The Key Role of CHP in Microgrid Systems

Presented at the Microgrid 2017 Conference

November 6-8, 2017, Boston, Massachusetts

Author/Presenter: William Steigelmann

CoAuthor: Roger Huggins

LOCKHEED MARTIN

Microgrid Purpose and Key Components-1

- A Microgrid consists of a group of Distributed Energy Resources (DERs) and a highly sophisticated control system
- DERs typically include two or more independent systems that generate electricity, and may also include:
    - One or more electrical and/or thermal-energy storage systems
    - Ability to modulate loads at the end-user facilities (i.e., Demand Response)
- The generating systems typically include fuel-burning engine-generator units and a solar PV array, and may also include:
    - Fuel Cell systems, wind-powered generators, solar-thermal generators
    - Ability to import power from remotely sited generating units

Microgrid Purpose and Key Components-2

- Fuel-burning generators may rely on: a) fuel stored on-site (typically fuel oil, gasoline, or propane), b) on fuel delivered as needed via a pipeline (typically natural gas), or c) a combination of on-site storage and pipeline delivery
- Fuel-burning generating systems inherently produce heat as well as electricity. The heat may be simply discharged to the atmosphere, or most of it can be captured and delivered by pipeline to one or more end-users. When the latter is done, the DER is called a CHP (Combined Heat and Power) System.
- Chilled water can be produced by using some of the hot engine exhaust to power an absorption chiller. The result is CHP system that delivers electricity, hot water, and chilled water to end-use facilities.

The Rational for Installing Microgrids-1

- **Microgrids are connected to both the electric grid and to one or more end-user facilities or buildings**
- **Their purpose is to provide electricity to the end-user facility(ies), operating in parallel with the grid when power from the grid is available, and operating in "island mode" whenever power from the grid is not available**
- **They may also supply thermal energy in the form of steam, hot water, and/or chilled water to the end-user facilities**
- **They may be owned by the electric or gas utility that normally serves the energy end-users, by a third-party, by one or more of the end-users, or by a combination of these entities**

The Rational for Installing Microgrids-2

- **Infrastructure resilience** (maintain operations during and for 2 or 3 weeks after a devastating event) means assurance that both electricity and water has become a key in disaster preparedness
- **Critical Facilities (CFs)** are those that, if incapacitated, would have a substantial negative impact on security, economic operations, or public healthy and safety
  - Examples: hospitals and nursing homes; water supply and wastewater treatment facilities; police, fire, emergency response, and prison facilities; military bases and and places of refuge (can include schools and hotels as well as homes); cell towers
  - Anticipate possibility of 2 or 3 weeks without power from the grid
- Microgrids can effectively ensure that Critical Facilities continue to function during extended grid outages, providing continuity of critical services and freeing power restoration efforts for other facilities
- Severe Hurricanes and storms in recent during the past dozen years have brought the need for more resilient CFs “front & center!”

The Rational for Installing Microgrids-3

Examples of severe natural events during and after which Critical Facilities must continue to be fully functional

- **Caribbean and Florida to New England: Hurricanes (Summer & Fall)**
- **Mid-West: Tornados (Anytime)**
- **California and Pacific Northwest: Earthquakes (Anytime)**
- **Northeast Region: Major Storms (Anytime, including winter)**
- **Anywhere near large bodies of water: Floods (Anytime)**
- **Pacific Northwest and Hawaii: Volcanic eruption**

In addition, there is always a possibility of an attack on cities or the electric grid

The Rational for Including CHP Systems

- Infrastructure resilience (the ability to maintain operations despite a devastating event) requires a continuous supply of electricity, space heating and cooling (when needed), clean domestic hot & cold water
- With regard to electricity:
  - Solar PV and Wind are expensive and vulnerable to damage from flying debris, and are reliable for extended periods as long as sun and wind are present. However, these are intermittent sources (the addition of battery storage helps to alieviate this problem, but at a significant additional cost)
  - Fuel-burning engine-generators are low-cost and small (hence they are unlikely to be damaged by flying debris, and are reliable for extended periods as long as fuel is available.
- CHP systems have reasonable cost, are small and unlikely to be damaged by flying debris, and also can provide space heating and cooling

Case Study: Microgrid Serving Police and Emergency Response HQ

- **Load to be served:**
  Electric: 2,000 kW peak demand, 10,000 MWh/year
  Space & Water Heating: 30,000 MMBtu/year
- **Microgrid Components:**
  1,200-kW Solar PV System supplying 1,500 MWh/year
  180-ton Absorption Chiller System
  800-kW CHP System supplying 6,000 MWh/year and 25,000 MMBtu/year to absorption chiller and for space and water heating
  2,000-kW Stand-By Diesel Generators (existing) producing power if and as needed during a grid outage
- **Cost and Payback:**
  Total Cost: $7.3 million; Cost Net of Incentives, Grants, etc.: $4.0 million
  Payback Period: 5.8 years

CHP Systems-1

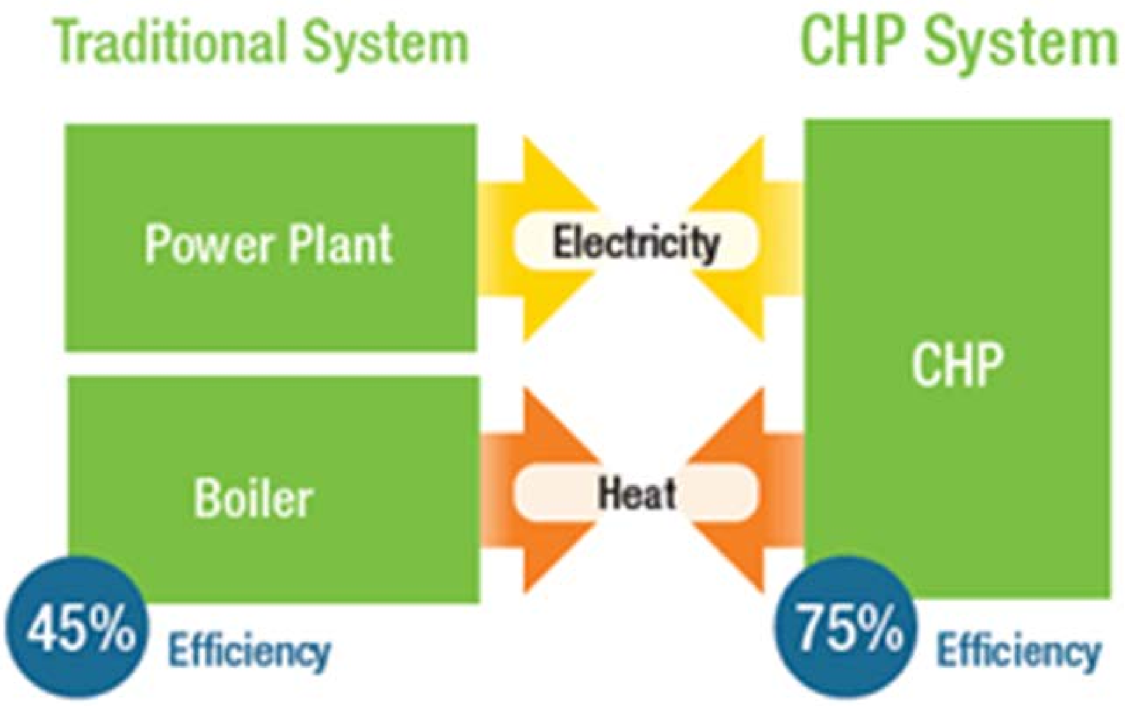
- **CHP systems range in size from 5 kW to more than 50 MW, and burn a variety of fuels including biogas. For Microgrid applications, the most common capacity ratings are likely to be in the 200-kW to 2,000-kW range. Total installed cost decreases as capacity increases, about $3,200/kW down to $2,400/kW in this size range.**
- **Reciprocating engines are the most common prime mover in this size range. Microturbine and fuel-cell systems are also used. Sound-attenuating enclosures are standard practice, so operation at hospitals, nursing homes, and apartment buildings is widely accepted.**
- **For capacity ratings up to 2.5 MW, the CHP systems have standardized designs and are assembled and tested at the factory before being shipped**

Why CHP systems are a better solution than backup generators

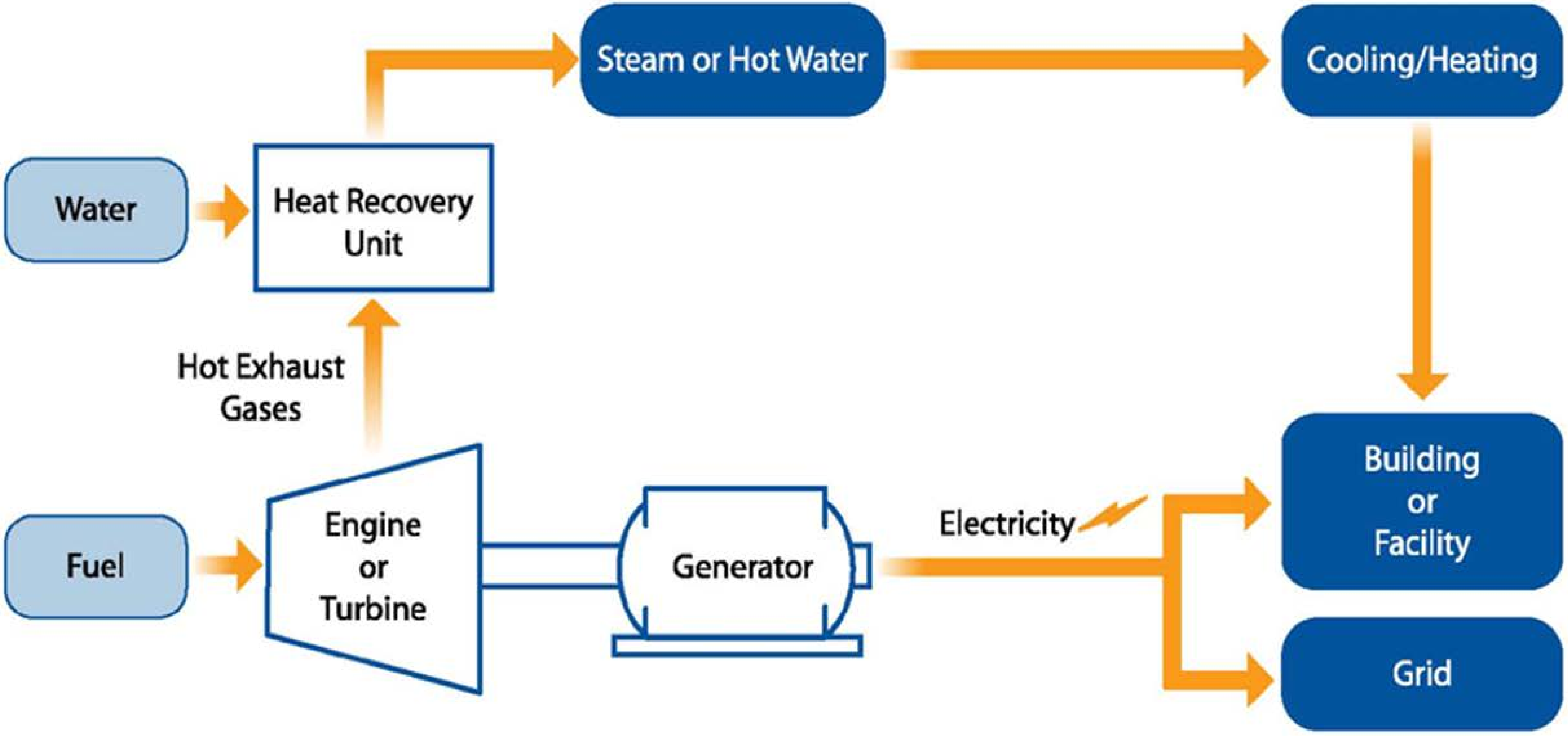
- CHP Systems:
  - Run daily under load, and not just during infrequent short-duration tests
  - Typically are better maintained
  - Use a highly reliable source of fuel (e.g., natural gas, which has underground transportation infrastructure)
  - Have greater efficiency, lower fuel cost, and lower emissions
  - Supply both electricity and thermal end-use loads
  - More economic, because they save energy costs every day, are eligible for tax credits, and may be eligible for efficiency program incentives

What is CHP

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

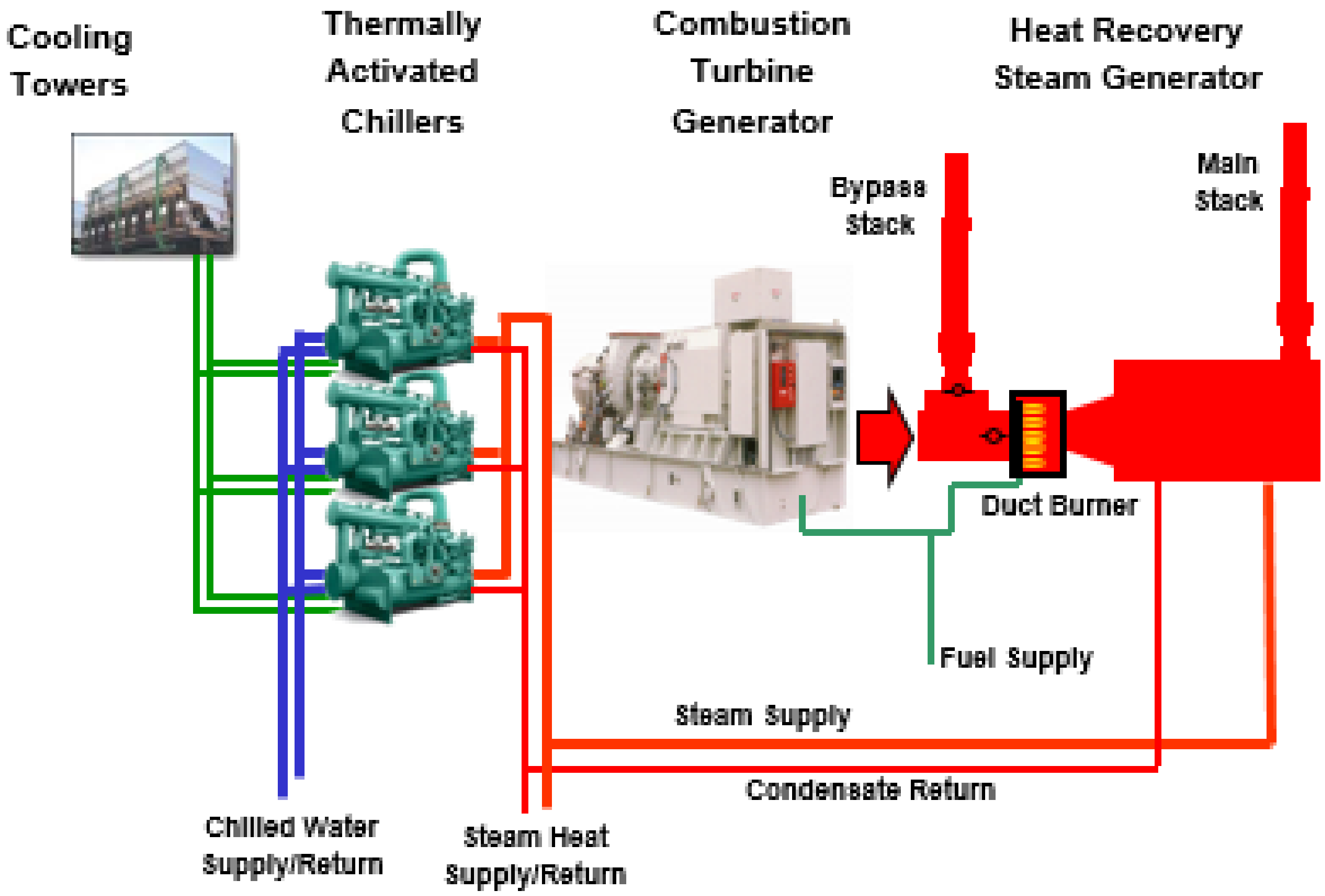


CHP Diagram


Steam or Hot Water
Cooling/Heating
Water
Heat Recovery Unit
Hot Exhaust Gases
Fuel
Engine or Turbine
Generator
Electricity
Building or Facility
Grid

CHP System Components

- Prime Mover
- Heat Recovery
- Thermal Technology
- Accessory Devices
- Switchgear
- Interconnection
- Fuel Supply
- Controls/M&V



Prime Movers

- Gas Combustion Turbines > 1 MW
- Microturbines 35 kW – 1 MW
- IC Engines 30 kW – 6 MW
- Fuel Cells 250 kW

Examples of CHP Systems

75-kW Packaged CHP Unit from AEGIS Energy

AEGEN THERMOPOWER

Weather tight, sound attenuated cabinet

100-kW Packaged CHP Unit from Tecogen

Examples of CHP Systems (cont.)

65-kW Packaged CHP Units from

Inside a 65-kW Microturbine CHP Unit

Contact Information

William Steigelmann

Senior Engineer

Lockheed Martin Energy Solutions

(301) 556-2046

william.h.steigelmann@lmco.com

Roger Huggins

Senior Engineer

Lockheed Martin Energy Solutions

(301) 556-2035

roger.a.huggins@lmco.com