CHP TODAY IN THE UNITED STATES

CHP Installations in the U.S.

- 80.8 GW of installed CHP at more than 4,600 industrial and commercial facilities
- 7% of U.S. Electric Generating Capacity; 13% of Manufacturing
- 82% of existing CHP capacity is in industrial applications
- 72% natural gas fueled; 15% biomass, biogas, and municipal and process waste fueled

Source: DOE CHP Installation Database (U.S. installations as of July 31, 2020)
CHP PROVIDES RESILIENCE/RELIABILITY FOR CRITICAL INFRASTRUCTURE

- Higher reliability and power quality are needed to meet critical requirements
- Increased incidences of grid outages cause major supply and production disruptions
- Consequences for health and safety of staff and clients, continuity of services, community support
- CHP can maintain power and heating/cooling during outages while providing financial benefits through operating savings every day

https://betterbuildingsinitiative.energy.gov/accelerators/combined-heat-and-power-resiliency
CHP AS A RESILIENT ANCHOR FOR CLEAN MICROGRIDS

- CHP provides efficient, resilient, baseload power and localized thermal energy
- CHP supports increased integration of renewable energy sources
- Storage adds additional flexibility and can help optimize CHP sizing and operation
- CHP supports the move toward a resilient, distributed, more renewable grid
OPERATIONAL MICROGRID INSTALLATIONS IN THE U.S.

Number of Operational Microgrids By Primary Application

- Currently **264** operating microgrid systems across the U.S.
- **84** operating microgrids are anchored with CHP systems
- Total operating microgrid capacity in the U.S. is **2.54 GW**

Source: ICF Microgrid Database (U.S. Installations as of August 28, 2020)
HYBRID SOLAR + STORAGE + CHP SOLUTIONS

• An optimized combination of solar, storage, and CHP can provide long-duration, on-site energy for sites with high resilience needs with the least possible carbon emissions.

• While CHP provides baseload power and thermal energy, PV can reduce grid demand and related emissions in peak hours, and storage can flexibly charge and discharge, helping to “firm” solar to meet peak site loads and avoid high demand or time-of-use charges.

• Adding photovoltaic (PV) and storage lowers the required CHP size and further improves emissions compared to the grid.
BUSINESS MODEL FOR UTILITY-OWNED CHP

End-Use Customer

Electric Utility

Utility continues to supply full electric load with long-term service agreement

Electricity to Customer (direct supply during grid outage)

Utility Grid 34-38% delivered efficiency

CHP System (Owned by Utility as Rate-Based Asset)

Gas Turbine HRSG

Natural Gas (purchased by utility)

Steam to Customer (discounted rate compared to self-production)
CHALLENGES

• Lack of awareness of CHP and benefits
• Project complexity and costs
• Interconnection/integration with the grid
• Monetizing value of resilience
• Monetizing value of grid support
• What is the role of CHP in a decarbonized future
CHP, NATURAL GAS, AND DECARBONIZATION

• Decarbonization is a major policy topic in many states and cities
  – Aggressive CO₂/greenhouse (GHG) reductions
    - 40% by 2030 and 80% by 2050
  – Focus on economy-wide electrification to get to net zero carbon

• Major push against natural gas in some areas
  – 20 cities in California and others in the Northeast have banned natural gas in new construction
  – Efforts to stop investment in natural gas infrastructure
    – Pipelines
    – Natural gas CHP
CHP’S HIGH EFFICIENCY PROVIDES SAVINGS TODAY

• CHP and renewables generally displace marginal grid generation (including T&D losses)

• Marginal generation is currently a mix of coal and natural gas in most regions of the country

• Natural gas CHP’s high net electric efficiency and high annual capacity factor result in energy and emissions savings on par with PV and wind

• Natural gas CHP is more efficient than state-of-the-art natural gas marginal generation (NGCC)

<table>
<thead>
<tr>
<th>Category</th>
<th>10 MW CHP</th>
<th>10 MW PV</th>
<th>10 MW Wind</th>
<th>10 MW NGCC</th>
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<tbody>
<tr>
<td>Annual Capacity Factor</td>
<td>85%</td>
<td>26.1%</td>
<td>37.4%</td>
<td>57.6%</td>
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<tr>
<td>Annual Electricity, MWh</td>
<td>74,460</td>
<td>22,864</td>
<td>32,762</td>
<td>50,458</td>
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<td>Annual Useful Heat Provided, MWh_th</td>
<td>97,505</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Annual Energy Savings, MMBtu</td>
<td>265,086</td>
<td>203,042</td>
<td>290,950</td>
<td>115,074</td>
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<tr>
<td>Annual CO₂ Savings, Tons</td>
<td>33,533</td>
<td>17,159</td>
<td>24,501</td>
<td>18,403</td>
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<tr>
<td>Annual NOx Savings, Tons</td>
<td>38.5</td>
<td>12.5</td>
<td>17.9</td>
<td>26.0</td>
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</tbody>
</table>

Savings based on EPA eGRID Non-Baseload Generation as a first level estimate of displaced marginal generation
CHP systems have higher effective generation efficiency than marginal natural gas generation due to thermal energy recovery and elimination of T&D losses.

CHP’s higher annual capacity factors generates additional energy and emissions savings compared to central station marginal generation.

Source: DOE CHP Deployment Program
CHP CAN BE PART OF THE LONG-TERM SOLUTION

• As the electric grid decarbonizes, marginal generation will continue to be served by natural gas in most areas of the country. CHP is the most efficient way to generate power with natural gas.

• CHP technologies currently use renewable fuels, low carbon waste fuels, and hydrogen mixtures where available, and will be ready to use higher levels of renewable natural gas (RNG) and hydrogen in the future.

• CHP can support the transition to a low carbon economy by enabling greater integration of renewables in the distribution grid, microgrids, and individual facilities, while helping businesses adapt to changing conditions by enhancing energy resilience and security.

• CHP’s efficiency, emissions, flexibility and resilience advantages will remain as the natural gas infrastructure decarbonizes.

• CHP can ultimately be carbon free by using RNG/hydrogen and/or carbon capture - CHP can decarbonize thermally based industrial processes and facilities that rely on on-site generation for resilience.