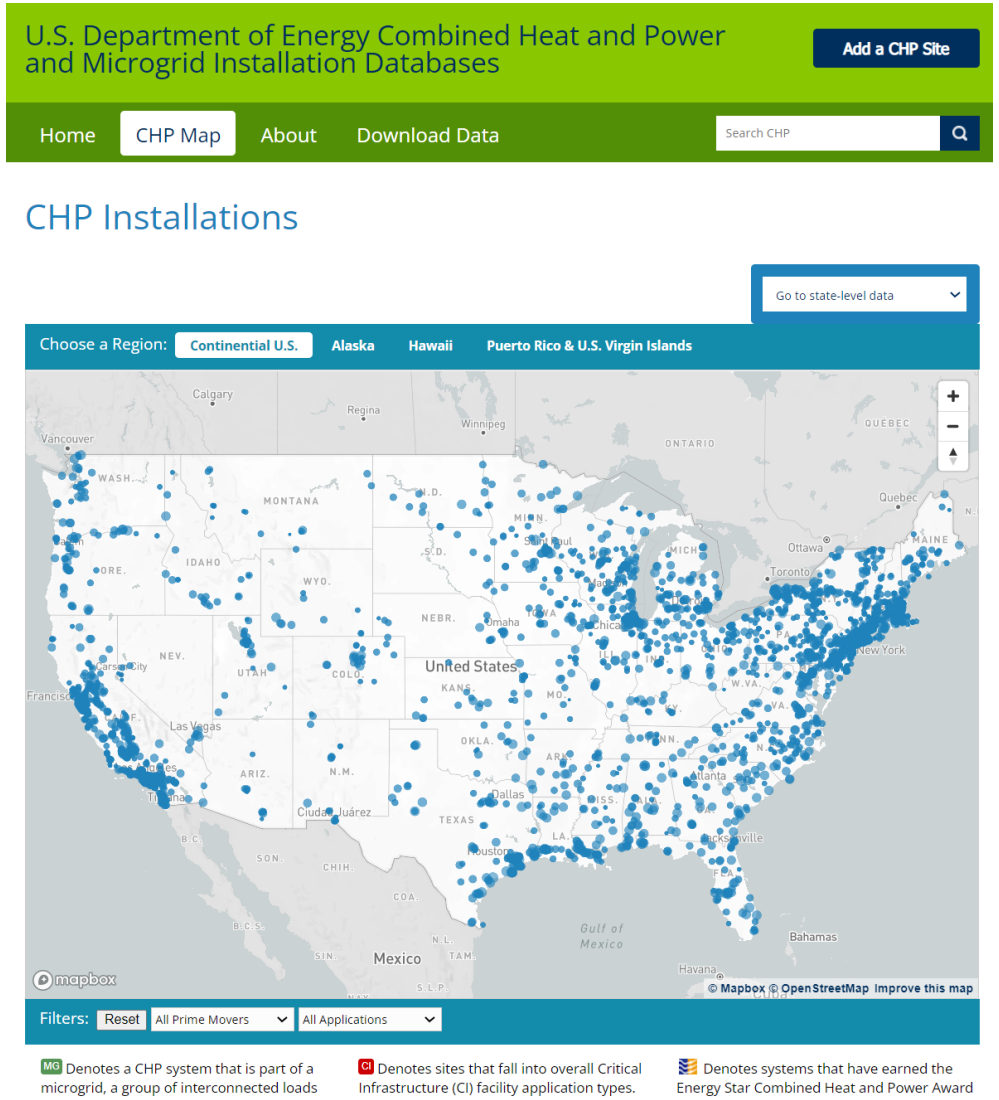
CHP: State of the U.S. Market

Data Summary & Trends

11/17/2022

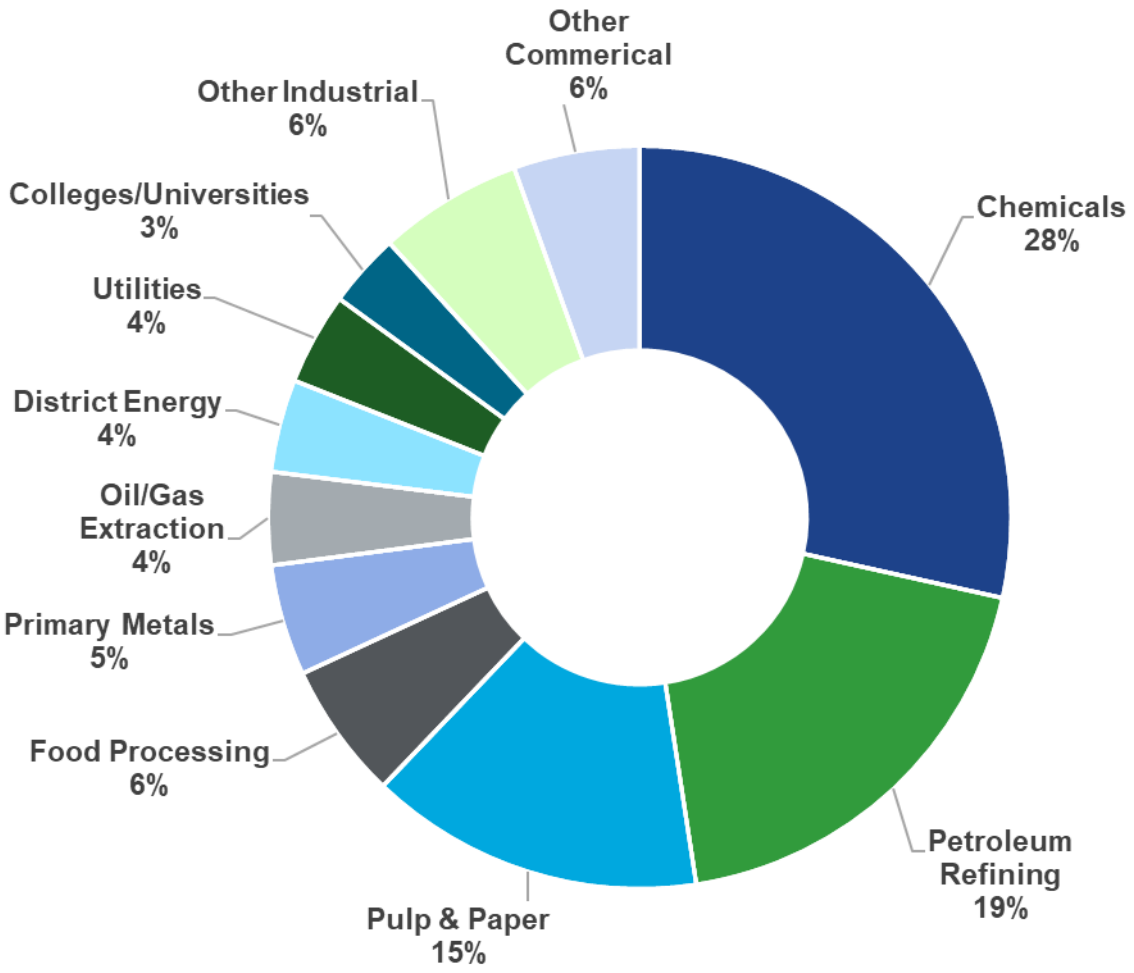
Annual Update of CHP Installation Database

- **ICF**, contracted to the U.S. Department of Energy through Oak Ridge National Laboratory, collects information on CHP installations and retirements on an ongoing basis
- Data is collected, verified, and added to the **CHP Installation Database**, hosted online at: https://doe.icfwebservices.com/chp
- Information on the following slides is based on data found in the CHP Installation Database



CHP Installations Today in the United States

Existing CHP Capacity (81.5 GW)



Avoids **1.3 Quadrillion Btus** of fuel consumption annually.

Avoids **218 million tons of CO^2** compared to separate production.

81.5 GW of installed CHP at more than **4,700** industrial and commercial facilities.

7% of U.S. electric generating capacity; 13% of generation.

Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

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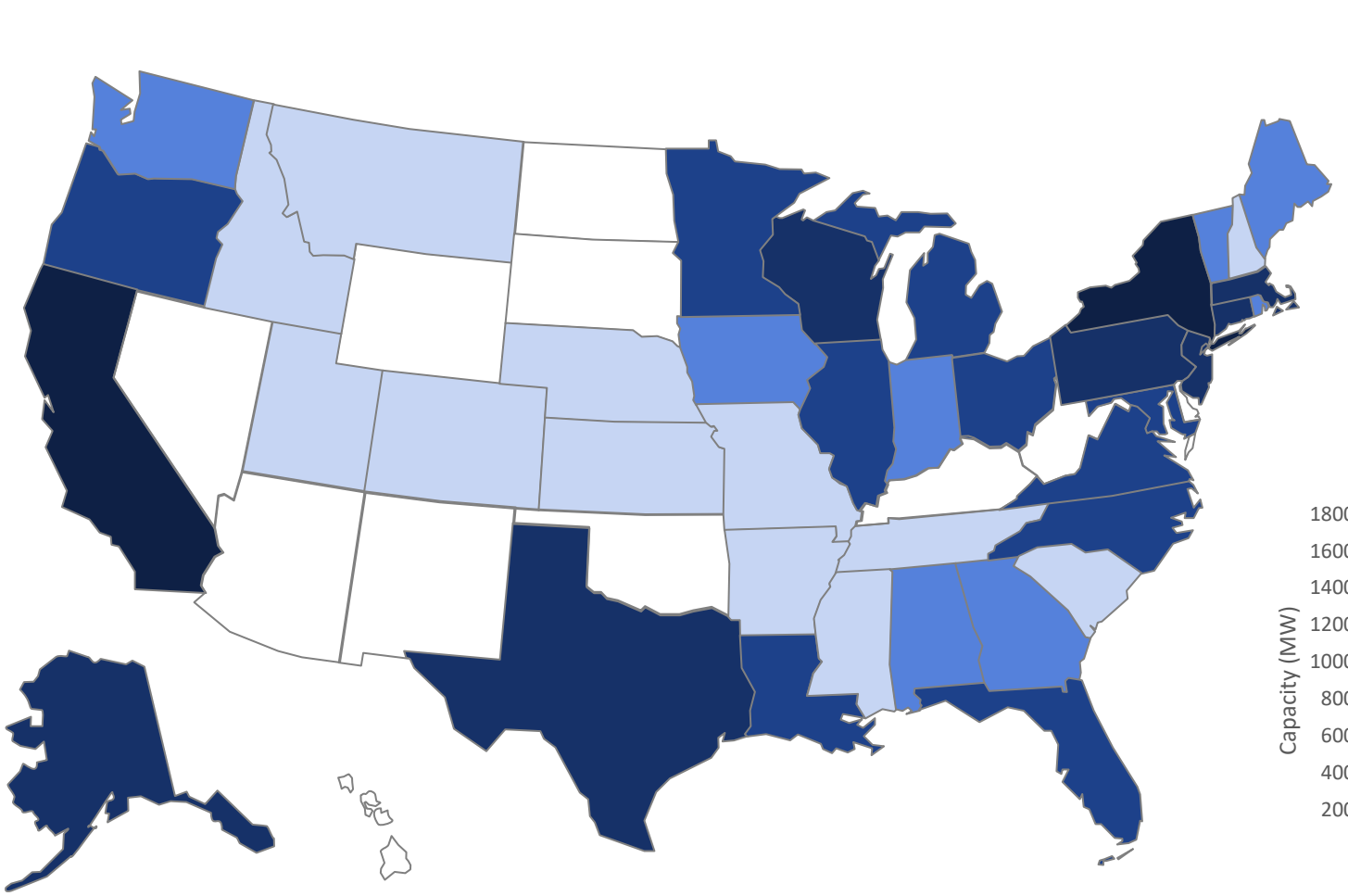
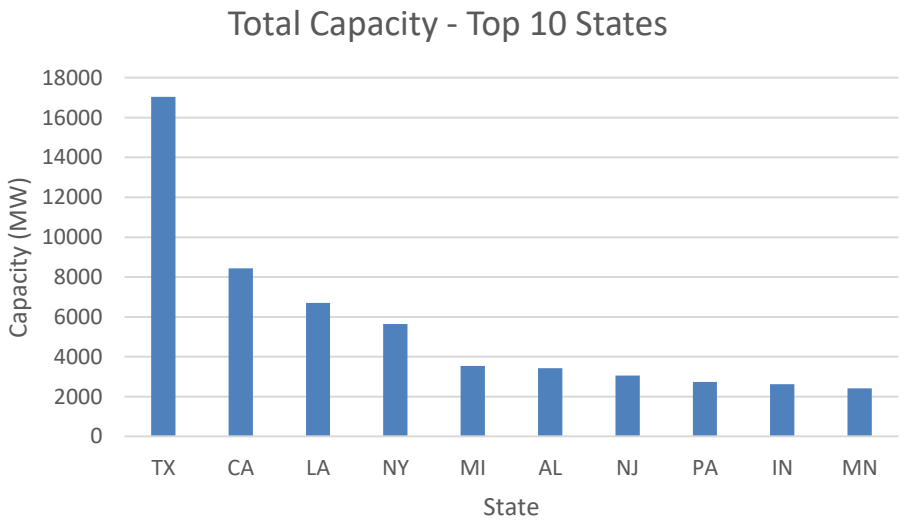
Existing U.S. CHP Installations by Sites and Capacity





Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

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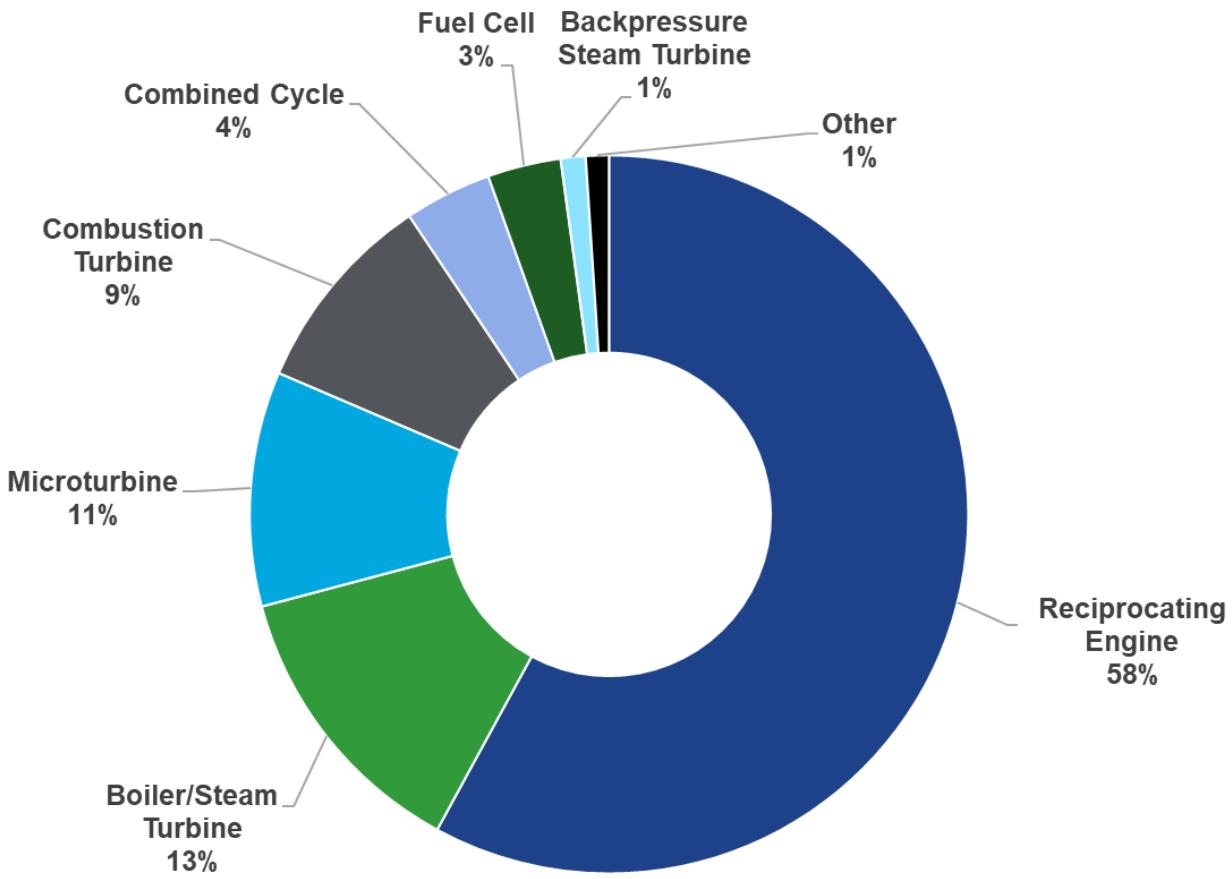
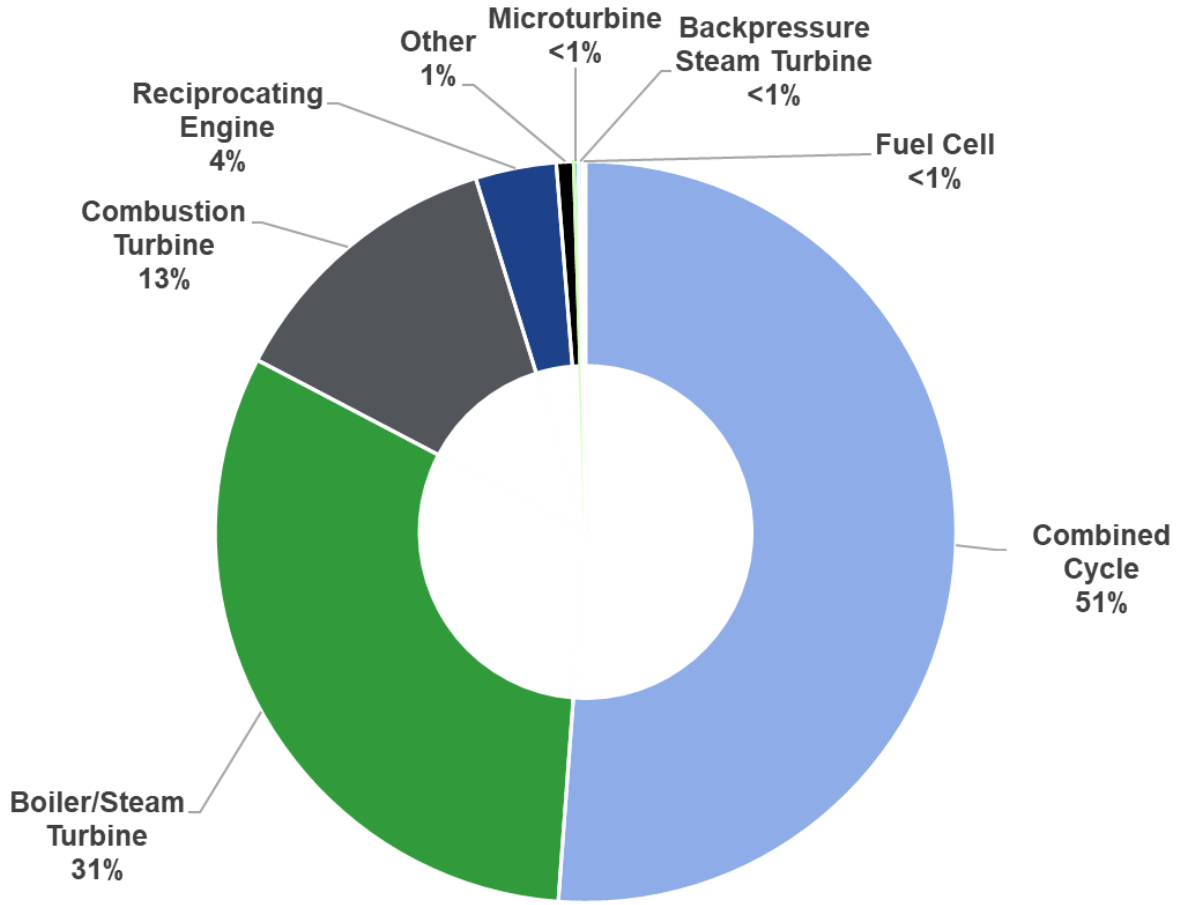
Existing CHP by Technology

By Site – 4,743 Sites



By Capacity – 81.5 GW



Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

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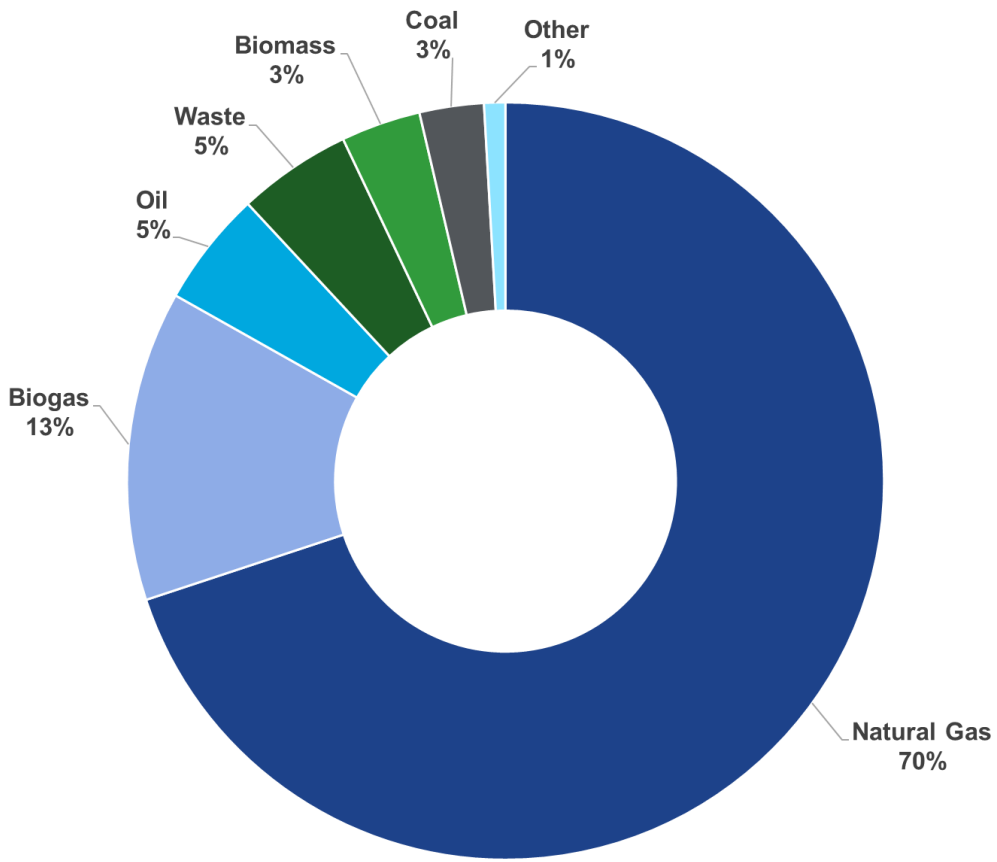
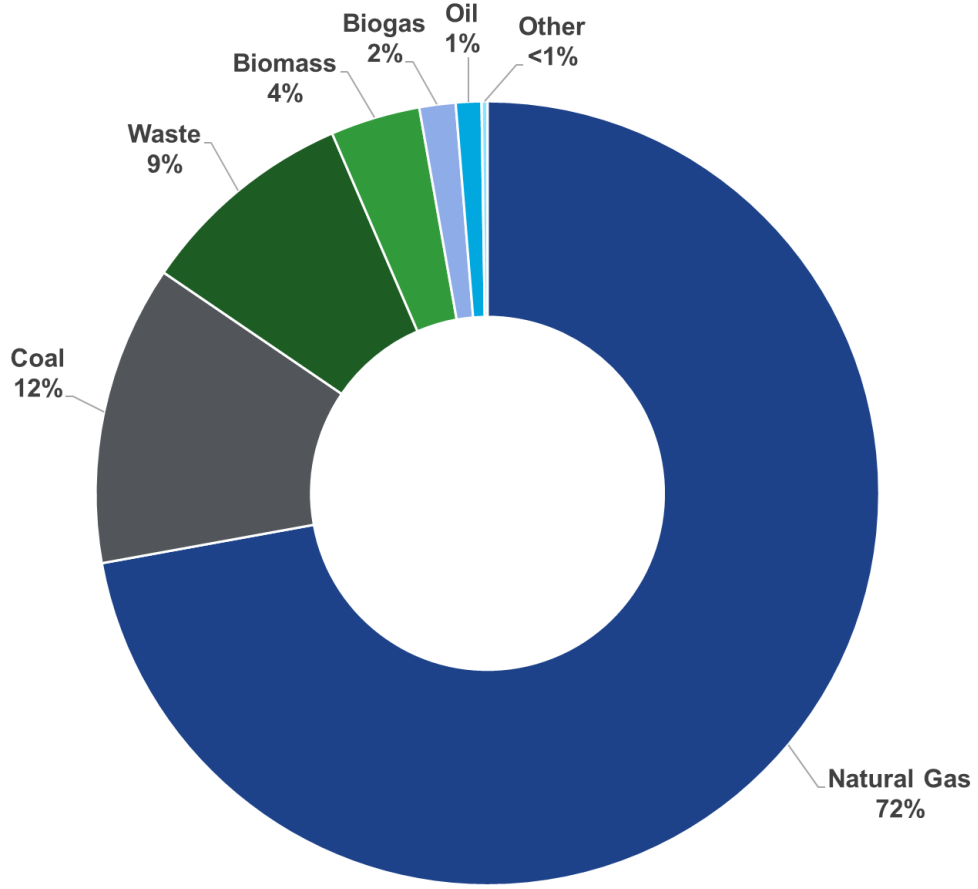
Existing CHP by Fuel Type

By Site – 4,743 Sites



By Capacity – 81.5 GW



Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

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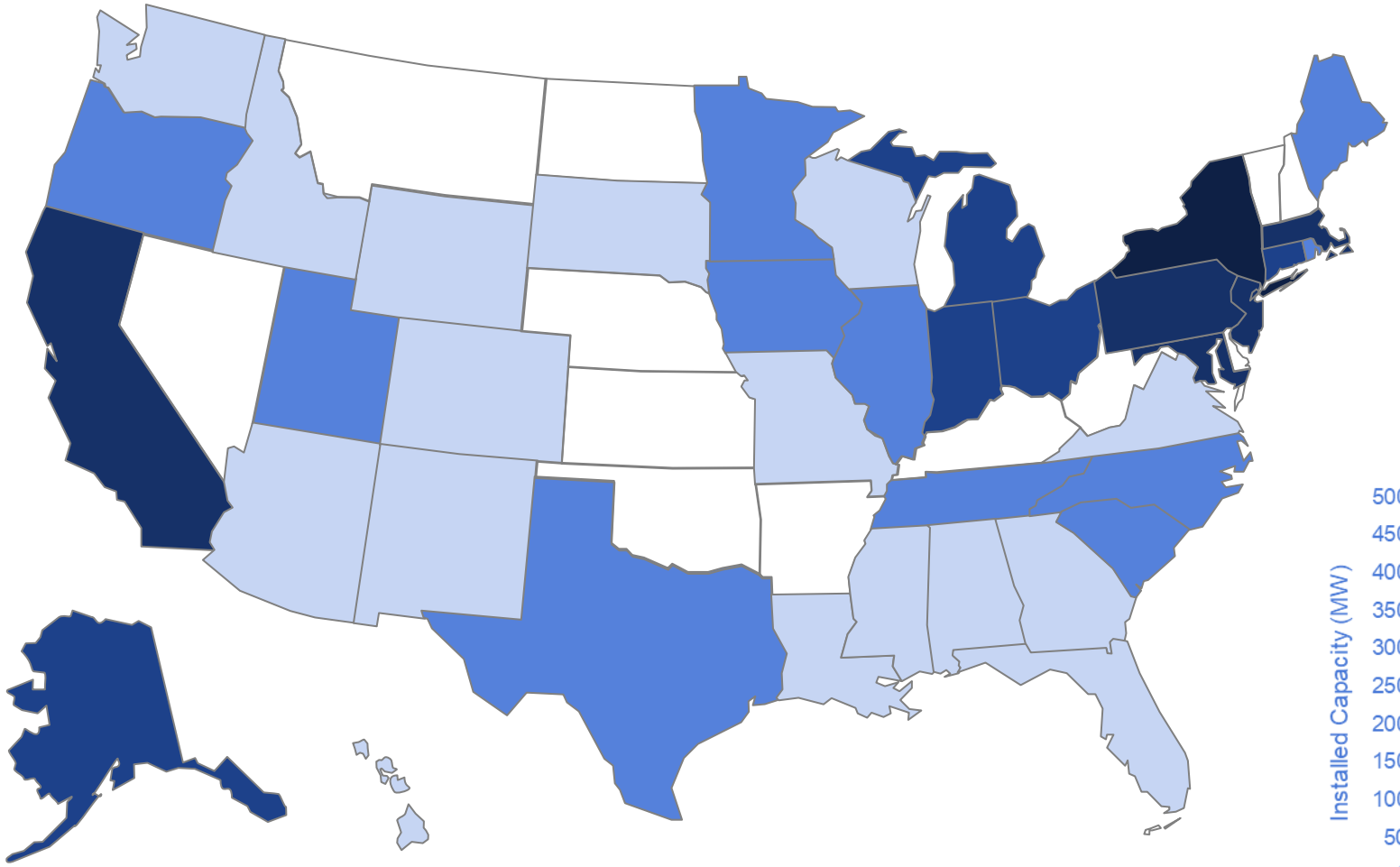
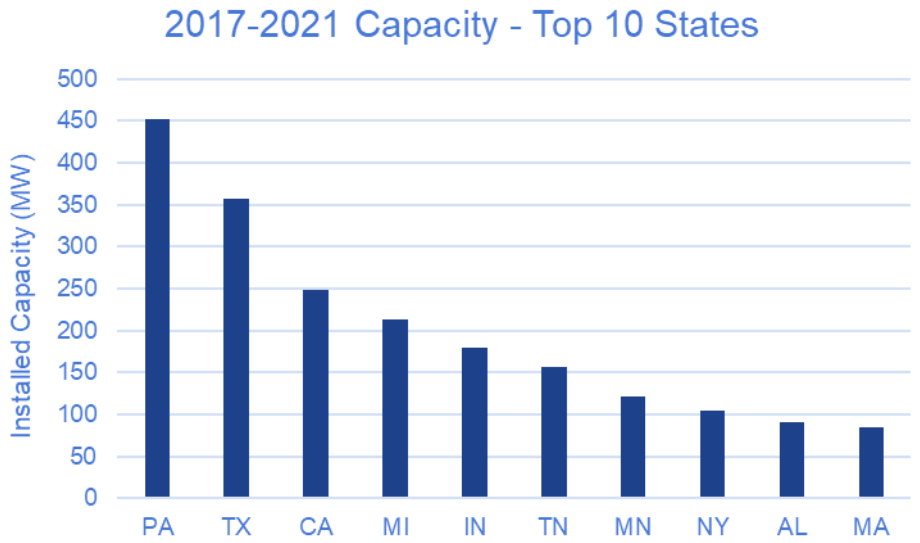
2017 - 2021 U.S. Combined Heat and Power Installations



- 0-1 installation
- 2-4 installations
- 5-9 installations
- 10-19 installations
- 20-99 installations
- >100 installations



Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

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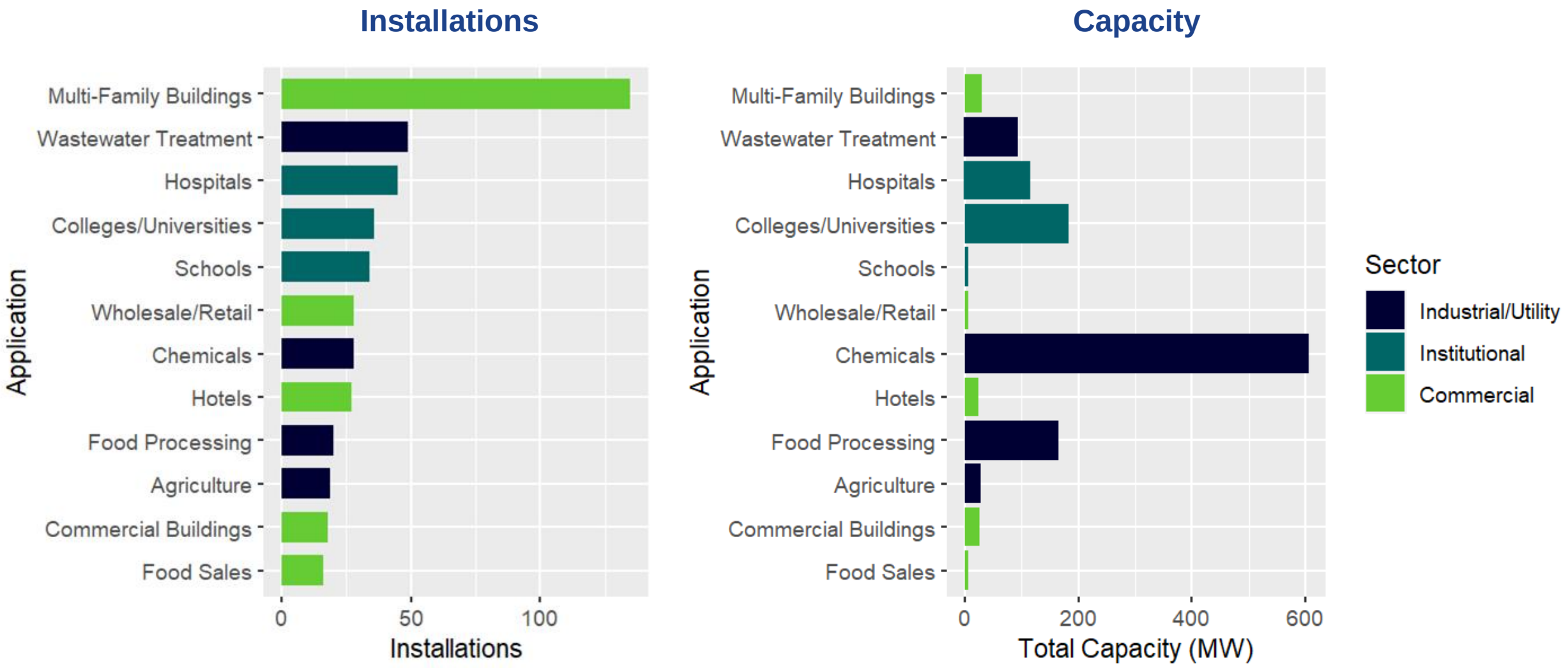
2017 - 2021 CHP Installations by Application



Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

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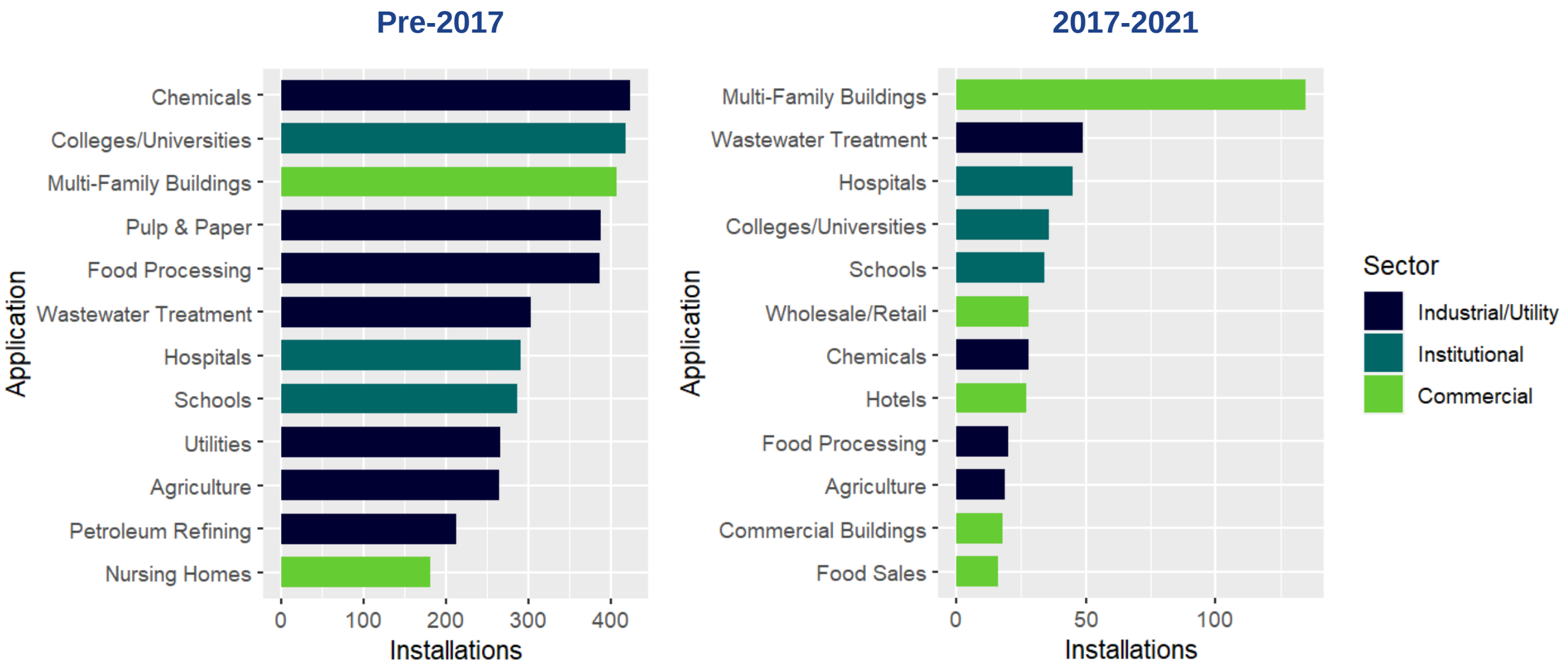
Top 12 Market Sectors – Pre-2017 vs. 2017-2021 (Installations)



Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

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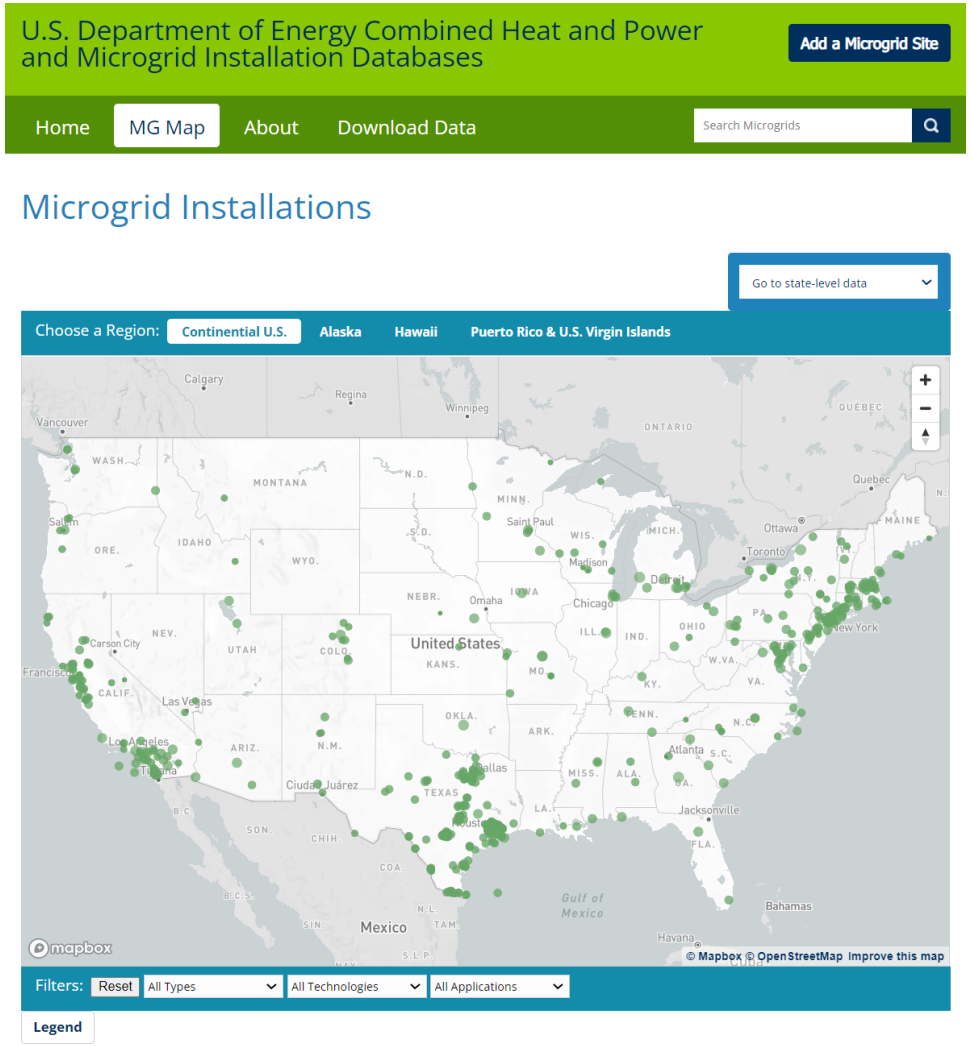
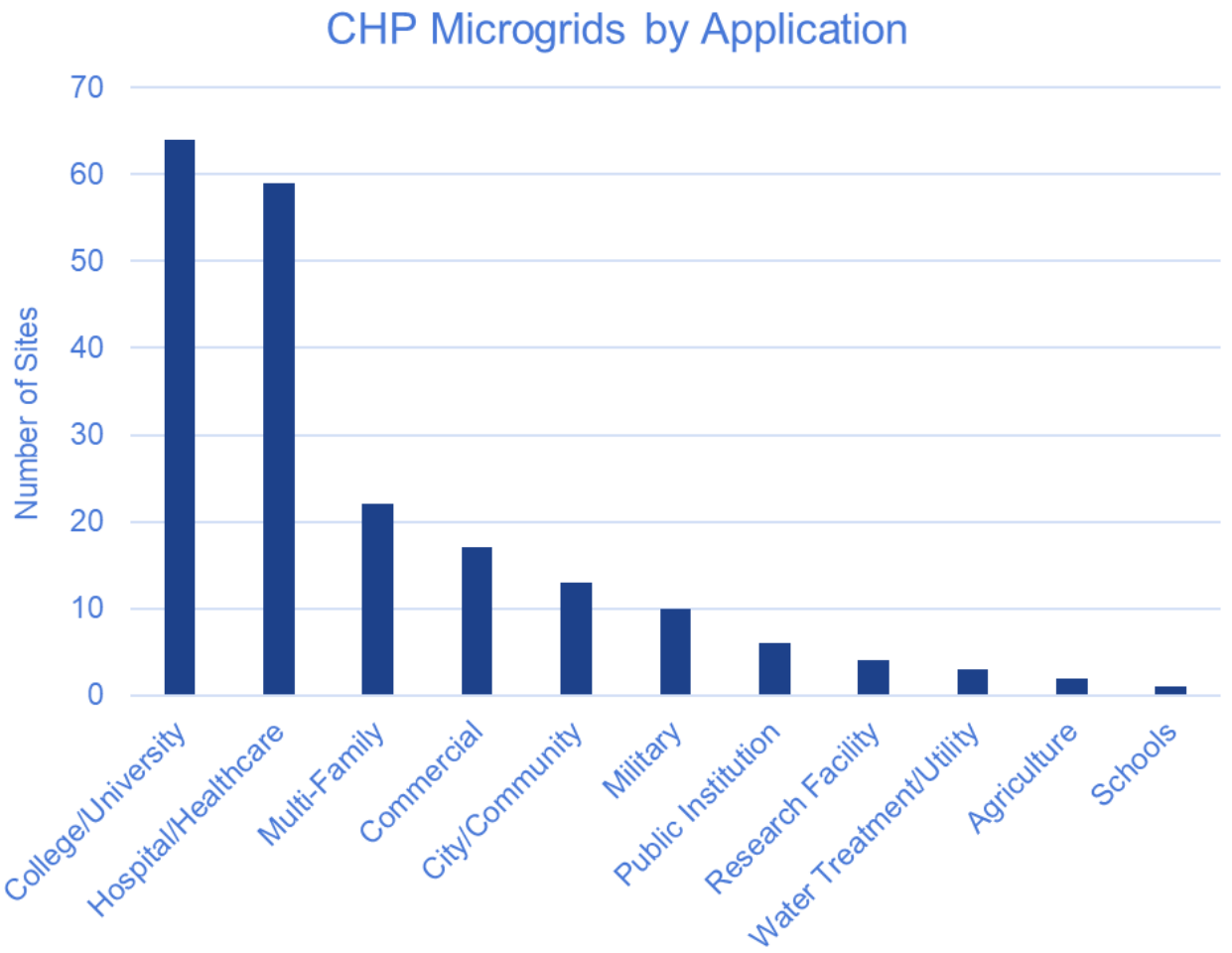
Microgrids

- Some CHP installations are part of a **microgrid,** and are included in the **Microgrid Installation Database**
- ***Microgrid:*** a network of distributed energy resources and loads that can disconnect and re-connect to the larger utility grid as a single entity, allowing the connected loads to be served during utility outages. Microgrids can also be found in remote locations where they may not be connected to a larger grid. *Definition from DOE Microgrid Installation Database*



CHP Enables Resilient Microgrids

- CHP provides reliable baseload heat and power, and can act as a resilient anchor for microgrids connecting multiple technologies and loads
- **>200 microgrids with CHP in U.S.**
  - Total capacity: 2.8 GW
  - 2.4 GW (85%) from CHP
- CHP is most often used for microgrids at colleges/universities and hospitals
  - Over 120 microgrids between the two sectors



Source: DOE Microgrid Installation Database, as of July 2022

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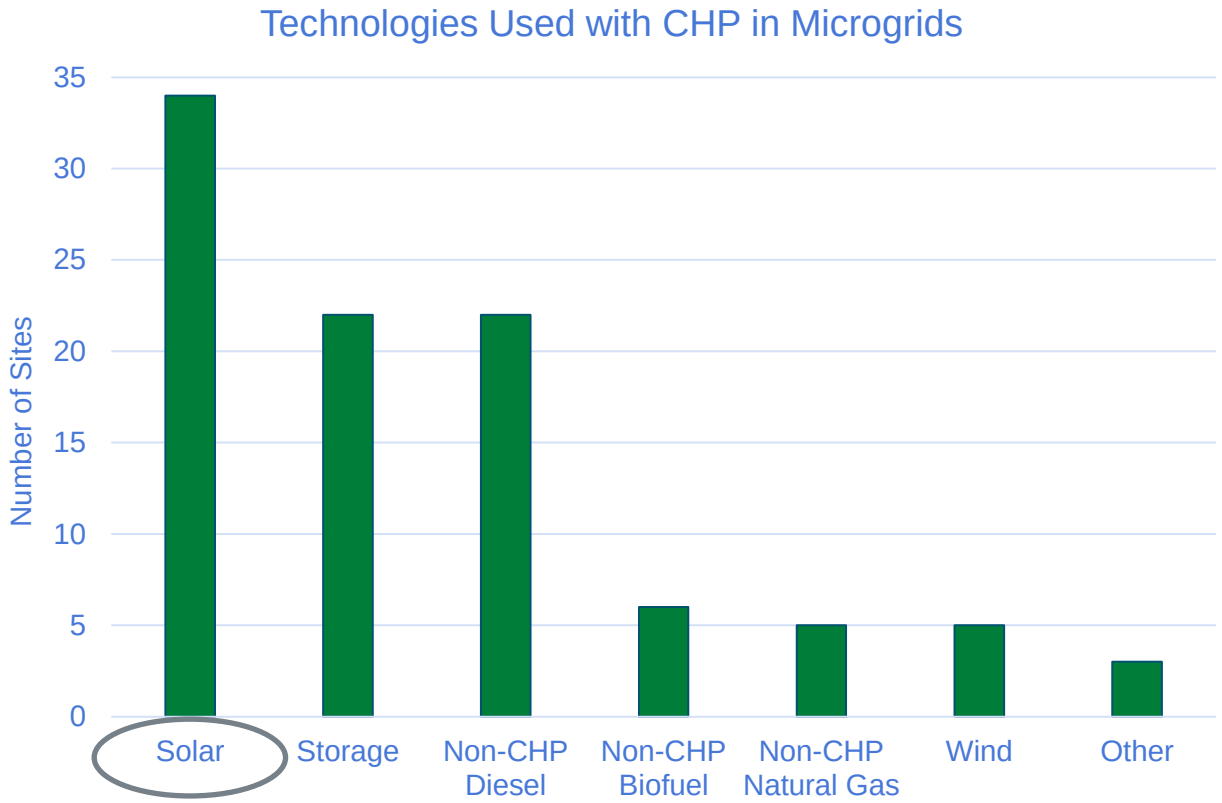
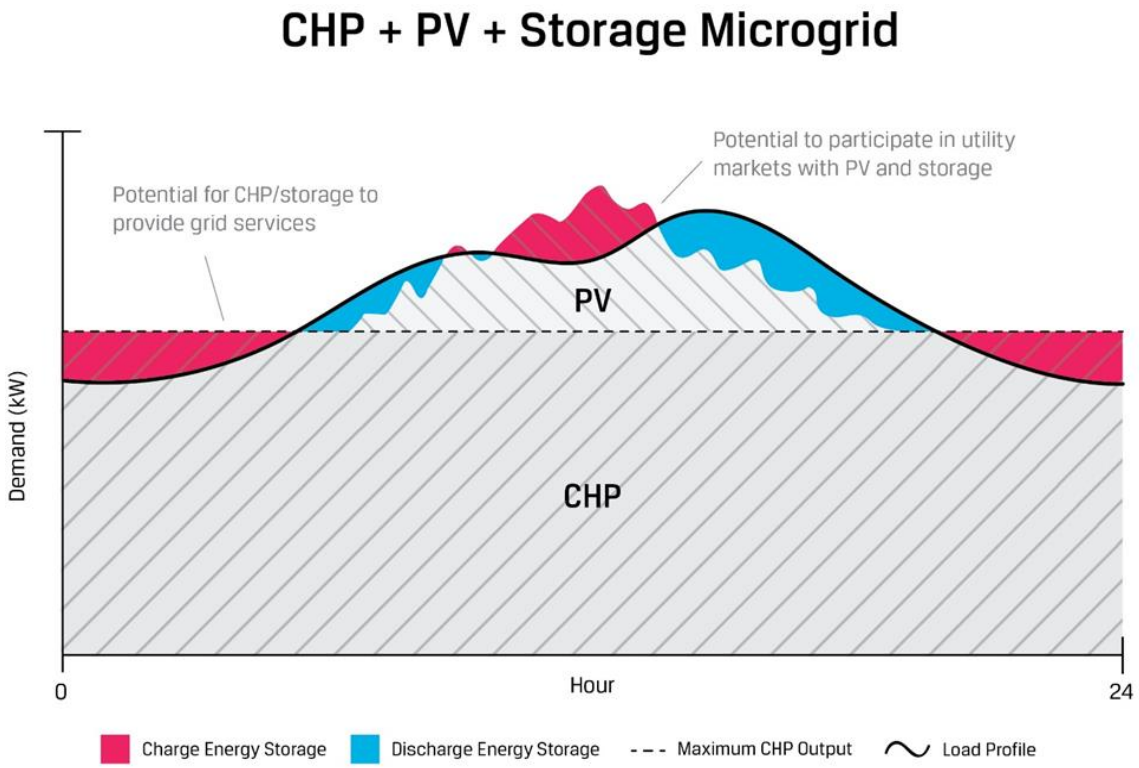
Hybrid On Site Generation Solutions for Microgrids with CHP

In microgrids, CHP is most often paired with solar PV, energy storage, and backup diesel generators





Source: DOE Microgrid Installation Database, as of July 2022

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Trends in the CHP Market

Microgrids and Hybrid CHP

- CHP working in conjunction with other technologies to deliver resilient power and heat for critical loads

Packaged CHP

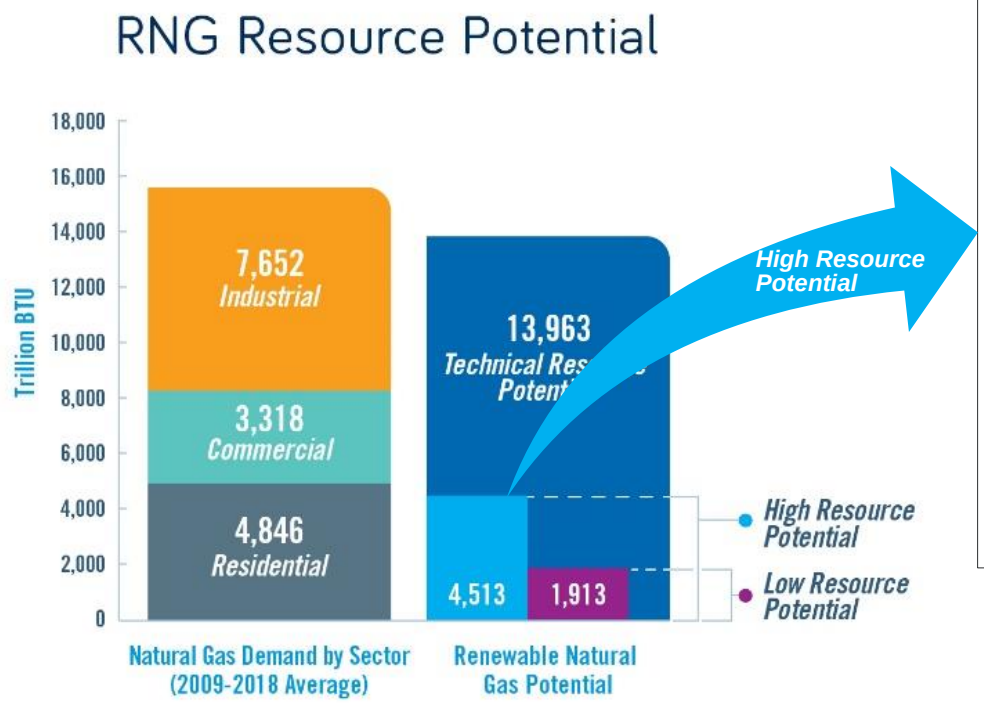
- Pre-engineered packages with standard inputs and outputs
- Reduces installation costs and timeframes

Decarbonization

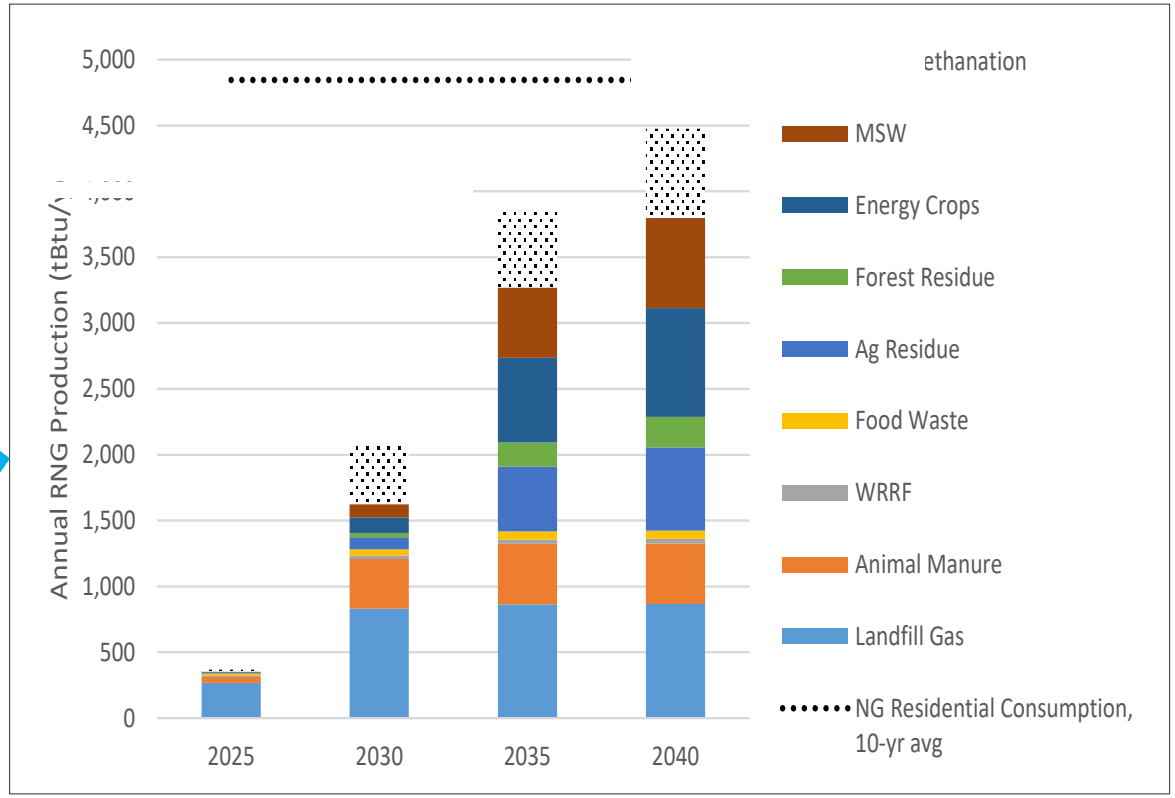
- CHP reduces emissions compared to separate heat and utility power
- As regional power grids go green, CHP can incorporate **Renewable Natural Gas (RNG)** and **Hydrogen** to continue reducing carbon emissions

Renewable Natural Gas (RNG) Resource Potential

- High resource case: 4.5 Tcf of RNG by 2040
- Represents 60% of current industrial natural gas use
- Cost competitive with other emission reduction strategies, $55-300/ton of GHG emission reductions

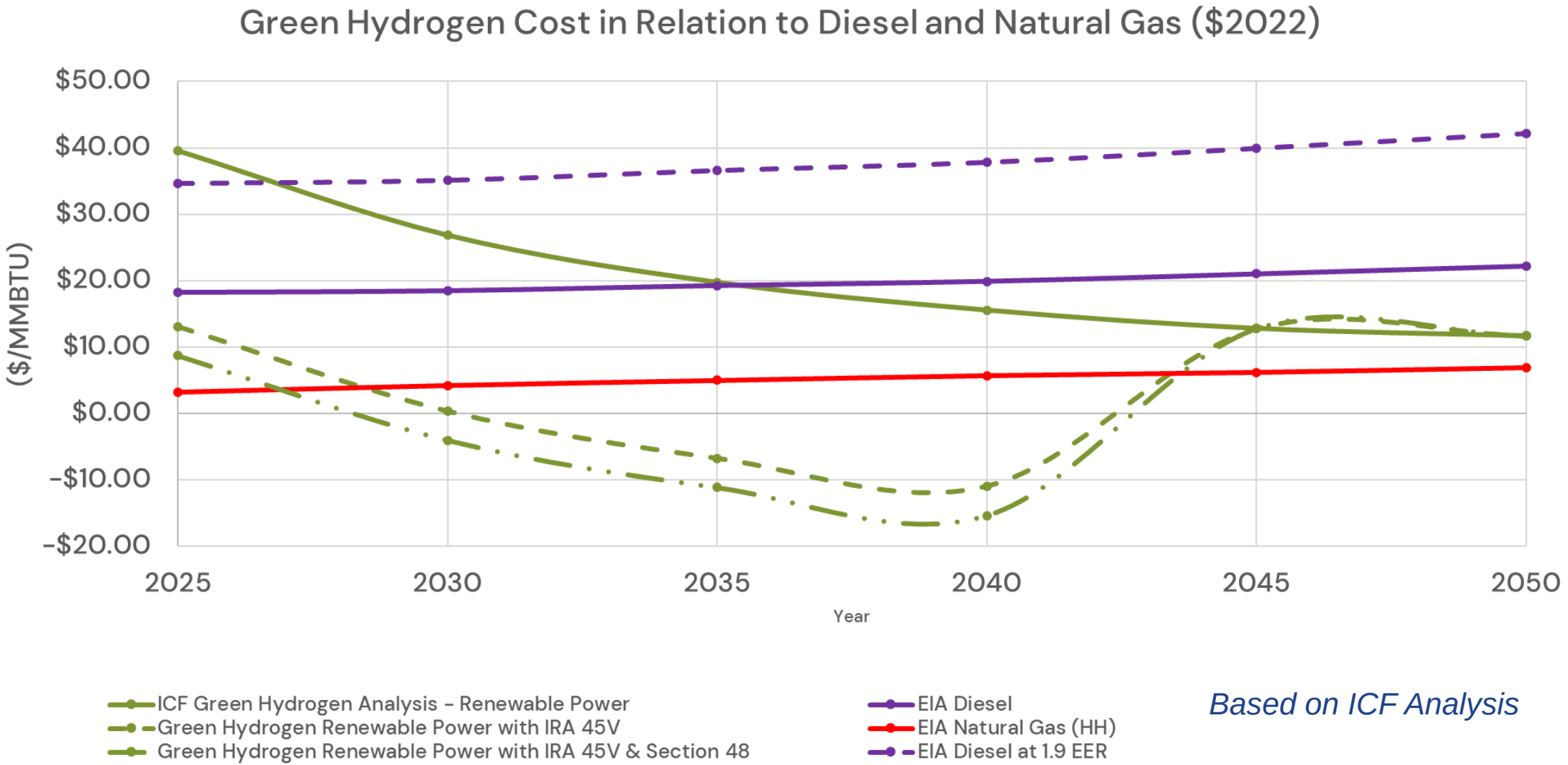


Estimated Annual Production



Source: AGA Foundation, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, 2019, conducted by ICF

Inflation Reduction Act will make Green Hydrogen Cost Effective

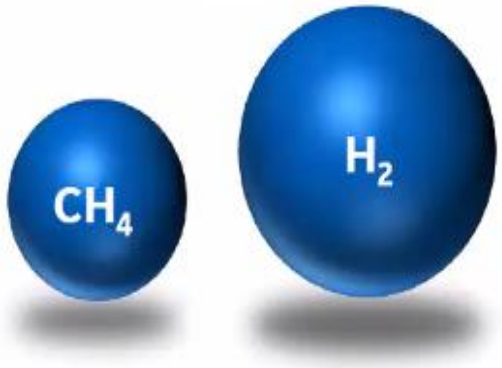


Based on ICF Analysis

Adapting CHP Systems for Green Hydrogen

Fuel System

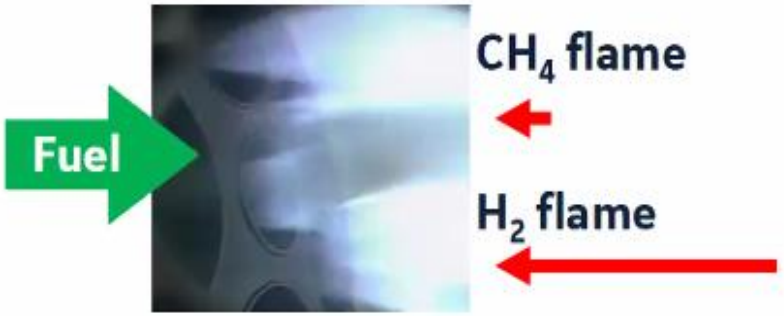
Methane (CH_4): 912 lb/ft^3
Hydrogen (H_2): 275 lb/ft^3



To deliver the same energy content, hydrogen requires 3X more volume flow

Combustion System

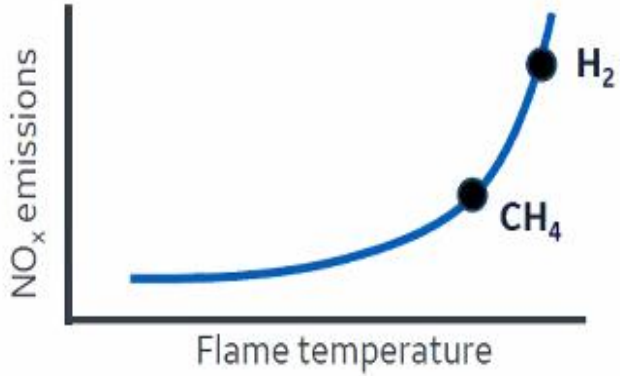
Methane (CH_4): ~30–40 cm/sec
Hydrogen (H_2): ~200–300 cm/sec



Hydrogen flames may increase risk of damage to combustion hardware

Emissions Aftertreatment

Methane (CH_4): ~3,565 °F
Hydrogen (H_2): ~4,000 °F



Operating on hydrogen may increase NO_x emissions

Summary

- CHP is highly used across the U.S., installed at over 4,700 sites
  - Large amount of existing CHP capacity at industrial facilities
  - Natural gas most common fuel, multifamily buildings most common sector for recent installations
- Packaged CHP systems are enabling non-traditional commercial and multifamily markets to benefit from CHP
- In microgrids, CHP acts as a resilient baseload anchor that allows critical loads to be served during extended grid outages
- CHP is more efficient than separate heat and grid power, and currently reduces carbon emissions
- In the future, RNG and hydrogen will enable more renewable CHP installations with zero carbon emissions

Source: DOE CHP Installation Database (U.S. installations through December 31, 2021 as of August 2022)

Thank You

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