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Benefits of Tri-generation for District Energy Systems, University Campuses & Data-Centers - Case Studies

2017 IDEA Conference

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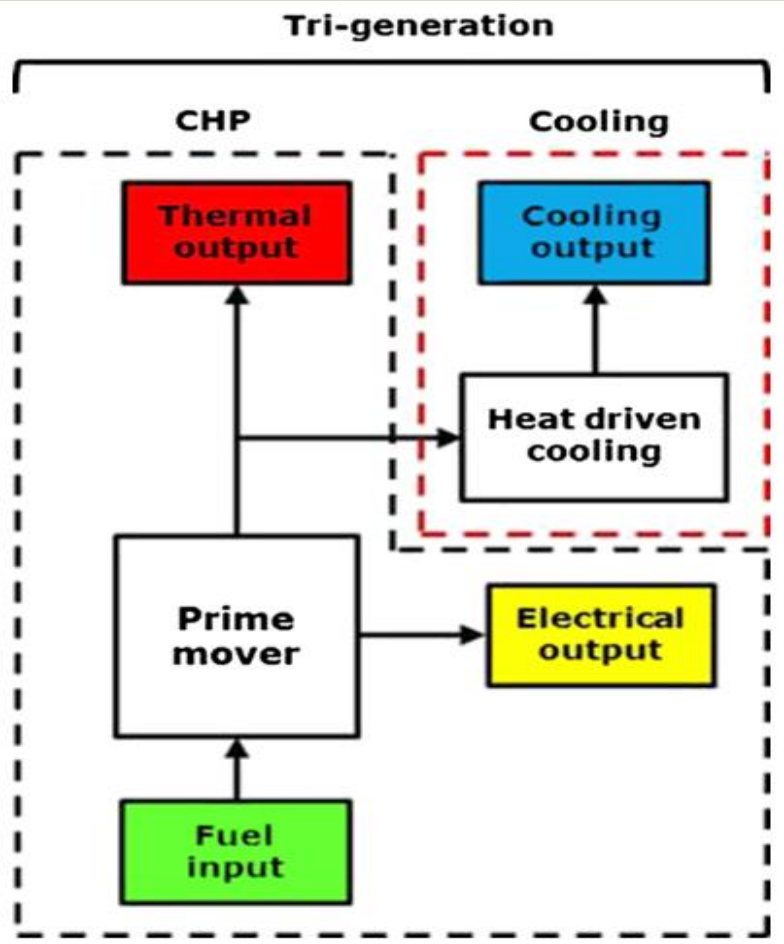
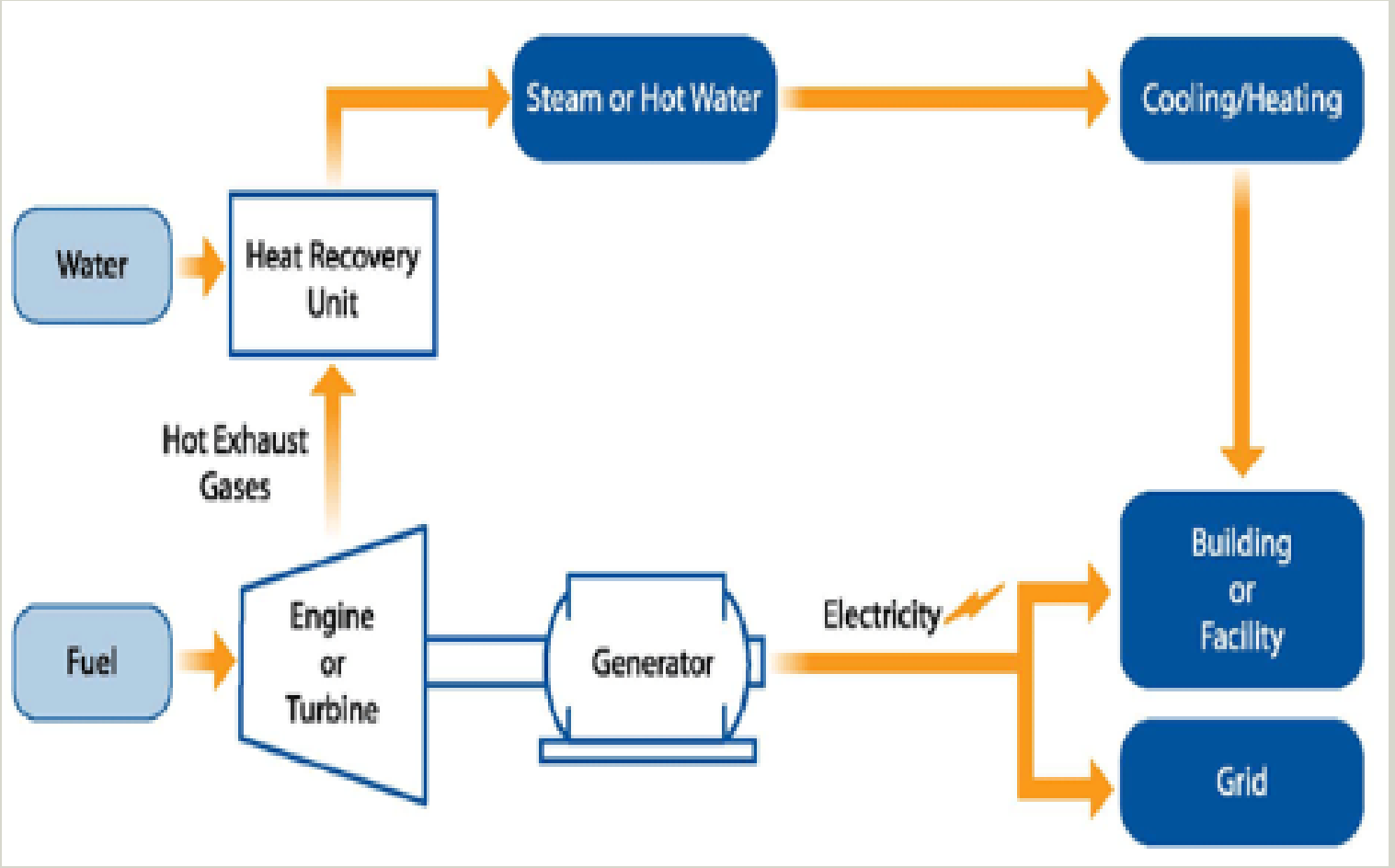
Agenda

- Tri-generation or Combined Cooling, Heat and Power (CCHP)
  - Overview
  - Technology options – prime movers and chillers
- Tri-generation examples
  - Case studies – different applications and technologies
- Cogeneration and tri-generation existing capacity and potential opportunities
- Q & A

Tri-generation overview



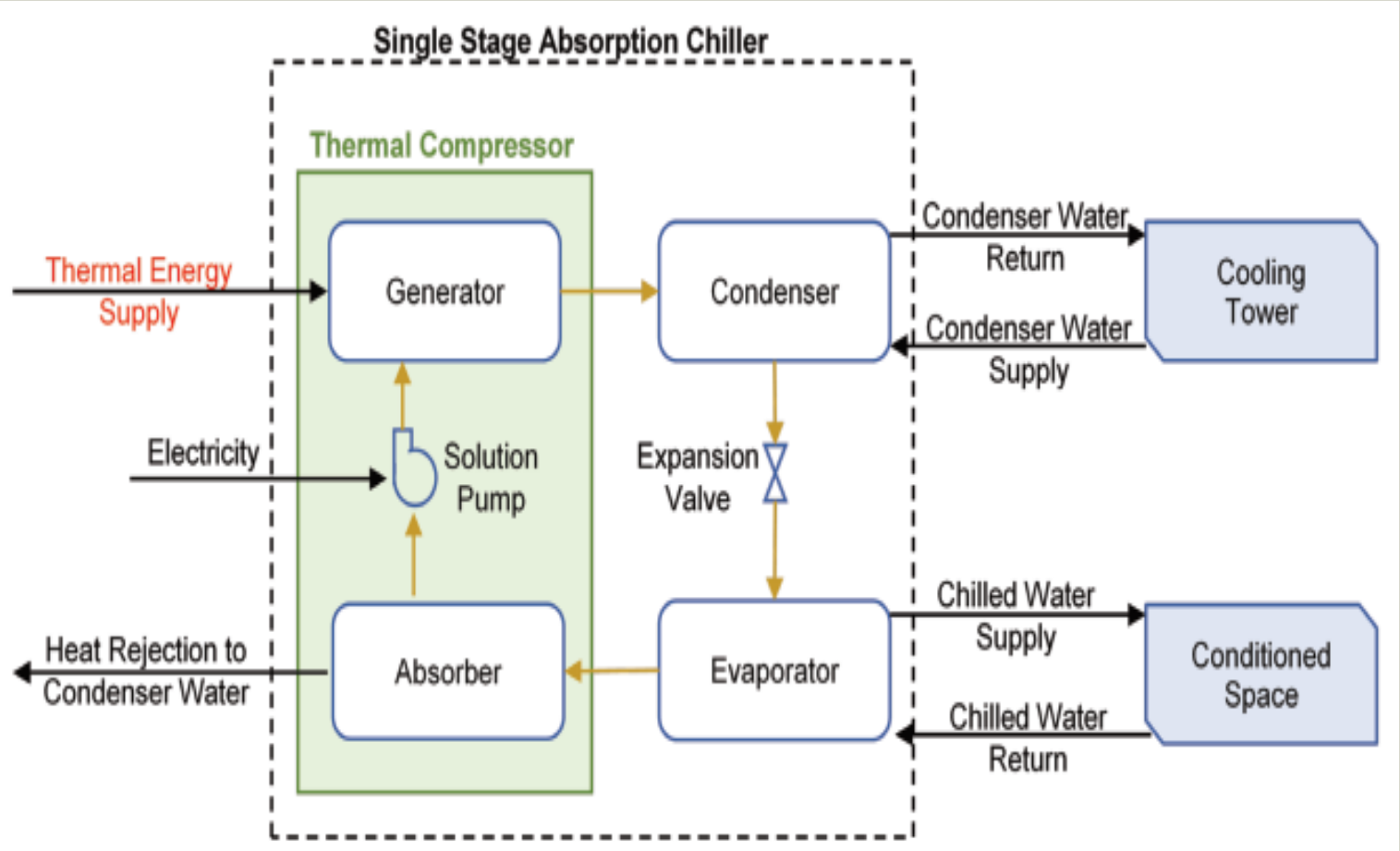
Source: International Journal of Low-Carbon Technologies



Source: U.S. EPA – Combined Heat and Power Partnership

Tri-generation overview

Absorption chiller for CHP systems



Size range	5 to 3,000 refrigeration tons
Input Heat	Hot water, steam, or prime mover exhaust
Configuration	Available in single and two stage designs. Single stage machines can be driven with hot water (200-240°F) or low pressure steam (15 psig) and are often used with reciprocating engine CHP installations. Compared to single stage chillers, two stage machines require higher temperature hot water (e.g., 350°F) or higher pressure steam (e.g., 115 psig) and are often used with combustion turbine CHP installations. In addition to hot water and steam, absorption chillers can also be exhaust fired (required exhaust temperatures typically above 750°F).
Refrigerant / Absorbent	For 40°F and higher chilling fluid temperatures (e.g., building air conditioning), a common mixture is water (refrigerant) and lithium bromide (absorbent). For chilling fluid temperatures below 40°F (e.g., cold storage), a common mixture is ammonia (refrigerant) and water (absorbent).

Source: U.S. DOE – Combined Heat and Power Technology, Fact sheet series

Examples & Case-studies

Tri-generation

Applications & Technologies

University of New Hampshire CHP

Tri-generation landfill gas-to-energy project

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- **Student population: over 15,000**
- **Tri-generation: heating, cooling, & electrical power**
- **Up to 7.8 MW(e) electrical power output and up to 12MW of heating and cooling**
- **Unit continuous operation 8,500 hrs/yr**
- **Overall system efficiency of 77%**
- **Tri-fuel operation: natural gas, processed land-fill gas, & liquid fuel**

ECOLine landfill pipeline to UNH campus **Source:** UNH website

Siemens SGT-300 gas turbine installed at the UNH Cogen plant

Riverbay Co-op City

Tri-generation plant in The Bronx, NY

- **60,000 residents at the Riverbay co-op development**
- **Development includes 14,000 apartments, 35 high-rises, 7 clusters of townhouses, 8 parking garages, 3 shopping centers, 1 high school, 2 middle schools and 3 elementary schools**
- **Tri-generation: electricity, heating, & cooling**
- **40 MW natural gas-fired combined cycle CHP plant, installed in 2011**
- **Co-op City only needs 24 MW of power at peak usage periods. Extra capacity can be sold to the local electric utility providing an additional income stream**
- **Steam generated by the exhaust heat is also used to provide heat in the winter and cooling via absorption chillers in the summer (200,000 lbs per hour of steam)**

Riverbay Co-op City
Tri-generation plant in The Bronx, NY

"*We decided to invest in an onsite cogeneration plant because we wanted to save money by producing our own electricity and capturing the waste heat to provide our residents with hot water and space cooling*," said Herb Freedman, a principal of Marion Real Estate, Inc., which manages Co-op City for the Riverbay Corporation.

Two Siemens SGT - 400 gas turbines and one Siemens SST - 300 steam turbine installed at the Riverbay tri-generation plant

Rya CHP – District heating & cooling plant

Tri-generation in Gothenburg, Sweden

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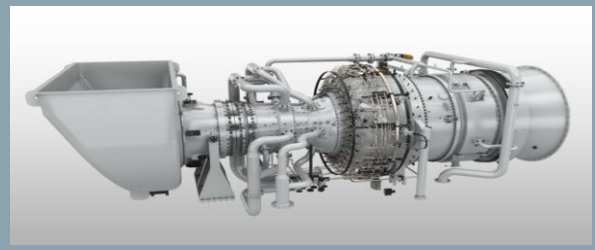
The Rya combined-cycle district heating/ district cooling plant in Gothenburg, Sweden, is powered by three SGT-800 gas turbines and one SST-900 steam turbine.



SGT-800 Gas Turbine

- **30 % of the city's electrical power (265 MW) is provided by the Rya combined cycle plant**
- **The plant also provides 35 % of district heating for the city (295 MW) at an overall plant efficiency of 94 %**
- **In the center of Gothenburg, a large-scale district cooling system (100 MW) is installed. It is partly driven by the district heating system via absorption chillers, partly by river water during the winter and by electrical chillers during summer peaks**

Grand Hotel VIDGOF CHP

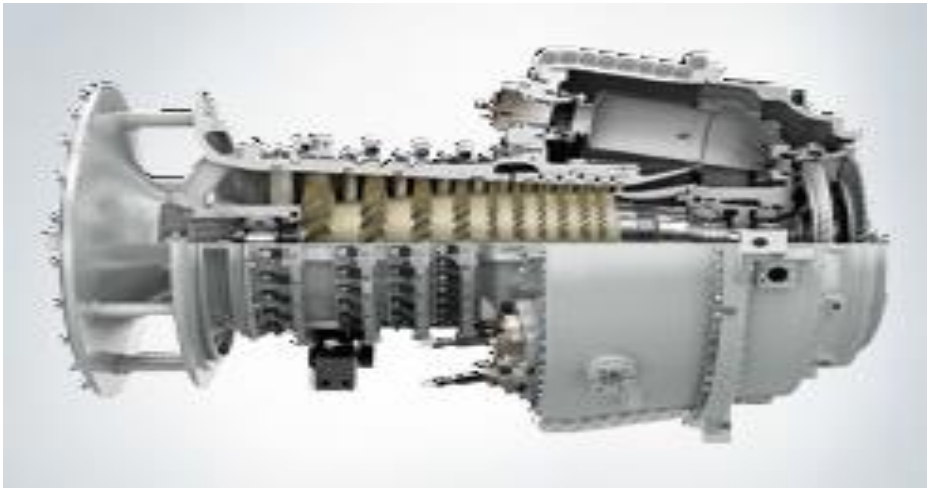
Power, heating, and cooling in Chelyabinsk, Russia

- **The Grand Hotel VIDGOF, is a 20-story, five-star hotel in Chelyabinsk, Russia**
- **The five star hotel has 35,700 square meters of floor space**
- **The multi-level power plant acts as the energy center of the complex**
- **The four level plant houses the reciprocating engines and control room on the ground level (3.78 MW), two water boilers and a heat recovery system on the second level, and water treatment, pumping and cooling systems on the third level. The roof houses a compression cooling system and horizontal cooler units.**
- **The exhaust recovery system provides air conditioning - central air and central system ventilation**

Siemens Guascor SFGLD360 natural gas reciprocating engine installed at the Grand Hotel VIDGOF CHP plant

BBC Television Centre CHP

Electricity, heating, and cooling in Wood Lane, London



Siemens SGT-100 gas turbine installed at the BBC CHP plant

- **The Centre provides studio, production, and office facilities for its operations in the UK and abroad**
- **A continual demand for heating and electrical power from the offices, post production areas, computer suites, and studio lighting all contribute to a large electrical load and a need for standby power in case of main failures as well as a substantial chilling requirement to prevent the overheating of electronic equipment.**
- **The gas turbine based CHP plant provides the BBC with an environmentally sensitive means of gaining substantial energy cost savings. A Heat Recovery Steam Generator provides the main source of steam, meeting the site's heating, cooling and hot water needs. Steam is also used as a source of energy for absorption chilling. (4.9 MW electric power and 11,000 kg per hour of steam)**

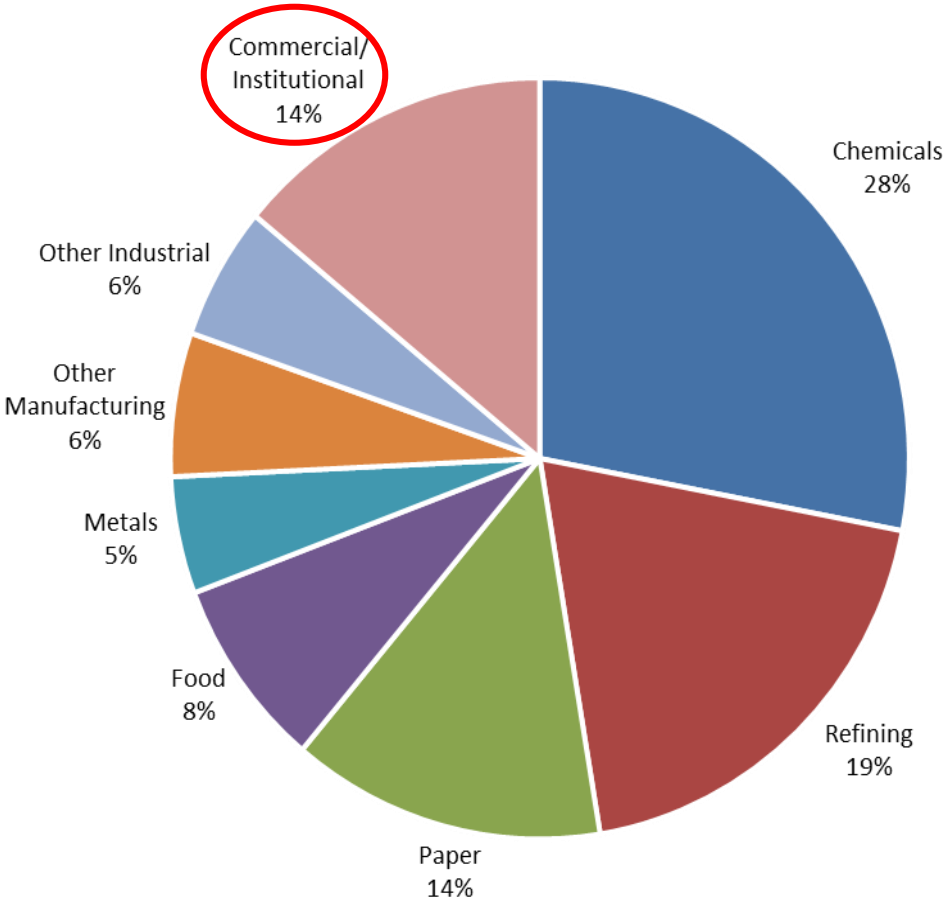
Cogeneration & Tri-generation

Existing capacity & potential opportunity in commercial applications and institutions in the US

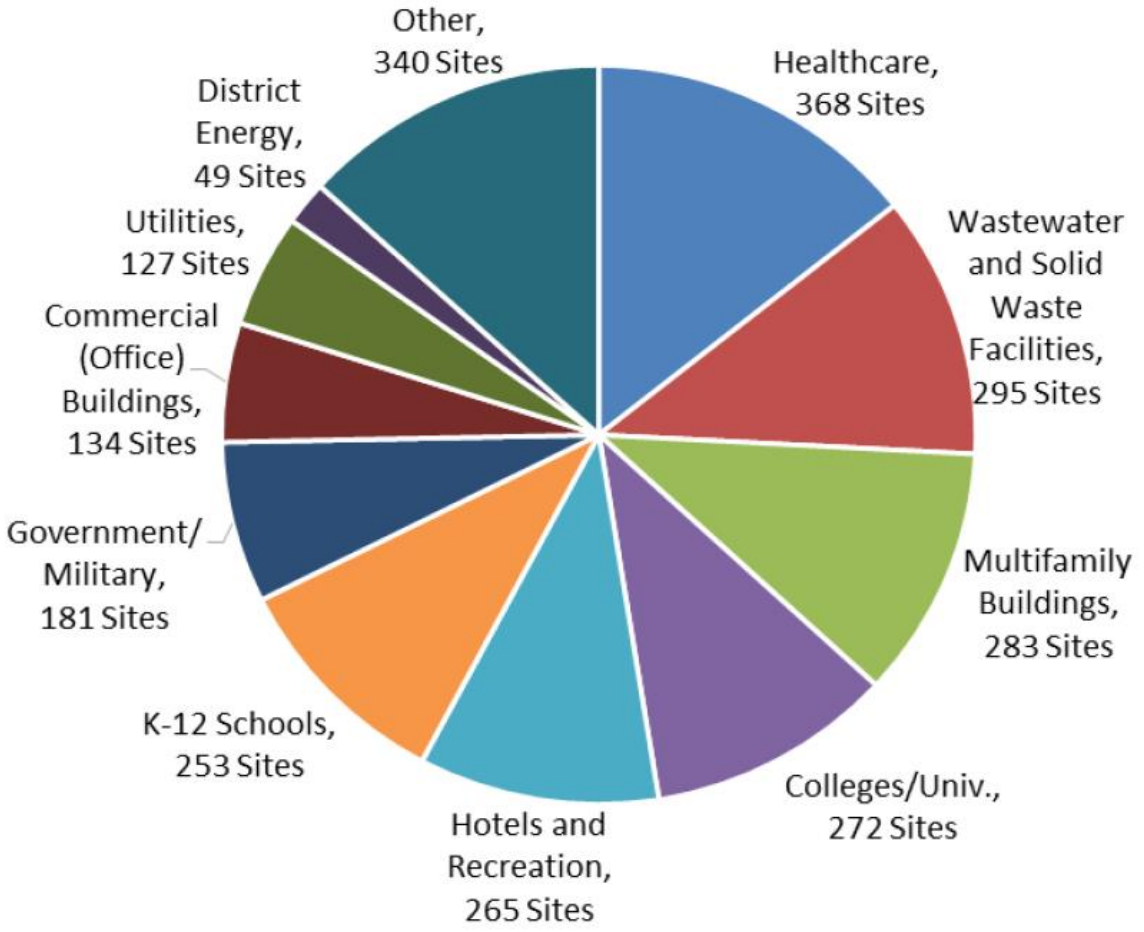
Cogeneration and tri-generation

Commercial/institutional installations in the US

Existing CHP Capacity (MW)



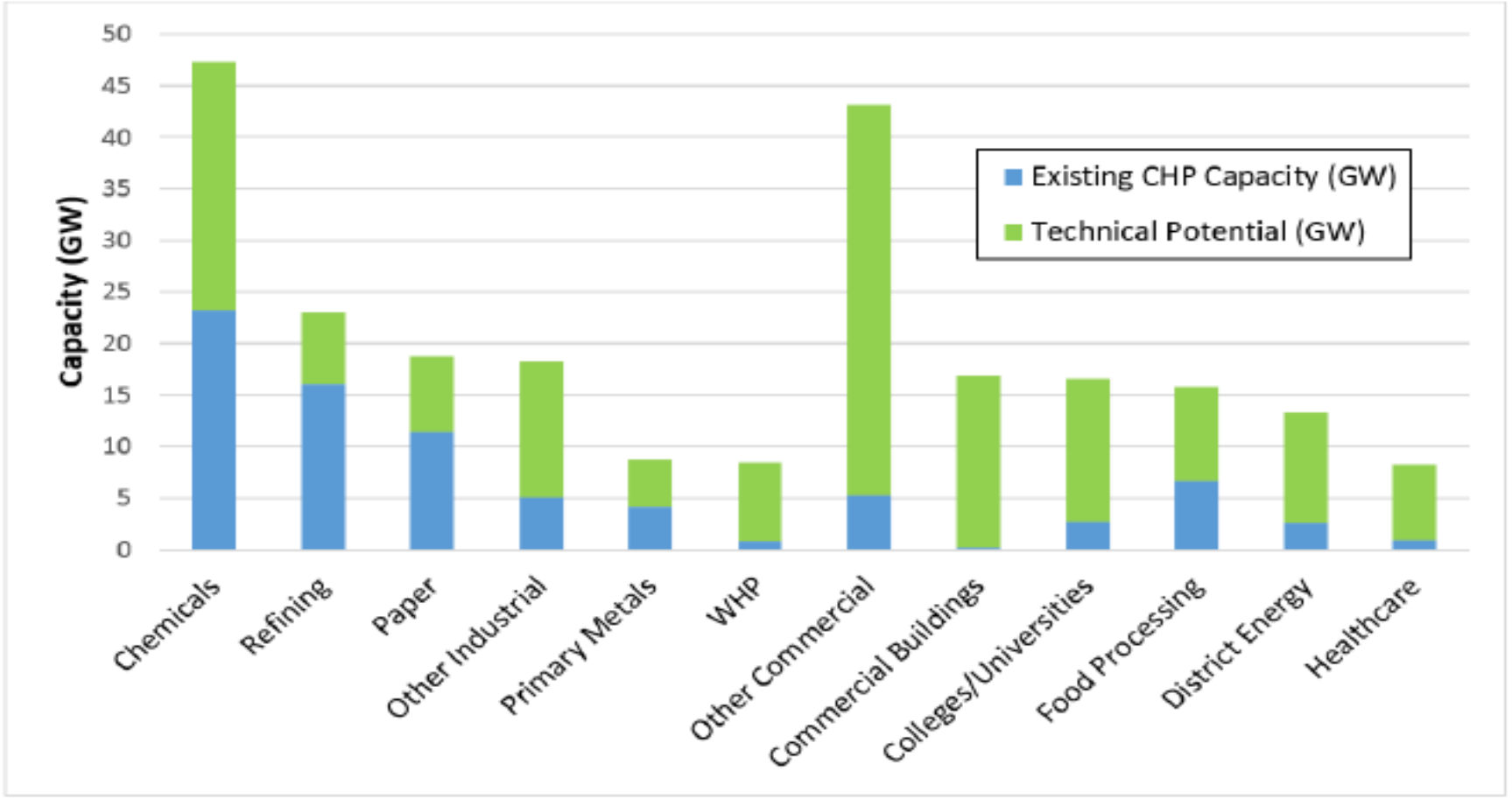
Existing Commercial CHP Sites by Business Type (2,567 sites)



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

Cogeneration and tri-generation

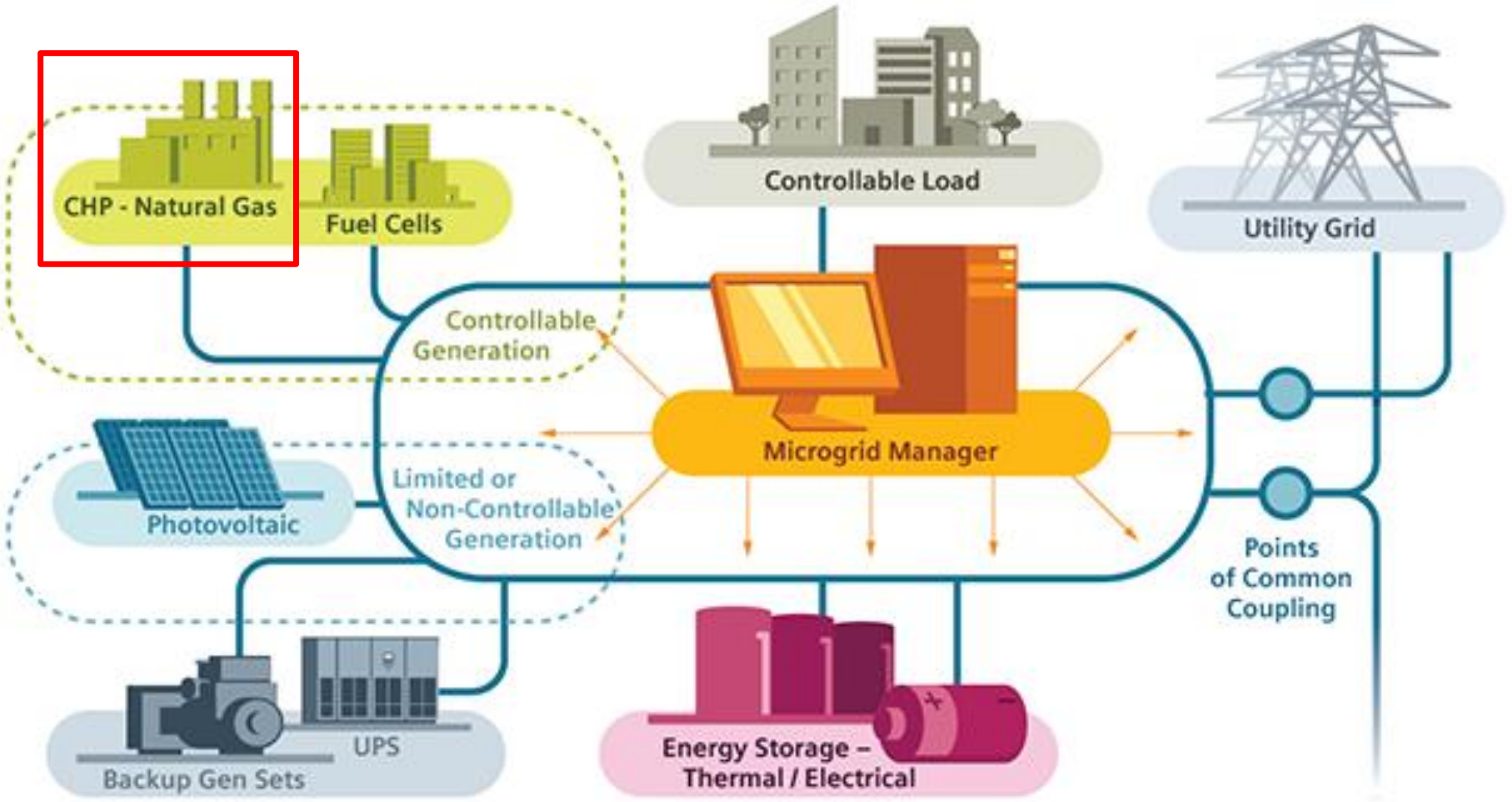
Opportunity in the US



Source: DOE CHP Deployment Program, 2016

75+ GW
<u>Technical</u> Potential of On-site Commercial & Institutional CHP

CHP/CCHP – the anchor of the microgrid



Summary

- Tri-generation offers cost effective and environmental friendly solutions in different applications based on proven technologies

- Tri-generation has been successfully implemented in several district energy plants, university campuses, and data-centers in the US and globally

- A significant opportunity for deploying cogeneration and tri-generation in the commercial applications still exists. CHP/CCHP is the anchor of the micro-grid and integration with renewable power sources

Questions?

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