Session: Smart Grid
Track L: Emerging Market Trends
Emissions from Integrated Renewable-CHP Microgrids
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Presentation Objectives:

Presentation Focus:

- Emissions profile of CHP integrated in a microgrid with renewable systems

Purpose:

- Quantify the environmental benefits of multiple clean energy projects in a microgrid

Approach Taken:

- Case study approach
  - Documented technology and operational characteristics based on project profiles for two microgrid applications
- Emissions estimator tool (CHPP's Emissions Calculator)
  - Entered documented microgrid project metrics into the CHP Emissions Calculator to determine the emissions profile + savings

Introduction: CHP and Microgrids

- Due to resiliency benefits and emerging incentive programs in Connecticut, New York, California, and other states, microgrids are starting to gain traction
- According to GTM Research, CHP is the most commonly deployed technology for microgrids
  - CHP is one of the most reliable and efficient sources of baseload power
  - CHP systems can be configured to operate in "island" mode during utility outages, with black start capability
  - There are currently over 4,000 U.S. CHP systems in operation
- Baseload CHP can serve as an "anchor" for microgrids, enabling other microgrid attributes
  - PV and other renewables
  - Energy storage
  - Demand management

Building Resilient Microgrids Around CHP Anchors

- An ideal microgrid anchor provides reliable baseload power, even when the electric grid is down
- Natural gas CHP systems are well-suited for this role
  - Natural gas supply lines are rarely affected by hurricanes, blizzards, or other natural disasters
  - With CHP, heat can be efficiently captured and utilized for hot water, chilled water, and steam production
  - Thousands of existing CHP installations could serve as foundations for future microgrids, with minimal capital investment
- CHP systems improve efficiency and reduce emissions compared to separate heat and grid-supplied electricity
  - When renewables like PV are added in a microgrid configuration, very significant emission reductions are possible

Study Approach

Microgrid Case Study

- City of Milford, CT– community microgrid under development (integrating PV + CHP)

Emissions Estimator Tool

- The CHP Emissions Calculator compares the anticipated CO_2, methane (CH_4), nitrous oxide (N_2O), SO_2, and NO_x emissions from a CHP system to those of a separate heat and power system with electricity supplied by the grid.
- The Calculator uses fuel specific CO_2, CH_4 and N_2O emissions factors from the EPA's GHG Reporting Program, region specific Transmission & Distribution (T&D) loss values, and data from eGRID 2012.

Overview of Emissions Estimation Methodology

- Type of inputs required –
  - CHP or solar electric capacity (kW)
  - Annual hours of operation
  - CHP fuel type
  - CHP thermal energy use: heating, cooling or both
  - Whether there is emissions control equipment (+ NOx emissions rate if there are controls)
- CHP/RE estimation approach –
  - Conduct individual runs of the Emissions Calculator for each technology type (e.g., 1 run for CHP, 1 run for PV)
  - Add the emissions calculator results from the individual technology runs for each microgrid project together.
    - For the CHP system, consider the overall emissions results from the Calculator
    - For the PV system, count the displaced electricity production results (did not include the CHP system or the displaced thermal production results)

CASE STUDY – CITY OF MILFORD, CT

Proposal is an outcome of CT DEEP Round 2 Microgrid Program – currently going through approvals

- 5 facilities will have the ability to operate independently of the UI grid
  - Parsons Center
  - Milford Senior Center
  - Harborside Middle School
  - City Hall
  - River Park Senior Apartments

Microgrid components

- Two 148 kW natural gas-fired reciprocating engine CHP systems will replace the existing outdated boilers in the Parsons Center.
- A 120 kW photovoltaic array accompanied by battery energy storage will help offset the daytime electric load.
- The PV system will be located in a parking lot adjacent to the Parsons Center and will provide supplemental power during the daylight periods.
- The necessary electrical and controls infrastructure will tie these buildings together as a microgrid that will operate in parallel with the utility grid.

Case Study – City of Milford, CT Inputs

	CHP System 1
Type of CHP System	**NG-Fired Reciprocating Engine**
CHP Electric Capacity (kW)	296 kW
Annual Hours of Operation	8,322 (95% availability)
CHP Fuel Type	Natural Gas
Thermal Energy: Heating, Cooling, or Both?	Heating
Hours in Cooling Mode?	NA
Emissions Control Equipment? (yes/no)	Yes
If Yes, what is NOx emission rate? (ppm, or lb/MWh)	0.15 lb/MWh
What type of thermal system was displaced?	Existing boilers
Fuel Type of Displaced Thermal System	Natural Gas

	Solar PV Array
Electric Capacity (kW)	120 kW
Annual Hours of Operation, or Capacity Factor	1,555

Case Study – City of Milford, CT Results

CHP System Results Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	0.18	0.38	1.01	1.21	87%
SO_2 (tons/year)	0.01	0.55	0.01	0.54	97%
CO_2 (tons/year)	1,755	1,329	1,181	755	30%
CH_4 (tons/year)	0.03	0.16	0.02	0.15	82%
N_2O (tons/year)	0.00	0.023	0.00	0.022	87%
Total GHGs (CO_2e tons/year)	1,757	1,340	1,182	765	30%
Fuel Consumption (MMBtu/year)	30,026	22,951	20,204	13,129	30%
Equal to the annual GHG emissions from this many passenger vehicles:				145	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				72	

PV Results Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	-	0.03	-	0.03	100%
SO_2 (tons/year)	-	0.04	-	0.04	100%
CO_2 (tons/year)	-	101	-	101	100%
CH_4 (tons/year)	-	0.012	-	0.012	100%
N_2O (tons/year)	-	0.002	-	0.002	100%
Total GHGs (CO_2e tons/year)	-	101	-	101	100%
Fuel Consumption (MMBtu/year)	-		-	1,800	100%
Equal to the annual GHG emissions from this many passenger vehicles:				19	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				10	

Case Study – City of Milford, CT Combined Results (CHP + PV)

CHP + PV Results Annual Emissions Analysis					
	CHP System (CHP only)	Displaced Electricity Production (CHP + PV combined)	Displaced Thermal Production (CHP only)	Emissions/Fuel Reduction (CHP + PV combined)	Percent Reduction (CHP + PV combined)
NO_x (tons/year)	0.18	0.41	1.01	1.24	87%
SO_2 (tons/year)	0.01	0.59	0.01	0.58	98%
CO_2 (tons/year)	1,755	1,430	1,181	856	33%
CH_4 (tons/year)	0.03	0.172	0.02	0.162	84%
N_2O (tons/year)	0.00	0.025	0.00	0.024	96%
Total GHGs (CO_2e tons/year)	1,757	1,441	1,182	866	33%
Fuel Consumption (MMBtu/year)	30,026	22,951	20,204	14,929	35%
Equal to the annual GHG emissions from this many passenger vehicles:				164	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				82	

Other Examples of CHP-PV Microgrids

- **University of California, San Diego**
  - 92% of UC San Diego's annual 250 GWh is generated through its microgrid, which has grown over the years to include:
    - 30 MW CHP plant, serving as the microgrid anchor
    - 2.8 MW biogas fuel cell, using ADG from wastewater treatment plant
    - 1.2 MW of solar PV panels distributed throughout the campus
  - Plans to expand microgrid capabilities to cover all campus electricity requirements
- **South Oaks Hospital in Amityville, NY**
  - 1.25 MW CHP system (five 250 kW IntelliGen engines)
  - 47 kW rooftop PV system
  - The microgrid provided 100% of the facility's electricity, thermal, and hot water demands for 15 days after Hurricane Sandy
- **Military Complex at Twenty Nine Palms, CA**
  - Two gas turbine CHP systems
    - 7.2 MW unit with black start capability, installed in 2003
    - 9.2 MW unit used for peaking power, installed in 2013
  - Two PV systems
    - 1.2 MW system installed in 2003
    - 4.5 MW system recently installed

CONCLUSIONS

- Microgrid projects that incorporate CHP with renewables are gaining traction in the U.S.
  - To date, CHP has been the most commonly deployed technology for U.S. microgrids, and deployments are expected to increase in coming years
  - At least six states have microgrid incentive programs either currently available or under development – more CHP-enabled microgrids can be expected in these states:

    - California
    - Connecticut
    - Maryland
    - Massachuestts
    - New Jersey
    - New York
- The CHPP Emissions Calculator can be used as an effective way to determine the emissions benefits of integrating CHP with renewables
- Microgrids that incorporate CHP and renewable technologies like PV can significantly reduce the production of greenhouse gases and other harmful emissions

Questions and Contact Information

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