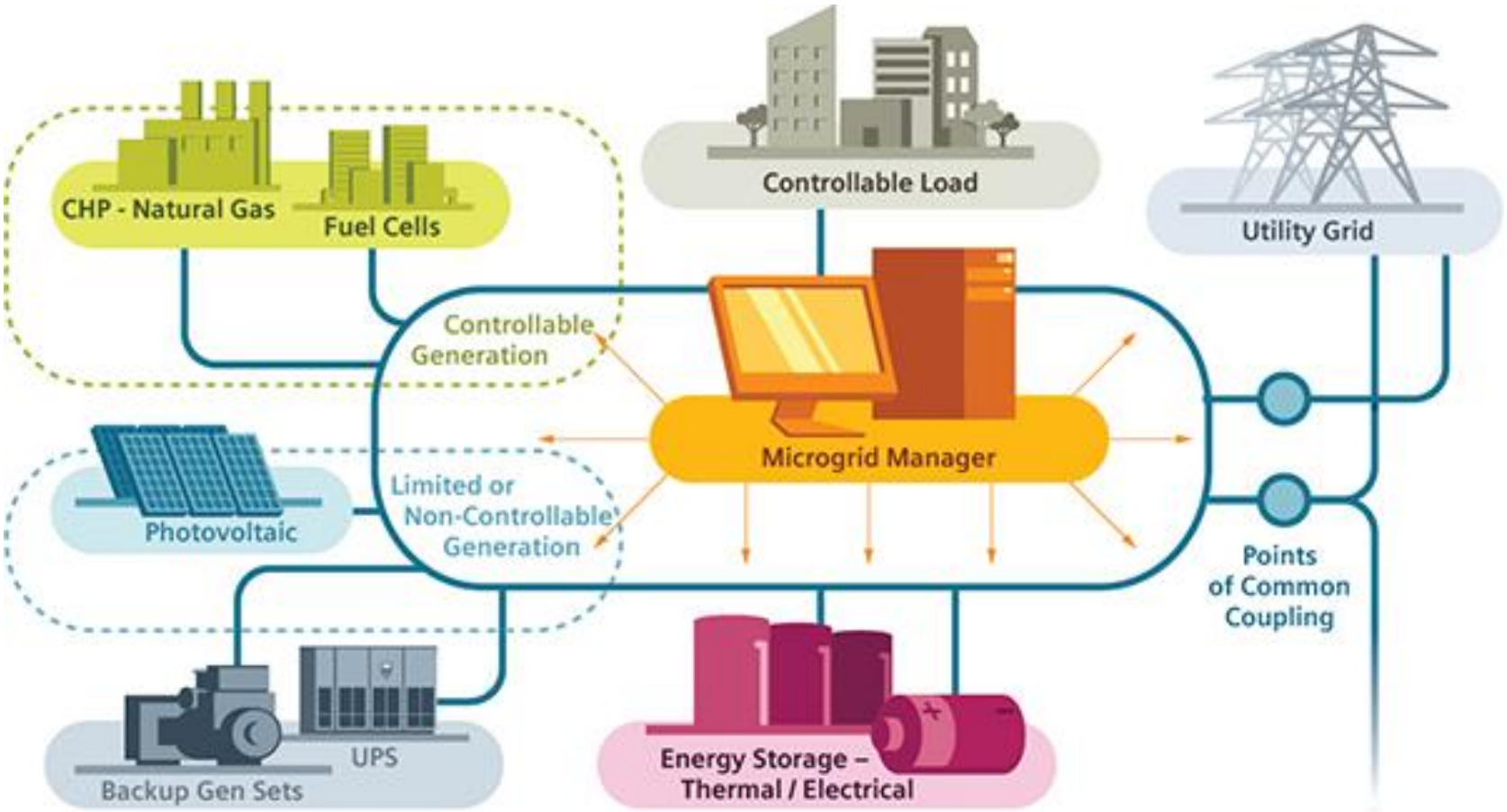
- A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in grid-connected or island-mode.

Key Attributes

- Grouping interconnected loads and distributed energy resources
- Can operate in island mode or grid-connected
- Can connect and disconnect from the grid
- Acts as a single controllable entity to the grid

Source: US DOE, OE

Microgrid Example



Source: Siemens

CHP can use a Variety of Technologies and Fuels

Natural Gas – Biogas - Propane

Microturbines

Gas Turbines

Reciprocating Engines

Fuel Cells

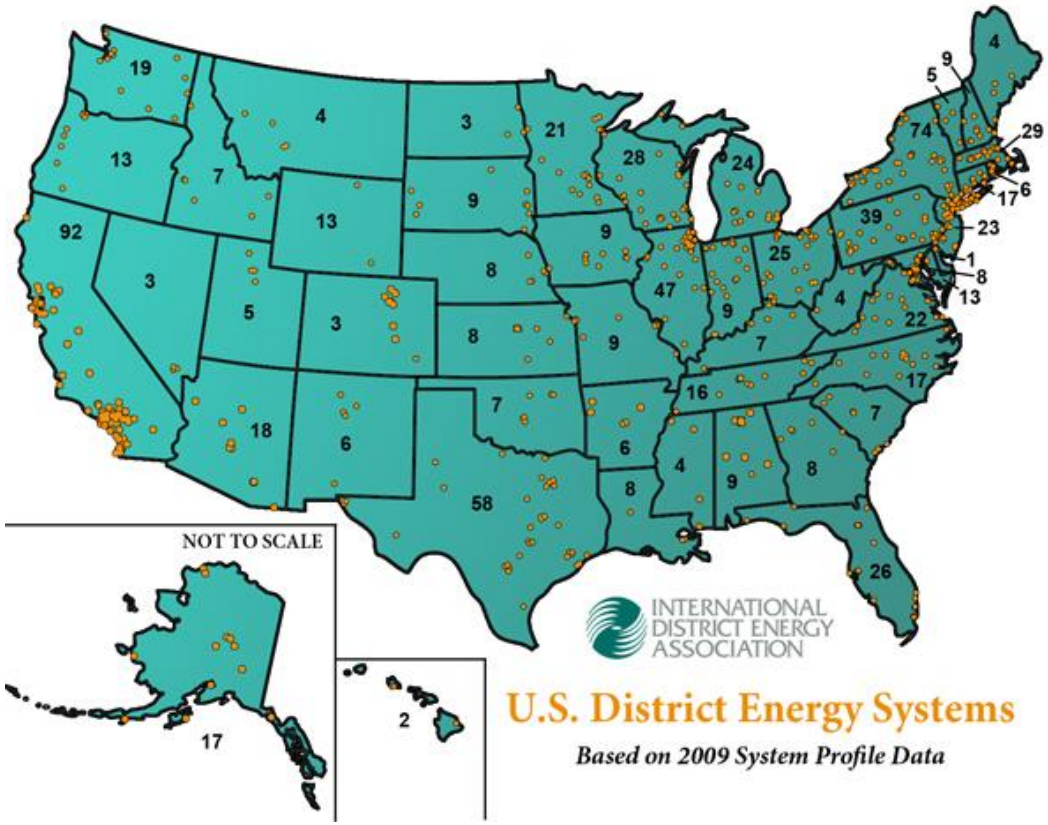
50 kW | 100 kW | 1 MW | 10 MW | 20 MW

District Energy Systems are Ideal Applications for CHP and Microgrids

District energy systems produce steam, hot water or chilled water at a central plant that is then piped underground to individual buildings for space heating, domestic hot water heating and air conditioning.

Benefits:

- Improved energy efficiency
- Ease of operation and maintenance
- Reliability
- Enhanced environmental protection
- Fuel flexibility
- Decreased building capital costs
- Comfort and convenience for customers



*According to the International District Energy Association, http://www.districtenergy.org

CHP, District Energy & Microgrids: Combined Benefits

- **Energy Assurance:** The need for stable and sustainable energy supply at sites
- **Reliability:** The need for greater resilience and reliability, risks, and financial costs
- **Clean Energy Development:** reducing greenhouse gas (GHG) and other emissions
- **Economic Development:** Imperatives for encouraging and facilitating economic development
- **Disruptive Technologies and Forces:** Transformative industry trends that make distributed generation (DG), energy storage, and energy management technologies more useful and cost-effective for a wider range of applications
- **Local Self-Reliance:** Energy end-users' interest in alternative service models, especially those that enhance local self-reliance, environmental quality, and economic health.

Resiliency of Microgrids with CHP

CHP can be the Keystone of Resilient Microgrids:

- CHP provides reliable dispatchable power
- CHP provides thermal energy during grid outage
- CHP results in daily operating cost savings that can significantly help offset costs of resilient microgrids
- CHP can offset some capital costs associated with investments in traditional backup power


Princeton University, NJ


Stony Brook Univ, NY


Fairfield, CT


Ewing, NJ

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/

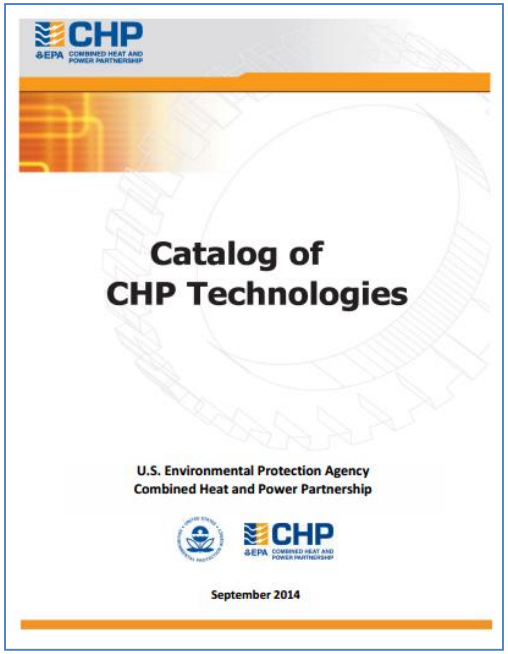
Resilient Critical Infrastructure in Superstorm Sandy

- Danbury Hospital (Danbury, CT) – 4.5 MW CHP
  - supplies 371 bed hospital with power and steam to heat buildings, sterilize hospital instruments & produce chilled water for AC
  - $17.5 million investment, 3-4 year payback, cut AC costs 30%
- Nassau Energy Corp. (Long Island, NY) – 57 MW CHP
  - Supplies thermal energy to 530 bed Nassau University Medical Center, Nassau Community College, evacuation center for County
  - No services lost to any major customers during Sandy
- The Long Island Home (Long Island, NY) – 1.3 MW CHP
  - Serves 197 bed South Oaks Hospital and 320 resident Broadlawn Manor
  - Stayed operational and isolated from LIPA grid for 15 days
- Hartford Hospital/Hartford Steam (CT) – 14.9 MW CHP
- Bergen County Utilities Wastewater (Little Ferry, NJ) - 2.8 MW CHP
  - Process sewage for 47 communities)

Resources and Tools

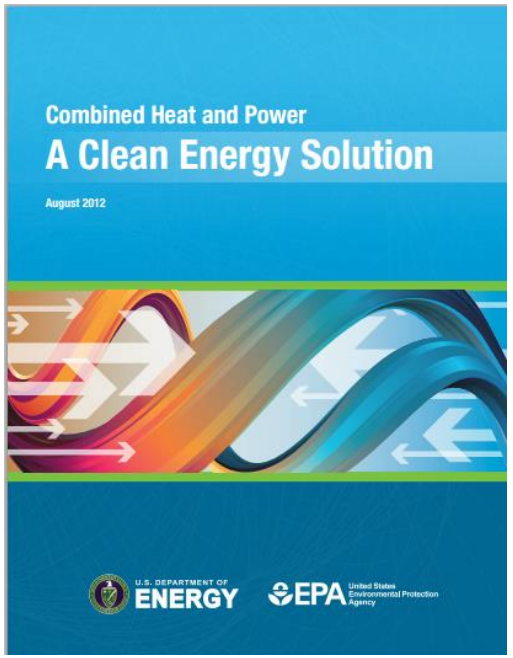
Resources and Tools

1. DOE/EPA Catalog of CHP Technologies (updated 2014)



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

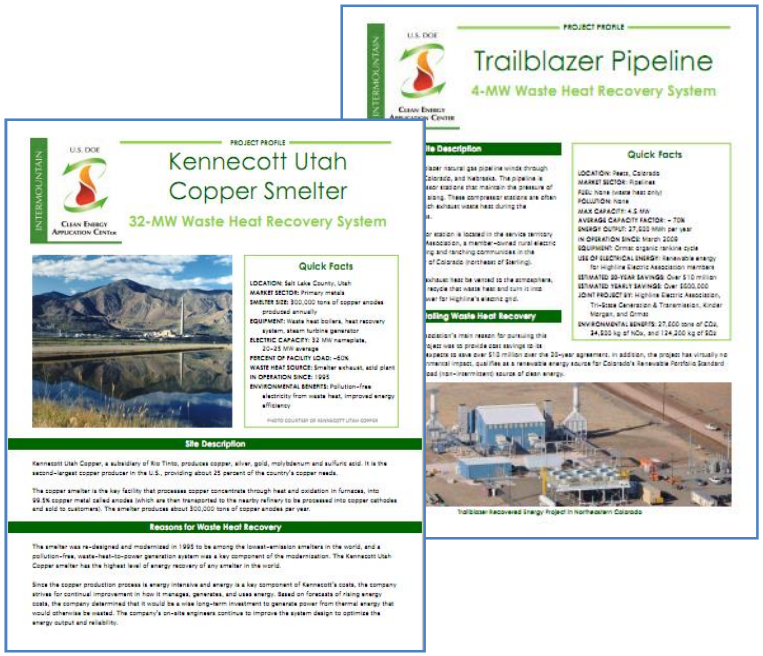
2. Good Primer Report



http://energy.gov/sites/prod/files/2013/11/f4/chp_clean_energy_solution.pdf

Resources and Tools

3. Project Profile Database (150+ case studies)



www.northeasttap.org/profiles

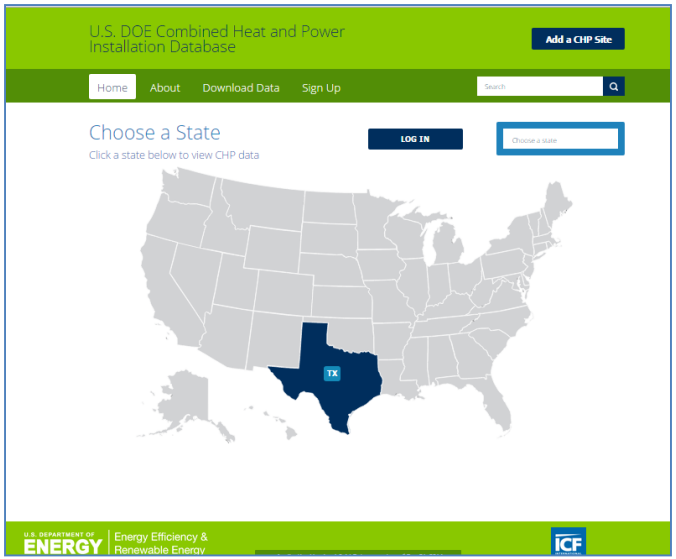
4. DOE Database of Incentives & Policies (DSIRE)

www.dsireusa.org

U.S. Department of Energy
CHP Technical Assistance Partnerships

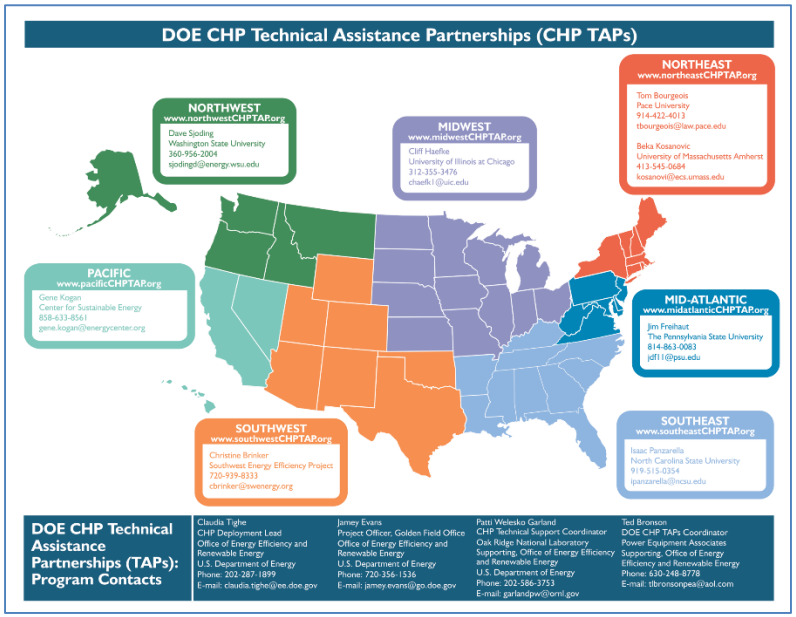
Resources and Tools

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



https://doe.icfwebservices.com/chpdb/

6. And of course… CHP Screening and Advanced Technical Assistance from the CHP TAP



U.S. DEPARTMENT OF ENERGY
CHP Technical Assistance Partnerships

DOE Report on CHP in Critical Infrastructure

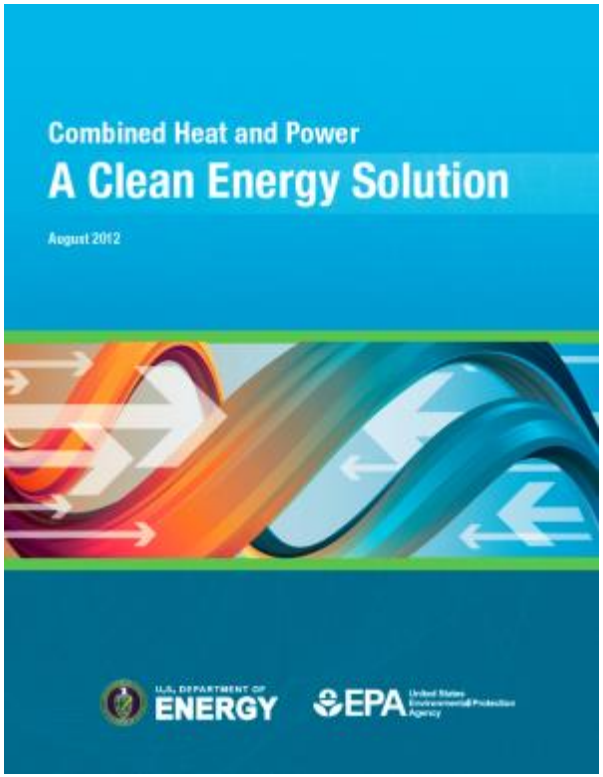
- Provides context for CHP in critical infrastructure applications.
- Contains 14 case studies of CHP operating through grid outages.
- Policies promoting CHP in critical infrastructure.
- Recommendations on how to design CHP for reliability

http://www.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf

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

Summary

- CHP gets the most out of a fuel source enabling:
  - Reduced operating costs
  - Reduced environmental footprint
  - More efficient power and thermal generation
  - Improved community resiliency
- Proven technologies commercially available that cover full range of sizes and applications
- Multiple buildings connected to a district system or Microgrid with CHP provides the heating, cooling and power infrastructure to cost-effectively deliver (and optimize & manage) energy from numerous sources: Renewables and very high efficiency non renewable sources.
- US DOE's CHP TAPs offer a suite of services to assist you

Packaged CHP Accelerator

CHP in a Microgrid

- CHP Can Function as the "Heart" of the Microgrid
- Serves as "baseload" providing stable, 24/7 thermal and power needs to the microgrid
- Enables other on-site generation (like solar, wind) and also thermal storage in terms of availability of service and costs
- Introduces resiliency to keep the microgrid operational regardless of outside events (like hurricanes, tornadoes, black-outs or brown-outs)

The Market: CHP Technical Potential

Application	50-500 kW (MW)	500 - 1 MW (MW)	1 - 5 MW (MW)	5 - 20 MW (MW)	>20 MW (MW)	Total MW
Industrial - Onsite Use	6,349	4,572	15,186	15,233	21,099	62,439
Commercial - Onsite Use	20,068	18,100	20,284	9,382	4,182	72,015
Total - Onsite Use	**26,417**	**22,672**	**35,470**	**24,615**	**25,281**	**134,454**
Incremental Export - Industrial Only	6,075	4,474	14,795	23,619	121,747	170,356
Total - Onsite and Export	**32,492**	**27,146**	**50,265**	**48,234**	**147,028**	**304,810**

Source: ICF internal estimates (2014)

U.S.DOE Packaged CHP Accelerator: A Better Building Initiative

CHP eCatalog

- Create a national eCatalog of pre-designed "packaged" CHP systems and pre-qualified vendors
  - CHP systems between 50 KW and 10MW (including WHP or bottoming CHP)
    - Reliable vendors, robust and reliable components, demonstrated system performance
  - Harmony "within the box" (components properly size-matched)
  - Bumper-to-bumper warranty
  - Single point of responsibility for product, installation, and service
  - "Turn-key solutions" with adequate local sales & service support
  - Easy access to consumers
- Vendors warrant system for at least 5-years

Market Engagement (sponsoring entities) Network

- Educate potential users about CHP
- Outreach to potential users on eCatalog and support services
  - Demystify CHP)
  - Match customers and vendors
- Technical assistance
  - Training on eCatalog
  - Provide model contracts, PPAs, etc.
  - Provide guidance through evaluation and buying process including reviewing bids (CHP TAPs)
  - Provide technical assistance as needed (CHP TAPS)
- Reduce consumer risk by verifying performance within vendor warranty timeframe
- Link any CHP incentive programs in this size range to the eCatalog

Next Steps

Resources are available to assist in developing CHP and Microgrid Projects. Contact the Northeast CHP TAP to:

- Perform a preliminary study to see if CHP with District Energy and Microgrid is a fit for your project
- Consider Additional Technical Assistance where warranted
- Explore and utilize our suite of tools

Thank You

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