

# Achieving Campus Sustainability Goals through CHP

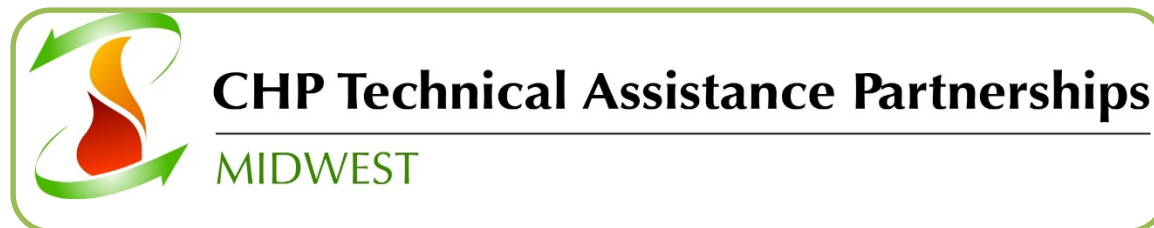
Presentation to IL APPA

Graeme Miller

Assistant Director

US DOE Midwest CHP Technical Assistance Partnership

May 16, 2019

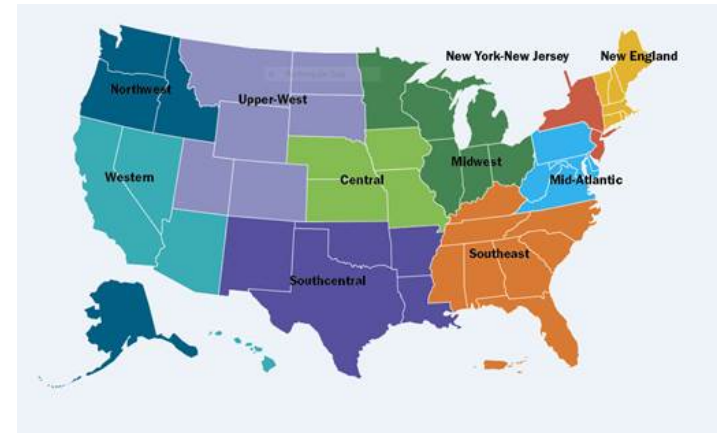


# Agenda

- DOE CHP Technical Assistance Partnerships
- CHP in Colleges/Universities
  - Development Trends and Technical Potential
  - Project Considerations
  - Addressing Issues of Sustainability
- Reducing emissions through CHP
- Hybrid Renewable CHP and Microgrids
- Case Studies + Project Snapshots
- How to implement a CHP project with the CHP TAP
- Additional Resources and Reports

# DOE CHP Technical Assistance Partnerships (CHP TAPs)

- **End User Engagement**  
Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.
- **Stakeholder Engagement**  
Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation's resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.
- **Technical Services**  
As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.



[www.energy.gov/chp](http://www.energy.gov/chp)

# DOE CHP Technical Assistance Partnerships (CHP TAPs)

## Upper-West

CO, MT, ND, SD, UT, WY  
[www.upperwestCHPTAP.org](http://www.upperwestCHPTAP.org)

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## Midwest

IL, IN, MI, MN, OH, WI  
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## New England

CT, MA, ME, NH, RI, VT  
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## Southeast

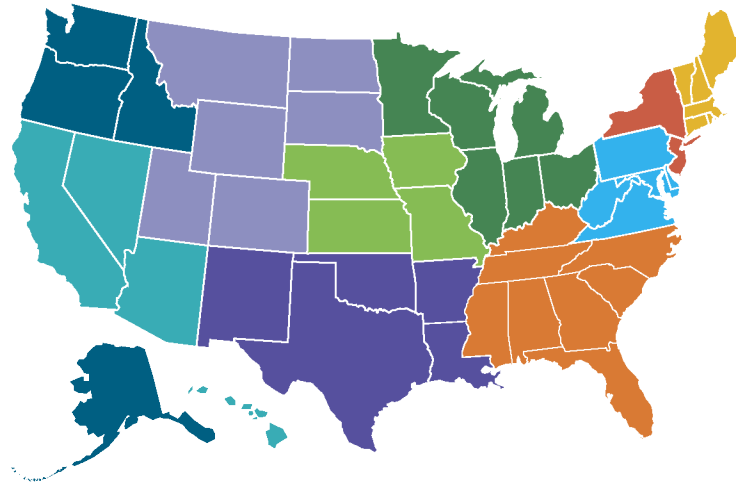
AL, FL, GA, KY, MS, NC, PR, SC, TN, VI  
[www.southeastCHPTAP.org](http://www.southeastCHPTAP.org)

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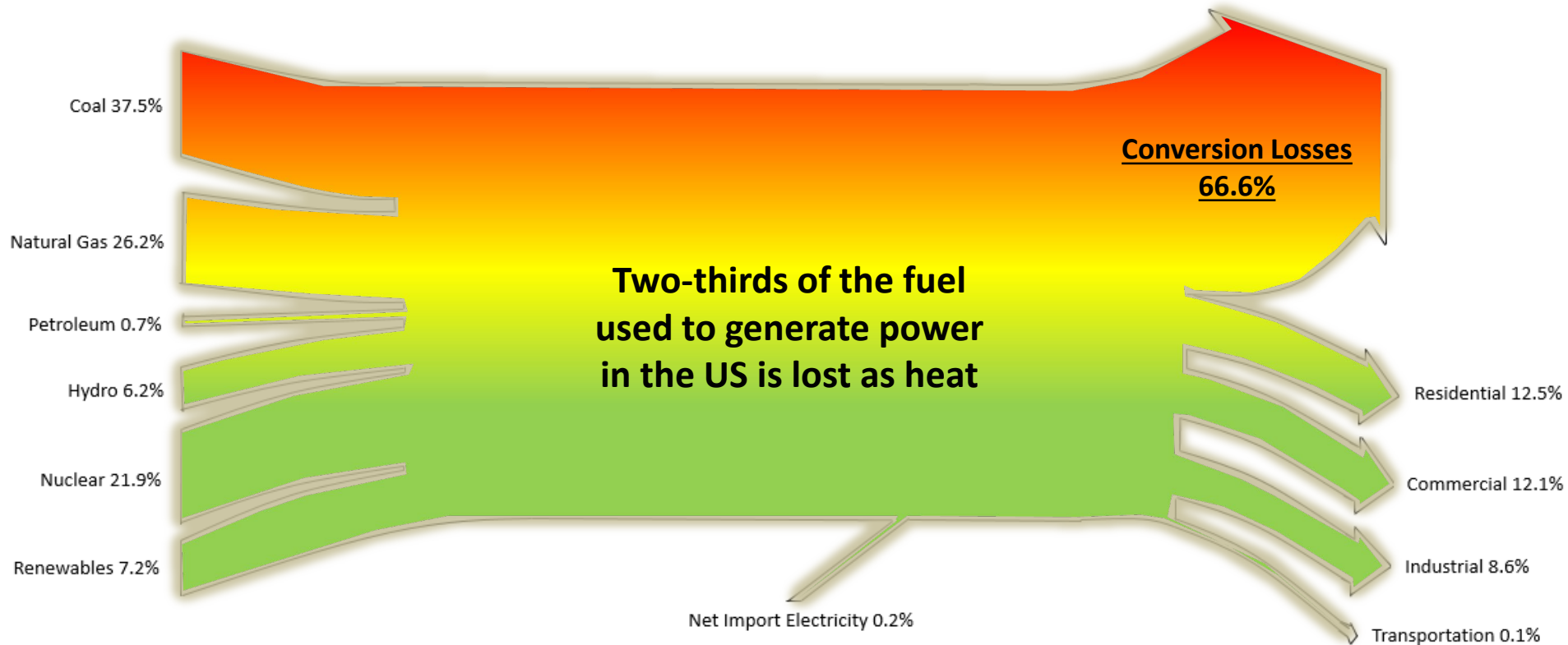
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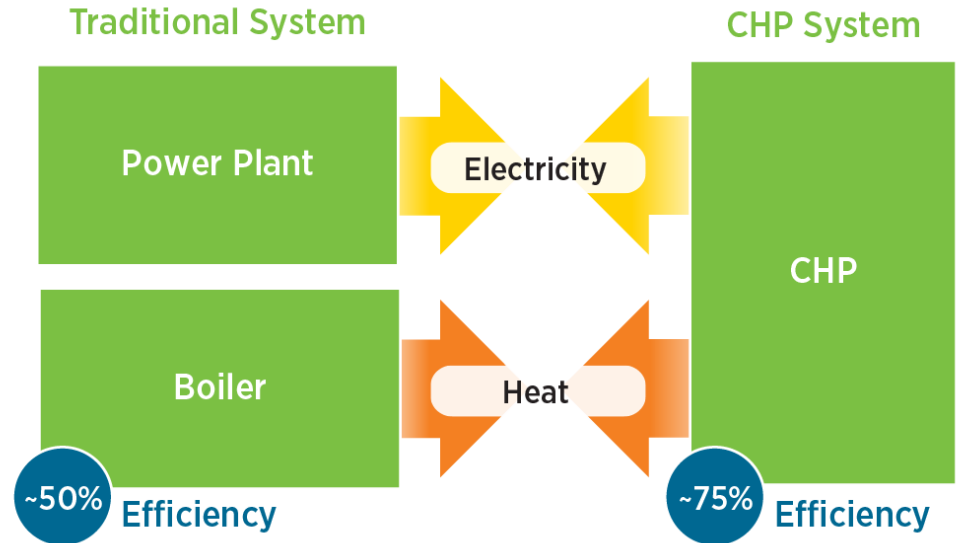
# Energy Utilization in the Utility Sector



Source: [https://flowcharts.llnl.gov/content/assets/images/charts/Energy/Energy\\_2015\\_United-States.png](https://flowcharts.llnl.gov/content/assets/images/charts/Energy/Energy_2015_United-States.png)

# CHP: A Key Part of Our Energy Future

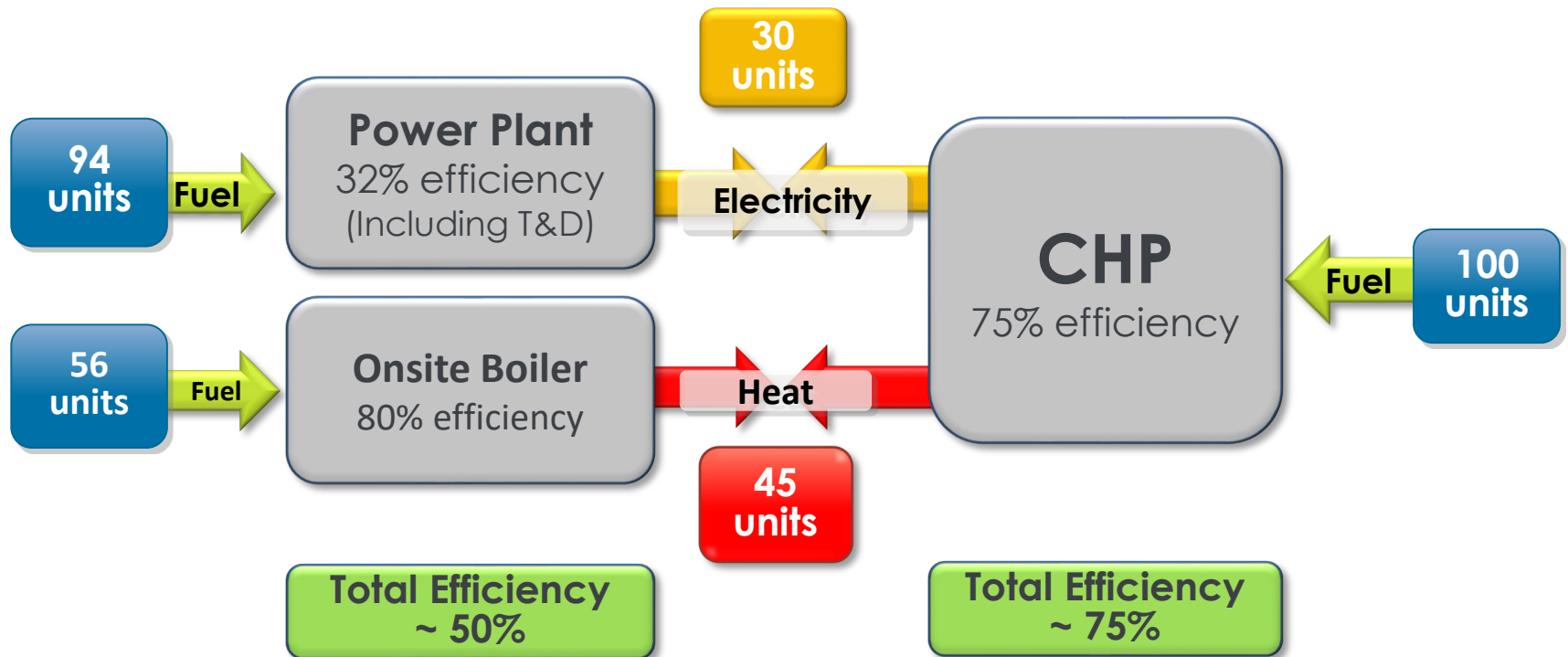
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



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

Source: [www.energy.gov/chp](http://www.energy.gov/chp)

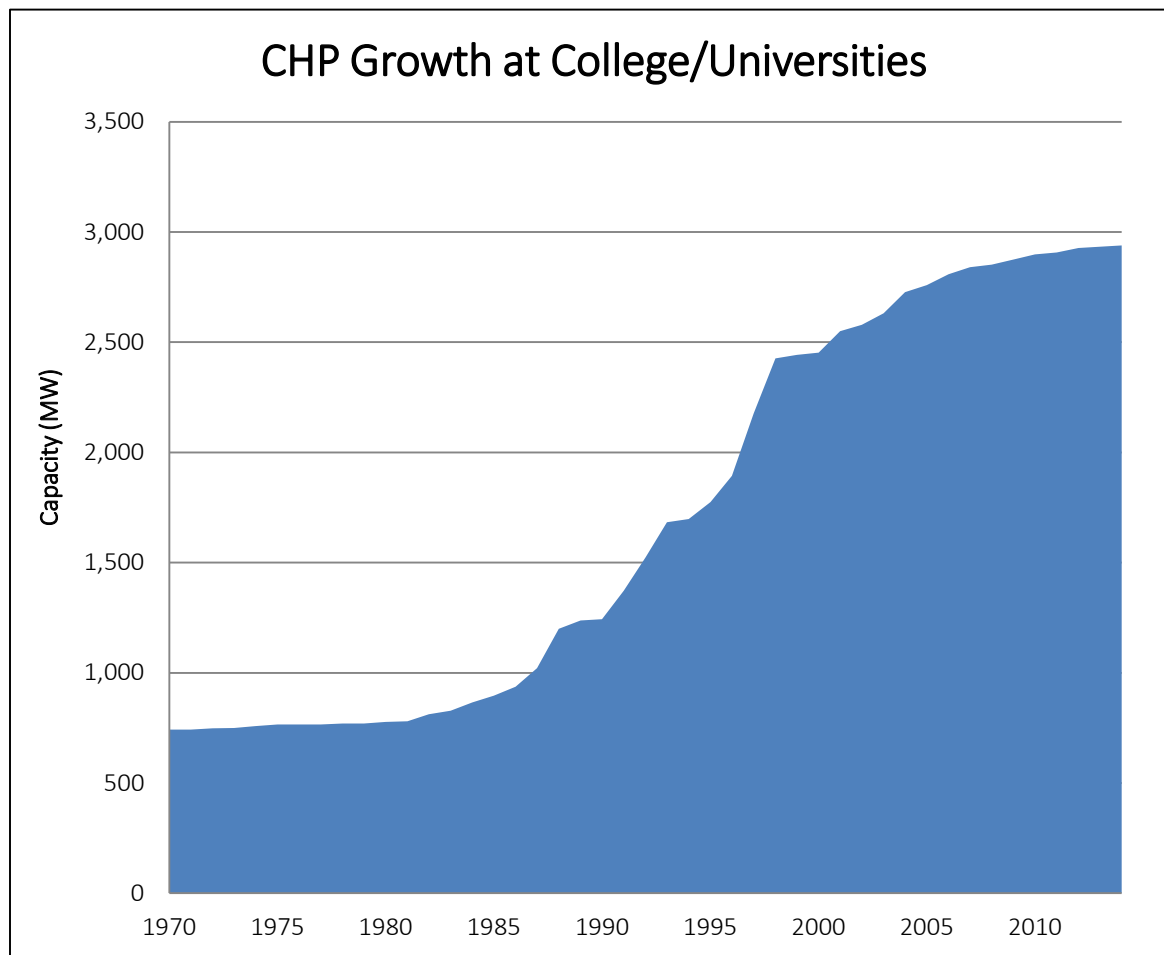
# CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing GHGs



30 to 55% less greenhouse gas emissions

# 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



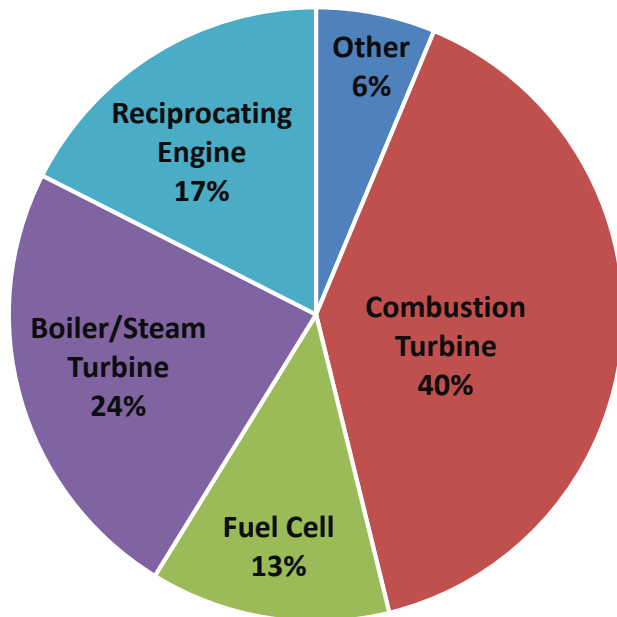
Source: DOE/ICF CHP Installation Database (as of December 31, 2014) and ICF Internal Estimates (2013)



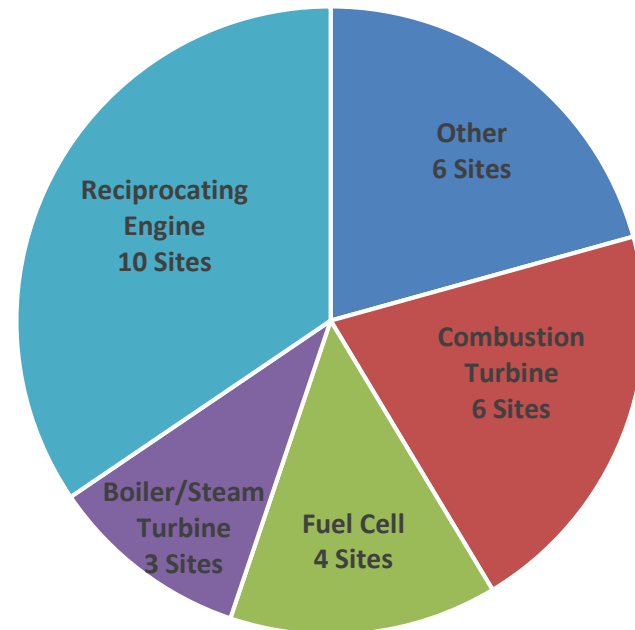
# CHP in Colleges & Universities New Installations 2014-2017

- 29 New Installations
- Over 53 MW of Total Capacity

New Capacity by Prime Mover

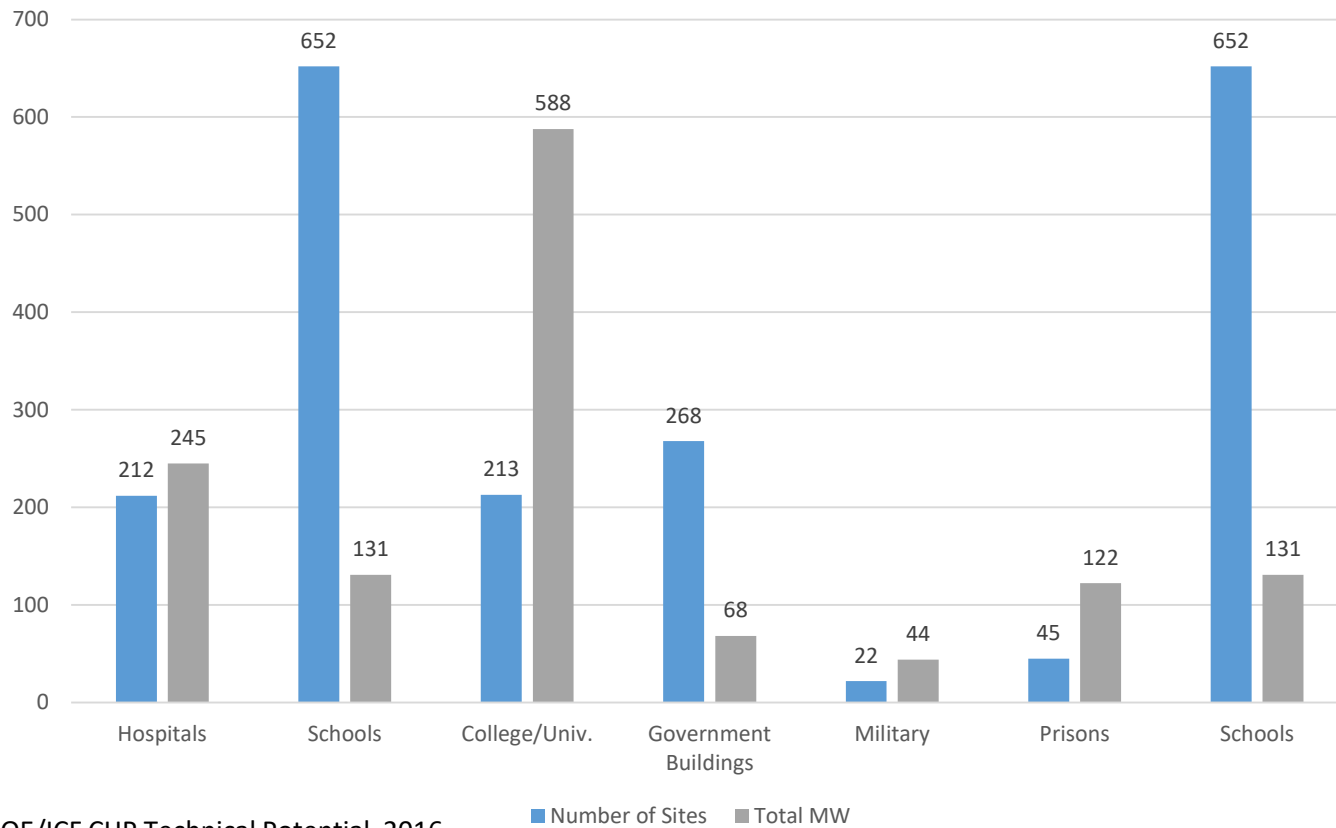


New Installations by Prime Mover



# CHP Technical Potential in Illinois

Top Commercial & Institutional Sectors by CHP Technical Potential in Illinois



Source: DOE/ICF CHP Technical Potential, 2016

# Energy Project Considerations

for Colleges/Universities



*Source: University of Minnesota; 2017 Minnesota Energy Expo*

# CHP Project Considerations

- Concern about energy costs
- *Concern about power reliability*
- ***Concern about sustainability and environmental impacts***
- Long hours of operation
- Existing thermal loads
- Central heating and cooling plant
- Future central plant replacement and/or upgrades
- Future facility expansion or new construction projects
- EE measures already implemented
- Access to nearby renewable fuels
- *Facility energy champion*

# 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>

# Duke University's experience with CHP

**2016:** Duke University and Duke Energy announced plans to construct a utility owned 21 MW CHP plant providing steam to the campus and electricity to the grid.

**2018:** Due to immense pressure from local groups, the project was delayed indefinitely

“Duke has an aggressive goal of becoming carbon neutral by 2024 while ensuring that the energy demands of a growing, vibrant campus can be met,” said Executive Vice President Tallman Trask III. “While CHP technology creates much greater efficiencies for both the consumer and the producer, we also recognize that advances in technology provide a constantly changing range of options and deserve further study.”

# Headlines from Local Papers

Duke eyes building a gas-turbine power plant on campus. Environmentalists wary. Why?

BY RAY GRONBERG  
*rgronberg@heraldsun.com*

Opponents unite against proposed natural gas plant at Duke University

BY JANE STANCILL  
*jstancill@newsobserver.com*

## Duke Energy cuts plans for combined heat-and-power partnerships

*March 09, 2018*

**Community organizations and individuals ask you to create a full, transparent review process of Duke University's energy system before finalizing decisions on CHP and biogas.**

# Duke University Lessons Learned

- CHP was primarily seen as fossil fueled electric generation and not as an inherently more efficient process for generating electric and thermal energy
- Skepticism with the Duke Energy ownership model – utilities seen as barrier to GHG reductions
- The resiliency benefits of CHP were largely ignored
- Use of agriculture bio-gas RECs seen as “accounting move,” and not as a legitimate approach to providing GHG offsets

What is the role for CHP in addressing climate change???



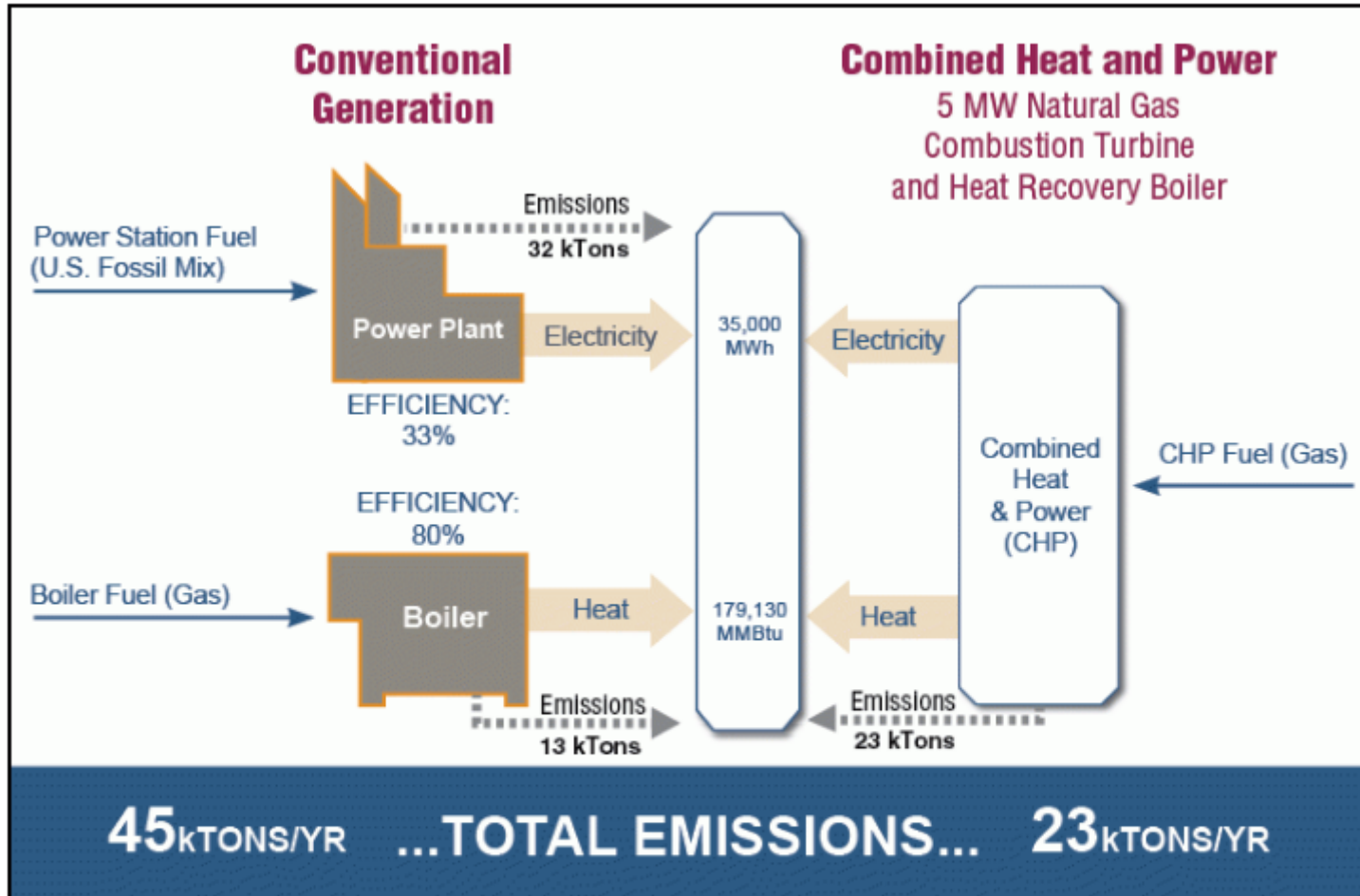
# Illinois University's Climate Plans

UIC and UIUC:  
Carbon Neutral by 2050



# Reducing emissions through CHP

# CHP Emissions Reductions



This diagram illustrates the CO<sub>2</sub> emissions output from electricity and useful thermal energy generation for two systems: (1) a fossil fuel-fired power plant and a natural gas-fired boiler; and (2) a 5 megawatt combustion-turbine CHP system powered by natural gas. The separate heat and power system emits a total of 45 kilotons of CO<sub>2</sub> per year (13 kilotons from the boiler and 32 kilotons from the power plant), while the CHP system, with its higher efficiency, emits 23 kilotons of CO<sub>2</sub> per year.

# Combined Heat and Power Value Proposition

Category	10 MW CHP	10 MW PV	10 MW Wind
Annual Capacity Factor	85%	22%	34%
Annual Electricity	74,446 MWh	19,272 MWh	29,784 MWh
Annual Useful Heat	103,417 MWh <sub>t</sub>	None	None
Footprint Required	6,000 sq ft	1,740,000 sq ft	76,000 sq ft
Capital Cost	\$20.0 million	\$60.5 million	\$24.4 million
Annual Energy Savings	308,100 MMBtu	198,462 MMBtu	303,623 MMBtu
Annual CO <sub>2</sub> Saving	42,751 Tons	17,887 Tons	28,172 Tons

Based on: 10 MW Gas Turbine CHP - 28% electric efficiency, 68% total CHP efficiency  
 Displaces National All Fossil Average Generation (eGRID 2012 – 2009 data) -  
 9,572 Btu/kWh, 1,743 lbs CO<sub>2</sub>/MWh, 6.5% T&D losses

Source: *CHP: A Clean Energy Solution*; US DOE and EPA, 2012

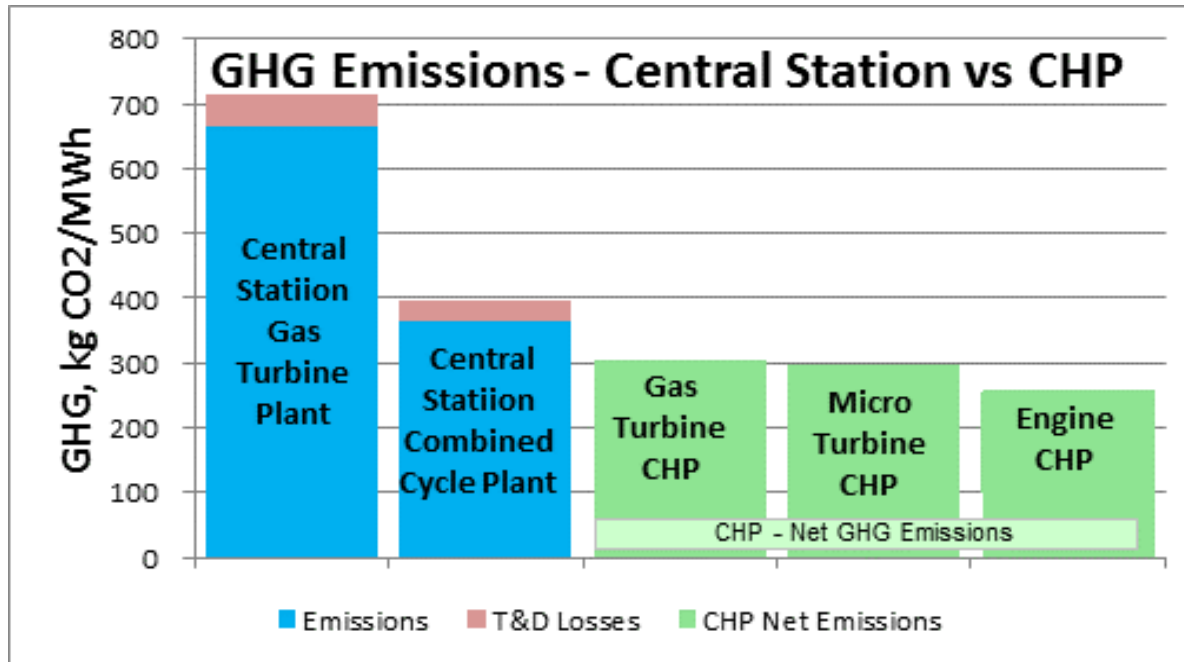
# Current Electric Generation by Source in Illinois

Fuel Source	Illinois Net Electricity Generation thousand MWh	Percentage of Electric Generation Mix
Petroleum-Fired	4	0.02%
Natural Gas-Fired	1,071	6.23%
Coal-Fired	5,875	34.15%
Nuclear	8,795	51.13%
Hydroelectric	13	0.08%
Nonhydroelectric Renewables	1,444	8.39%

- In 2016 the power sector in Illinois emitted 66.4 million metric tons of CO<sub>2</sub>
- Illinois ranks 7<sup>th</sup> in the nation for carbon dioxide emissions with overall emissions at 205.2 million metric tons

Source: U.S. Energy Information Administration.  
<https://www.eia.gov/state/?sid=IL#tabs-4>

# The Role for CHP While Transitioning to a carbon neutral grid

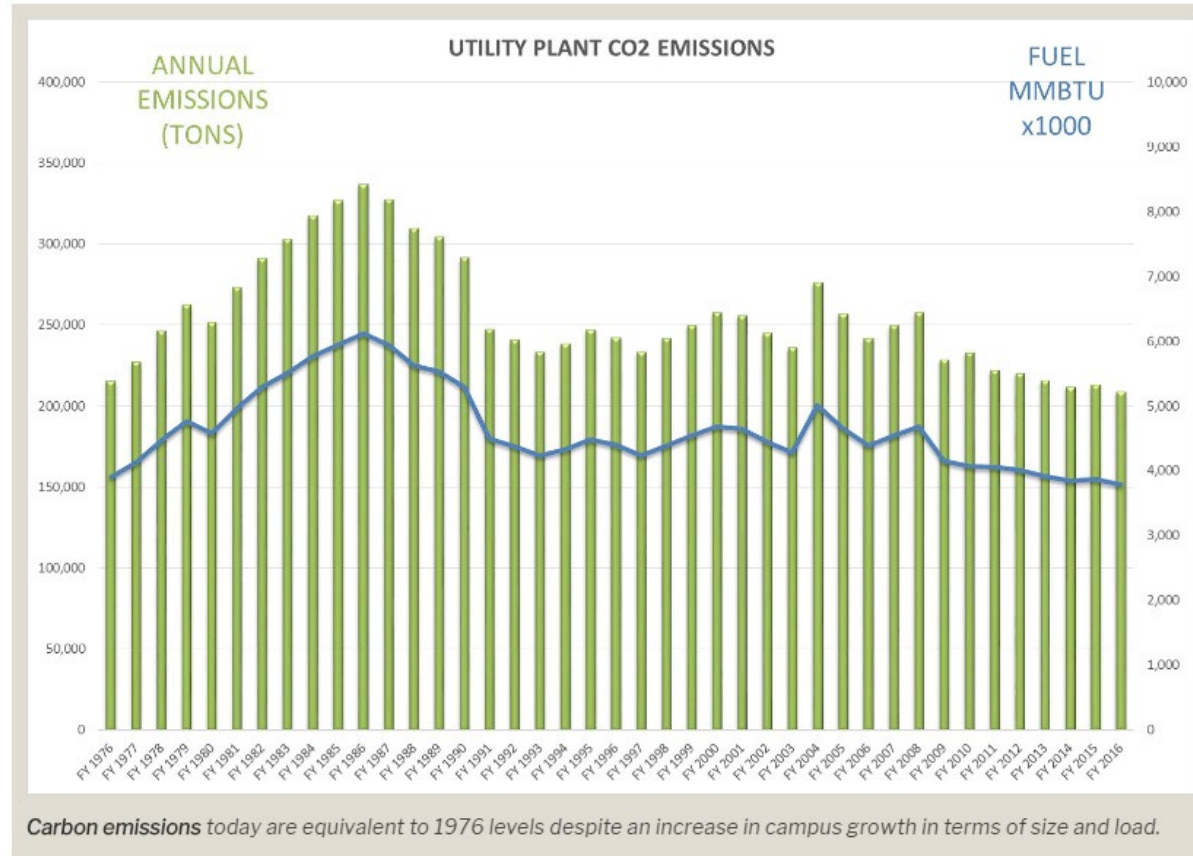


Source: California Energy Commission

- Natural Gas generation will be a significant part of the electricity mix in the U.S. for years to come
- Properly designed and operated natural gas CHP is the most efficient and lowest GHG emitting fossil technology. Until the electric grid is completely decarbonized, this technology will remain the most available, least cost resource to *immediately* reduce GHG emissions.

# CHP Installations and Emissions Reductions – University of Texas

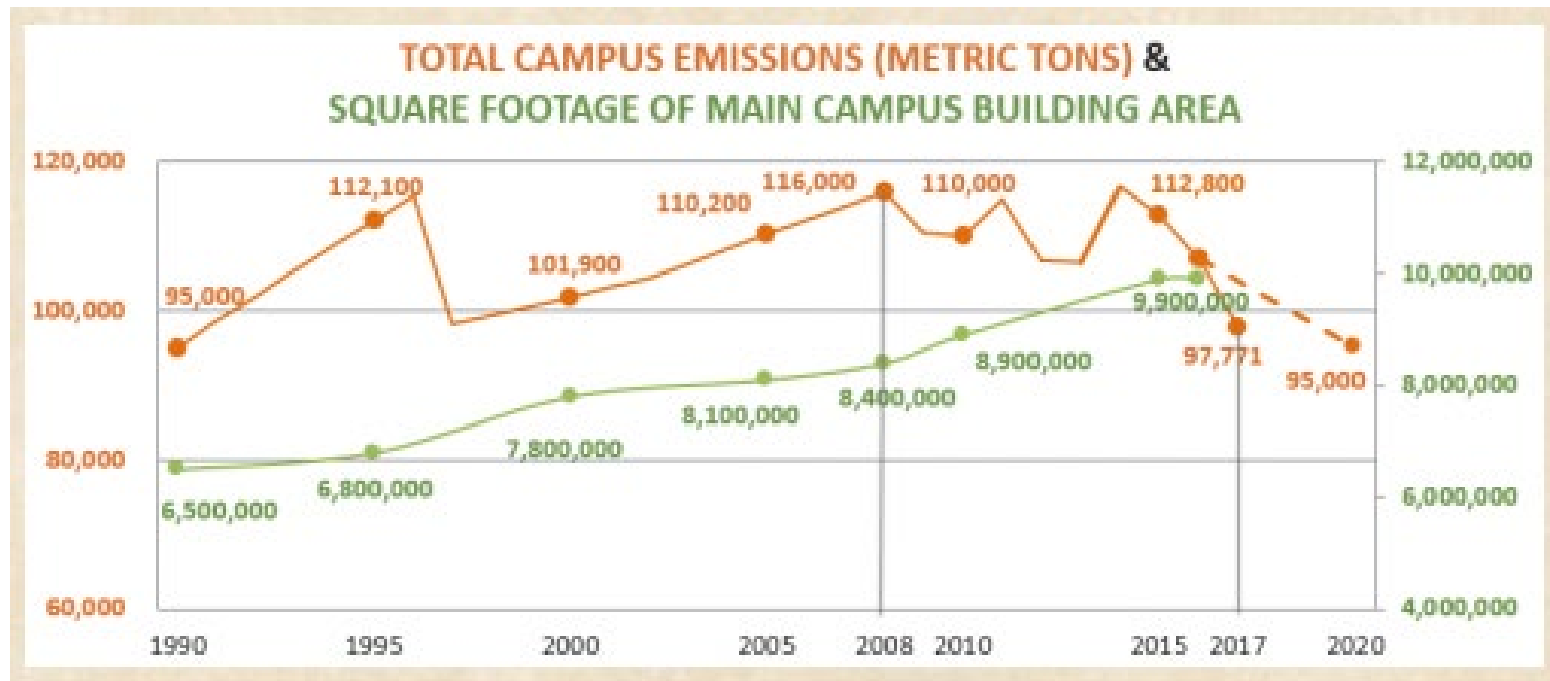
- “The most efficient university utility in the U.S.”
- 135 MW
- 1.2 million lb/hr steam
- 60,000 tons cooling
- Efficiencies up to 88%
- 99.9998% reliable
- Avoided 862,000 lbs CO<sub>2</sub> since 1996



Source: <https://utilities.utexas.edu/chp/about-carl-j-eckhardt-combined-heating-and-power-complex>

# CHP Installations and Emissions Reductions – Princeton University

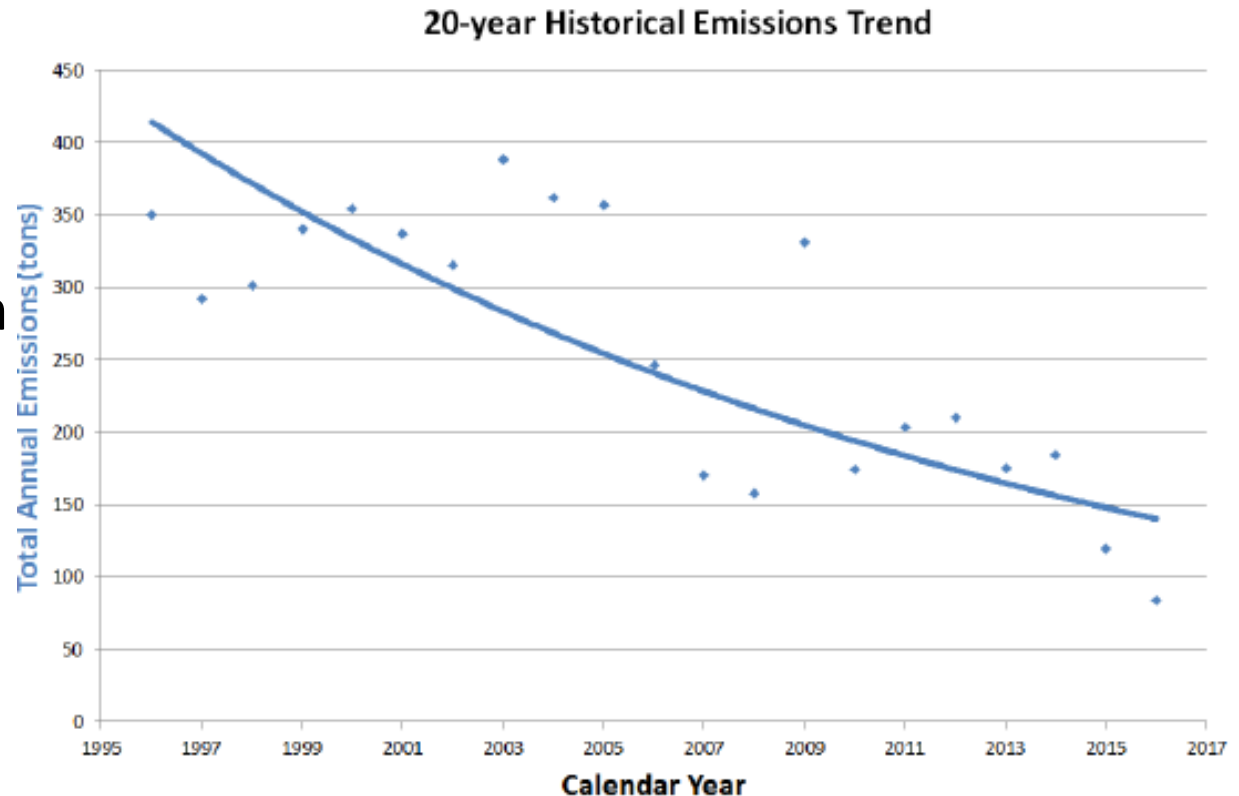
- 15 MW Capacity (1<sup>st</sup> in world of its type to be able to operate on bio-diesel)
- 300,000 lb/hr steam
- 20,000 tons cooling
- 40,000 ton-hours thermal storage
- On-track to reduce emissions to 1990 levels by 2020





# CHP Installations and Emissions Reductions – University of New Hampshire

- 12.5 MW Capacity
- Uses piped in landfill gas
- Estimated reduction in greenhouse gas emissions of 21%



Source: <https://sustainableunh.unh.edu/ecoline>

# CHP Installations and Emissions Reductions – University of New Hampshire

“Ending the consumer society is an important concern, and we're not going to get to carbon neutrality without addressing it in a sustainable way. *However, since we have only a decade in which to substantially reduce our greenhouse gas emissions to avoid the worst impacts of climate change, we need to explore renewable power sources like landfill gas.*”

Source: <https://sustainableunh.unh.edu/ecoline>

# Hybrid Renewable CHP: Microgrids to Make Everyone Happy

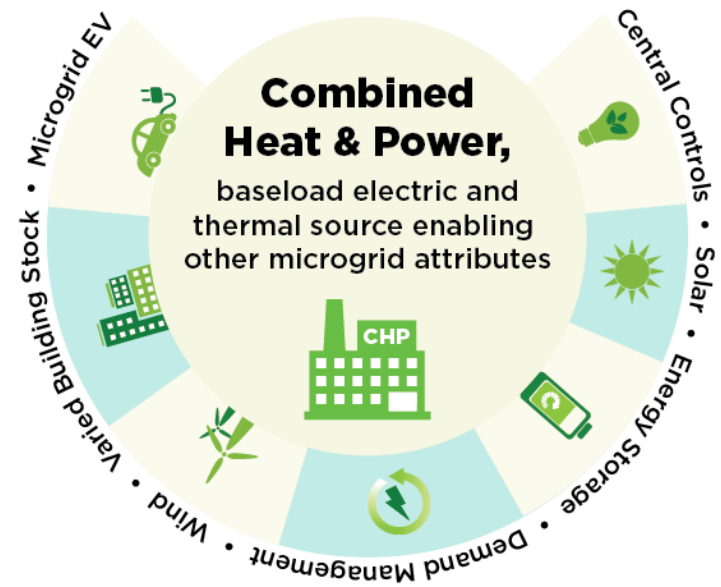
# CHP and Microgrids

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 larger utility grid to enable it to operate in both **grid-connected** or **island-mode**.

Source: U.S. Department of Energy Microgrid Exchange Group

- With a CHP system providing reliable baseload electric and thermal energy, microgrids can add renewables and storage
- Increased focus on resilience for critical infrastructure
  - Universities, Hospitals, Military bases, Communities

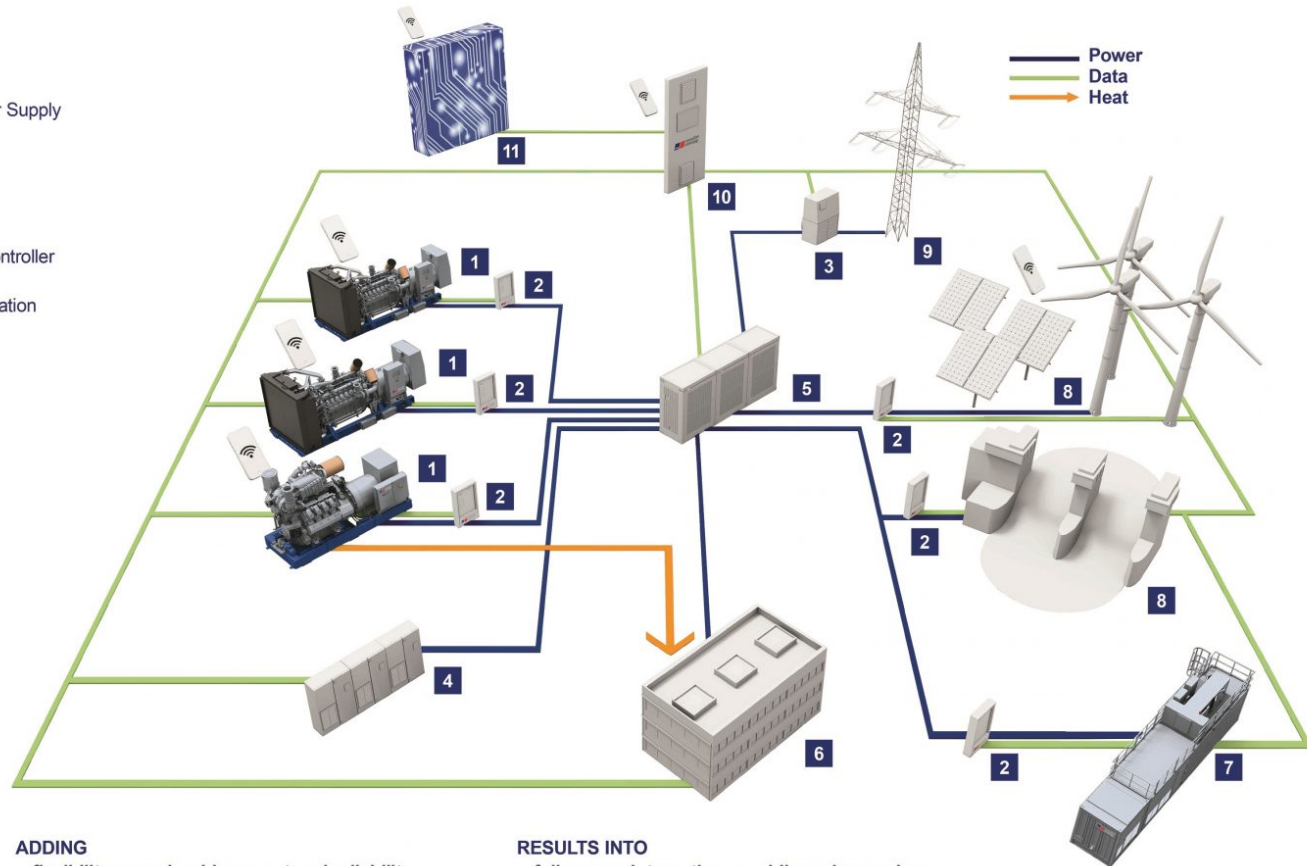


# “The Movement Toward Microgrids” – 2/20/19

<https://dieselturbine.com/the-movement-toward-microgrids/>

## The Power under the Hybrid Microgrids

1. Genset
  2. Circuit Breaker
  3. Main Breaker
  4. Uninterrupted Power Supply
  5. Switch Gear
  6. Load
  7. Energy Storage
  8. Renewables
  9. Main Supply
  10. Master/Microgrid Controller
  11. Intelligent System
- 📶 Wireless Communication

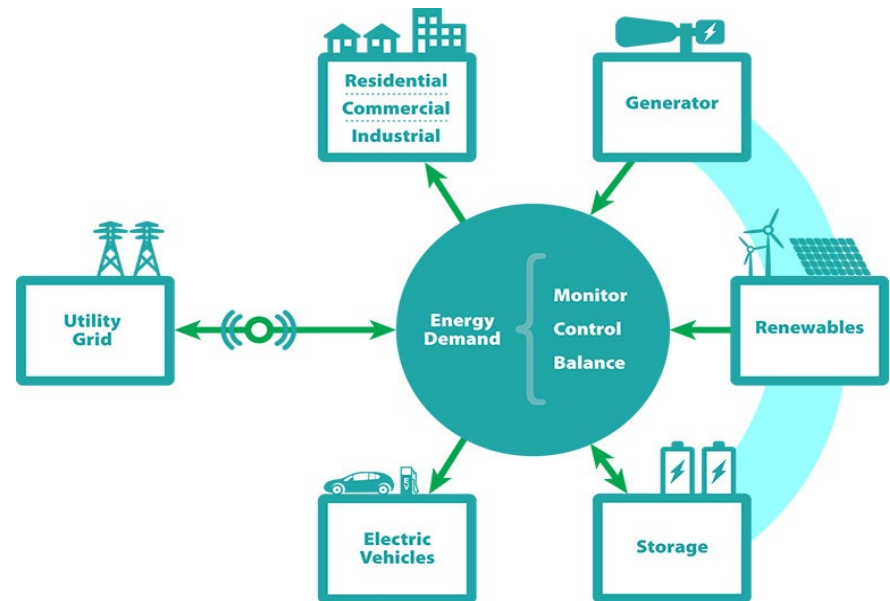


**ADDING**  
flexibility, speed, grid support and reliability  
by our diesel and gas gensets TO  
the renewable energy and storages

**RESULTS INTO**  
full energy integration providing a low-carbon,  
autonomous and distributed energy system

# Motivating factors for installing a microgrid

- Reliability / Constant Power
- Saving Money
- Energy Independence
- Grid Resiliency
- GHG Reductions
- Power Stability
- Decentralization
- Decarbonization
- Demand charge management
- Participating in Grid Services



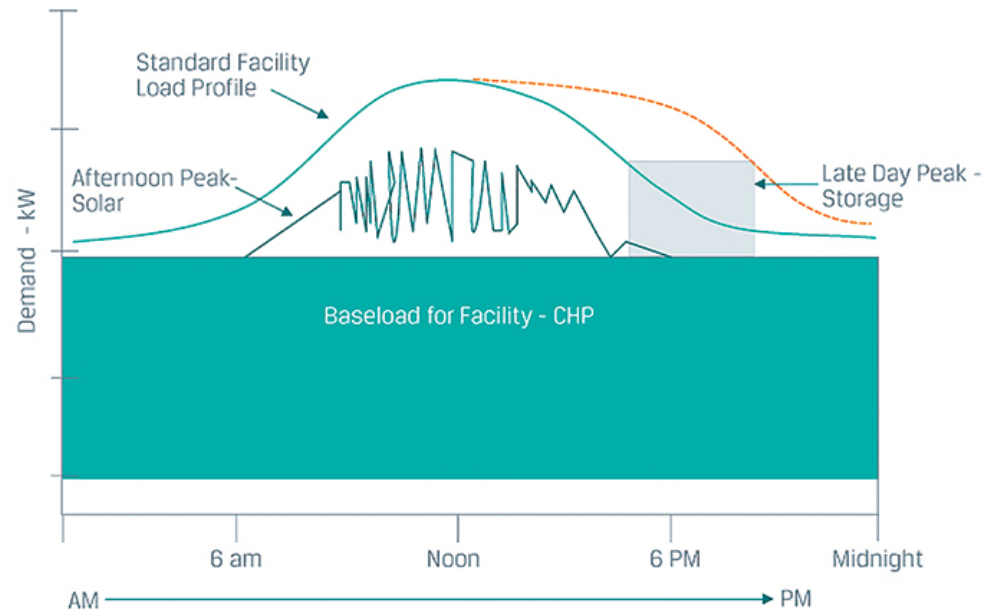
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Representation of Modern Microgrid

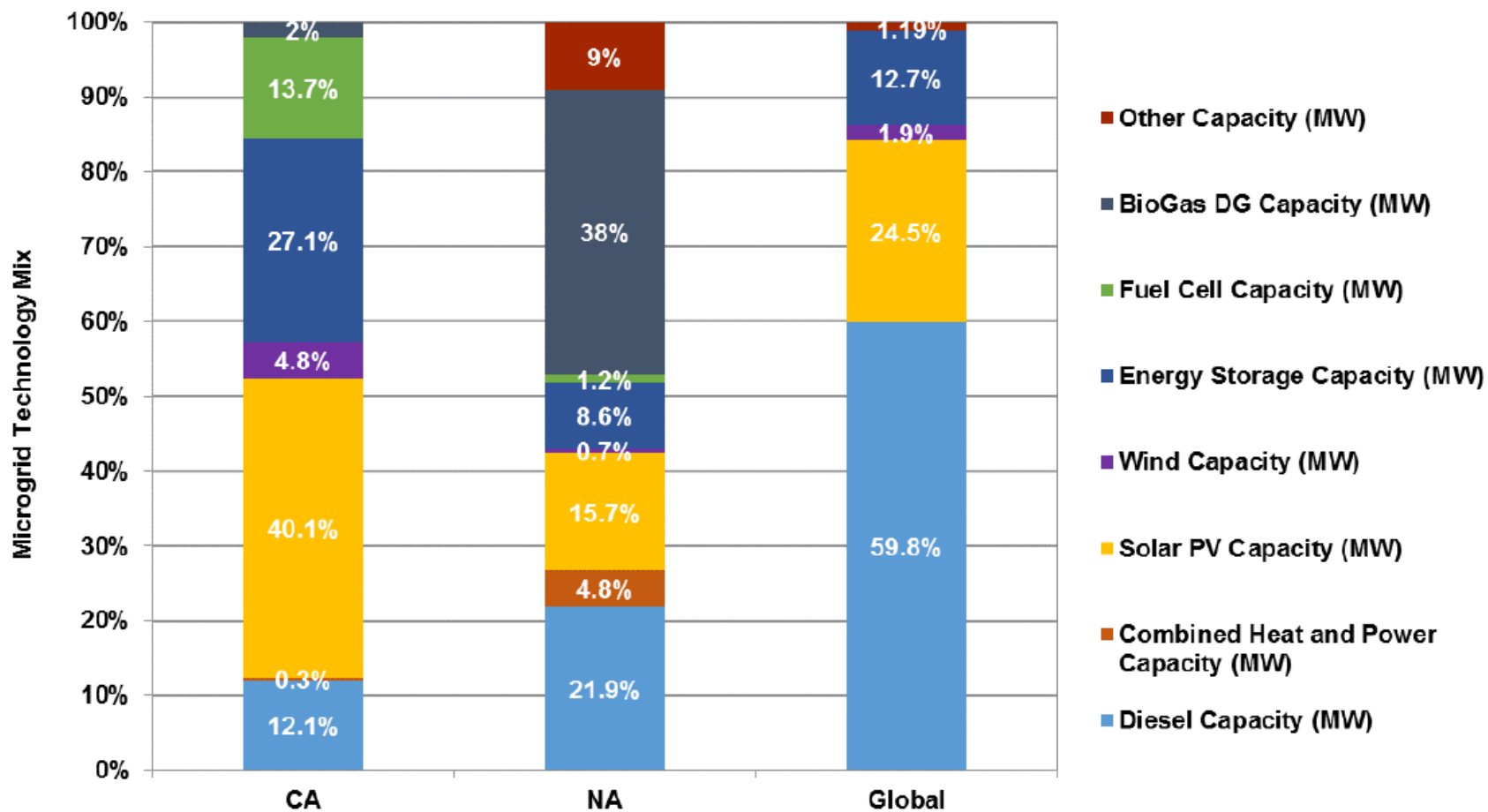
SOURCE: Center for Sustainable Energy

# Growth of Hybrid DER Systems

- Hybrid DER approaches offer the opportunity for technologies to complement one another
- Hybrid systems combine characteristics of individual technologies
  - CHP – provides baseload energy
  - Solar – variable renewable generation can now be “firmed”
  - Storage – adding flexibility
- Allows CHP to be a key part of the move toward a distributed/renewable grid



# Comparison of Microgrid DER Mix, by Region



“Microgrid Analysis and Case Studies Report: California, North America, and Global Case Studies”,  
 CA Energy Commission Report Provided by Navigant Consulting, August 2018



# CHP Microgrid Snapshot:

## Naval Air Station (NAS) Miramar

- 6.5 MW diesel / natural gas CHP
- 3.2 MW landfill gas CHP
- 3 MW energy storage
- 1.3 MW solar PV
- 390 kW ZnBr flow batter
- 157 kW thermal energy storage
- EV charging station controller
- Vehicle-to-Grid Integration (VGI)
- SCADA System upgrades
- Advanced microgrid controller



Source: Photo by Dennis Schroeder / NREL



Source: Photo By [Cpl. Christopher Johns](#)

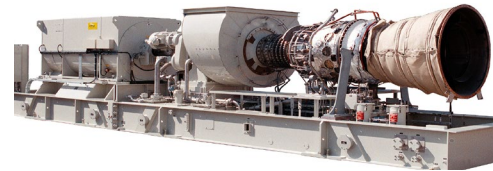


Source: ESTCP

# CHP Microgrid Snapshot:

## UCSD Microgrid

- 27 MW Natural Gas Turbine CHP
- 2.8 MW Directed Biogas Fuel Cell
- 2.5 MW / 5MWh Battery Storage
- Thermal Driven Cooling Loop
- Chilled Water Storage w- Smart Control
- Backup Gensets & UPS
- Vehicle-to-Grid Integration (VGI)



# CHP Microgrid Snapshot:

## SMUD Microgrid at Central Utility Plant

- Three 100 kW engine inverter based CHP units
- 10 kW solar PV
- 128 ton absorption chiller
- Chilled water storage
- Smart Switch



# Project Snapshot:

## University Campus

University of Minnesota

Minneapolis, MN



**Application/Industry:** University Campus

**Capacity:** 25 MW

**Prime Mover:** Combustion turbine

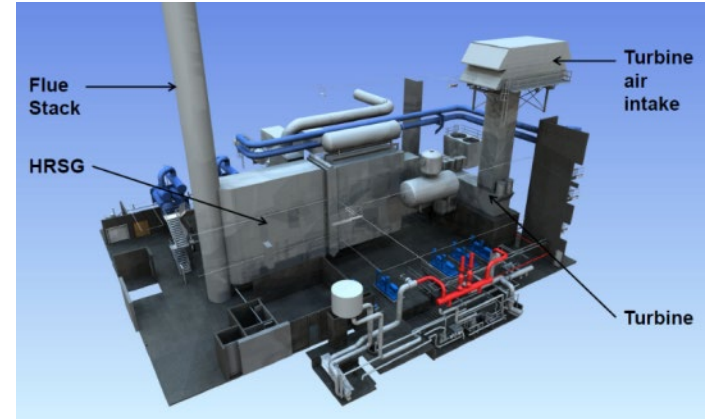
**Fuel Type:** Natural gas

**Thermal Use:** Steam, heating, cooling

**Installation Year:** 2017

**Highlights:** The CHP system decreases the Twin Cities Campus carbon footprint by 15% and provides an 8-year return on investment. The 25 MW system heats the entire campus and meets half of its electricity demand.

**Testimonial:** *“We see CHP as a way to be competitive with other schools and to protect research if we had a catastrophe.”*  
- Jerome Malmquist, University Director of Energy Management



Rendering of turbine and heat recovery steam generator.



Minimal changes will need to be made to the existing building's exterior.

Source: <http://www1.umn.edu/regents//docket/2012/february/heatandpower.pdf>  
<http://midwestenergynews.com/2014/12/02/university-turns-to-combined-heat-and-power-for-climate-goals/>



CHP Technical Assistance Partnerships

MIDWEST

# Project Snapshot:

## Co-firing Biomass

**University of Iowa**  
Iowa City, IA



**Application/Industry:** University

**Capacity:** 25.5 MW

**Prime Mover:** Steam turbine

**Fuel Type:** Coal, oat hulls, wood chips, giant miscanthus

**Thermal Use:** Space heating and electricity

**Installation Year:** 1947

**Highlights:** As early as 1947, the University introduced CHP into its central plant, utilizing coal to produce high pressure steam. The steam was used to generate electricity and provide for thermal loads at the University through the use of extraction steam turbines. The CHP plant at the University of Iowa continues today to supply 100% of the campus heat and 30% of the campus electrical demand.



Source:

<http://www.midwestchtpap.org/profiles/ProjectProfiles/UniversityofIowa.pdf>



U.S. DEPARTMENT OF ENERGY  
CHP Technical Assistance Partnerships

# Project Snapshot:

## Green University Campus



University of Missouri

Columbia, MO

**Application/Industry:** University Campus

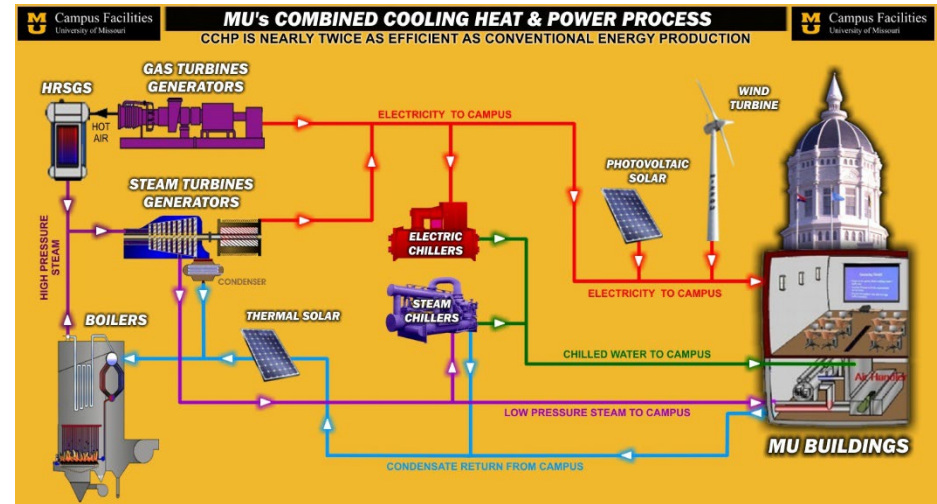
**Capacity:** 99.5 MW

**Prime Mover:** Steam turbines, gas turbines

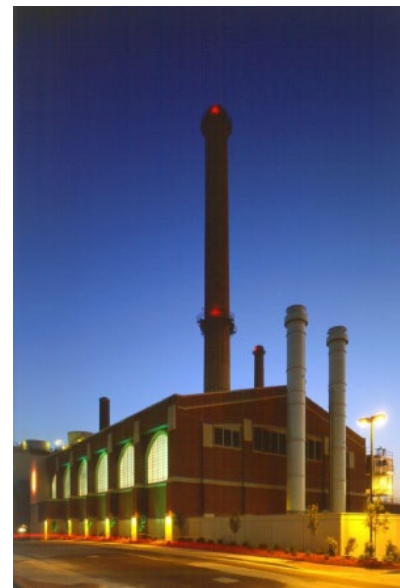
**Fuel Type:** Biomass

**Thermal Use:** Steam, heating, cooling

**Installation Year:** 1961



**Highlights:** MU has been producing energy using various forms of CHP since 1892. The plant serves a wide variety of campus buildings and facilities, including two hospitals, a veterinary teaching hospital, a research reactor, numerous research facilities and laboratories, as well as classroom buildings, residence halls, dining facilities, athletic facilities, computer centers, and administrative buildings. The university recently replaced one of its coal-fired boilers with a 100% biomass-fired boiler integrated with the existing steam turbines, reducing coal use by 54%.



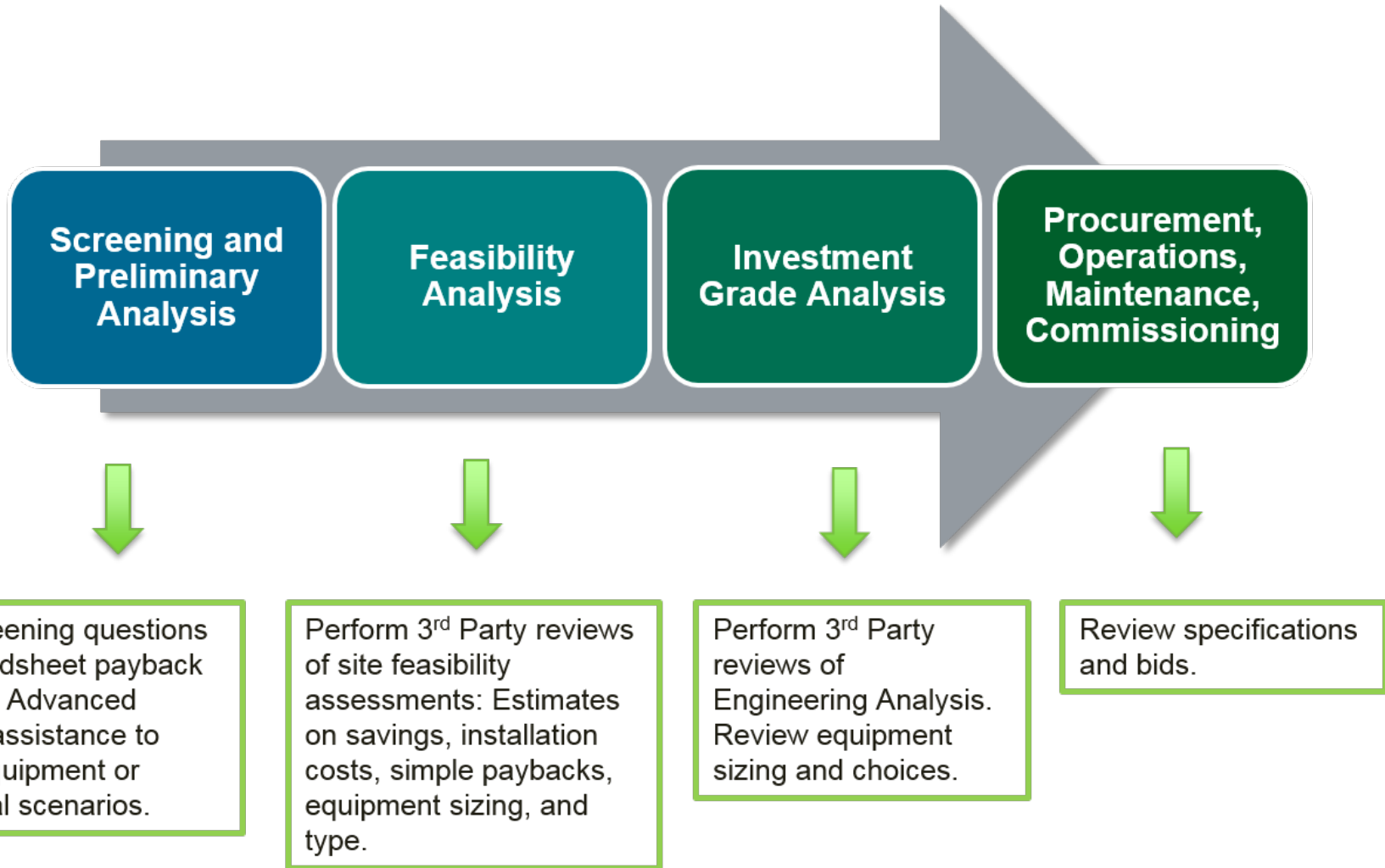
Source:

- [www.energy.gov/chp-installs](http://www.energy.gov/chp-installs)
- [www.epa.gov/chp/our-partners](http://www.epa.gov/chp/our-partners)
- [www.cf.missouri.edu/cf/em/eff](http://www.cf.missouri.edu/cf/em/eff)

Slide prepared 6/2017

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

# CHP TAP Role: Technical Assistance







# CHP Project Resources

## DOE Project Profile Database

The screenshot displays two project profiles from the DOE Project Profile Database. The top profile is for the East Bay Municipal Utility District (EMUD) 11-MW CHP System, located in California. It includes a 'Quick Facts' section with details on location, capacity (11 MW), and equipment. The bottom profile is for the North Carolina State University 11 MW CHP & District Energy System, located in North Carolina. It also includes a 'Quick Facts' section with details on location, capacity, and equipment. Both profiles feature images of the respective CHP plants and descriptions of their operations and benefits.

## EPA dCHPP (CHP Policies and Incentives Database)

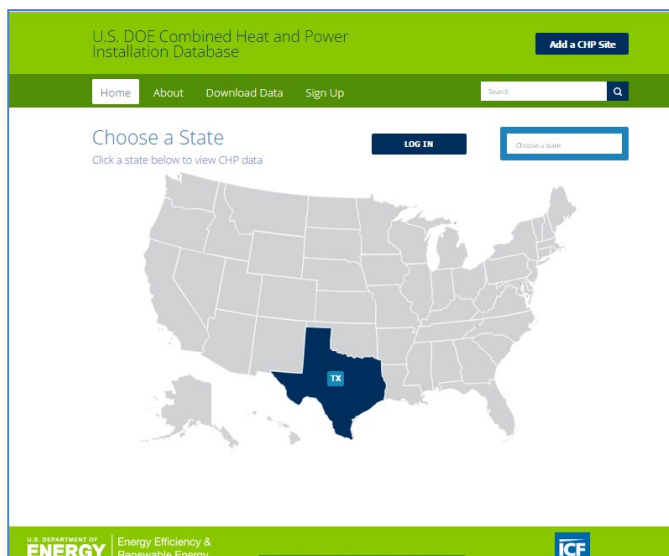
The screenshot shows the EPA dCHPP (CHP Policies and Incentives Database) website. The header includes the EPA logo and navigation links for Environmental Topics, Laws & Regulations, and About EPA. The main content area is titled 'Combined Heat and Power (CHP) Partnership' and features a search bar. Below the search bar, there are sections for 'About Us', 'Discover CHP', 'Project Development', 'Energy Star CHP Awards', 'Webinars and Presentations', 'Documents and Tools', and 'Frequent Questions'. The 'Discover CHP' section provides an overview of the database and lists key features, such as the ability to search for CHP policies and incentives by state or at the federal level. It also mentions that the database contains definitions for policy and incentive types.

[energy.gov/chp-projects](http://energy.gov/chp-projects)

[www.epa.gov/chpdchpp-chp-policies-and-incentives-database](http://www.epa.gov/chpdchpp-chp-policies-and-incentives-database)

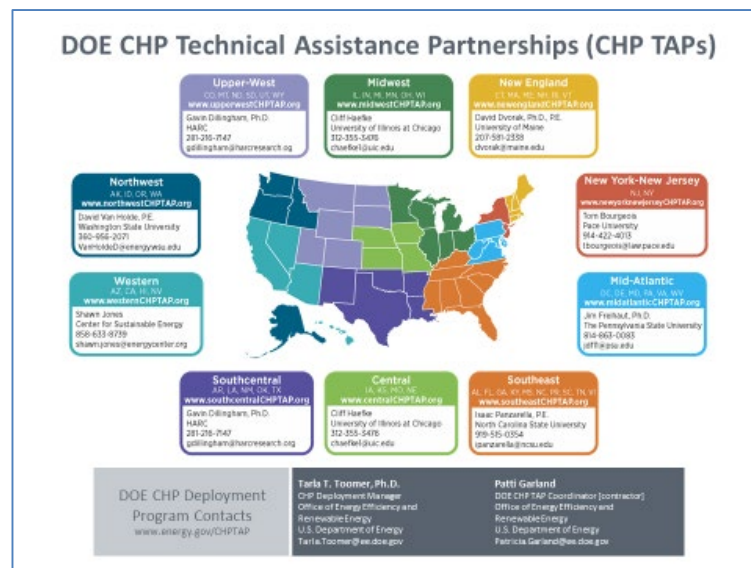
# CHP Project Resources

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



[energy.gov/chp-installs](http://energy.gov/chp-installs)

Low-Cost CHP Screening and  
Other Technical Assistance from  
the CHP TAP



[energy.gov/CHPTAP](http://energy.gov/CHPTAP)

# Summary

- CHP gets the most out of a fuel source, enabling
  - High overall utilization efficiencies
  - **Reduced environmental footprint**
  - **Lower overall emissions**
- There is a lot of technical potential for CHP at Illinois colleges/universities but...
- CHP projects at colleges/universities must be seen as helping promote campus climate goals
- Hybrid renewable CHP systems along with CHP centered microgrids offer campuses environmental, economic and resiliency benefits

# Next Steps

- Contact Midwest CHP TAP for assistance if:
  - Interested in having a Qualification Screening performed to determine if there is an opportunity for CHP at your site
  - If you already have an existing CHP plant and interested in expanding it
  - Need an unbiased 3rd Party Review of a proposal
  - If you want to explore how CHP can help your campus reduce emissions to achieve climate goals

# Thank You

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