CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Integration of CHP with Renewables

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

Study Approach

Microgrid Case Studies Considered

- MCAGCC Twentynine Palms – military base in California (PV + CHP)
- City of Milford, CT– under development (will integrate PV + CHP)

Emissions Estimator Tool

- The CHP Emissions Calculator calculates the difference between 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.
- 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 integration component details –
  - Conducted individual runs of the Emissions Calculator for each technology type (e.g., 1 run for the CHP system, 1 run for the PV systems)
  - Added the emissions calculator results from the individual technology runs for each microgrid project together.
    - For the CHP system took the overall emissions results from the Calculator
    - For the PV systems only counted the displaced electricity production results (did not include the CHP system or the displaced thermal production results)

Case Study 1 – Twentynine Palms, California

- Located at Twentynine Palms, California, in the Mojave Desert. Over 900 square mile of land area.
- The facility has two gas turbine CHP systems
  - A 7.2 MW unit (installed 2003); system has "black start capability"
  - A 9.2 MW system (installed 2013)
- The military complex has two solar installations
  - A 1.2 MW PV system (installed 2003), and a subsequent 4.5 MW PV system
  - Future plans are to bring total capacity to 6 MW

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Case Study 1 – Twentynine Palms Emissions Calculator Inputs

The following are the key parameters used in the Emissions Calculator:

	CHP System 1	CHP System 2
Type of CHP System	**Gas Turbine**	**Gas Turbine**
CHP Electric Capacity (kW)	7,200	9,200
Annual Hours of Operation	8,403	1,000 (peaker)
CHP Fuel Type	Natural Gas	Natural Gas
Thermal Energy: Heating, Cooling, or Both?	Both	Both
Hours in Cooling Mode?	1,008	50
Emissions Control Equipment? (yes/no)	Yes	Yes
If Yes, what is NOx emission rate? (ppm, or lb/MWh)	3 ppm	3 ppm
What type of thermal system was displaced?	Existing gas boiler	Existing gas boiler
Fuel Type of Displaced Thermal System	Natural Gas	Natural Gas

	Solar PV Array
Electric Capacity (kW)	4,500
Annual Hours of Operation, or Capacity Factor	1,324

Case Study 1 – Twentynine Palms Individual Results by Technology

CHP System Results (7.2 + 9.2 MW Units) Annual Emissions Analysis	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	4.54	80.64	21.68	97.77	96%
SO_2 (tons/year)	0.24	246.29	0.13	246.18	100%
CO_2 (tons/year)	48,112	76,898	25,337	54,123	53%
CH_4 (tons/year)	0.91	1.493	0.48	1.067	54%
N_2O (tons/year)	0.09	1.250	0.05	1.212	93%
Total GHGs (CO_2e tons/year)	48,160	77,317	25,362	54,519	53%
Fuel Consumption (MMBtu/year)	823,138	777,608	433,478	387,948	32%
Equal to the annual GHG emissions from this many passenger vehicles:				10,657	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				6,970	

PV Results Annual Emissions Analysis	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	-	6.66	-	6.66	100%
SO_2 (tons/year)	-	20.34	-	20.34	100%
CO_2 (tons/year)	-	6,351	-	6,351	100%
CH_4 (tons/year)	-	0.123	-	0.123	100%
N_2O (tons/year)	-	0.103	-	0.103	100%
Total GHGs (CO_2e tons/year)	-	6,386	-	6,386	100%
Fuel Consumption (MMBtu/year)			-	64,226	100%
Equal to the annual GHG emissions from this many passenger vehicles:				1,213	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				793	

Case Study 1 – Twentynine Palms 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)	4.54	87.30	21.68	104.43	96%
SO_2 (tons/year)	0.24	266.63	0.13	266.52	100%
CO_2 (tons/year)	48,112	83,249	25,337	60,474	56%
CH_4 (tons/year)	0.91	1.616	0.48	1.190	57%
N_2O (tons/year)	0.09	1.353	0.05	1.315	94%
Total GHGs (CO_2e tons/year)	48,160	83,703	25,362	60,905	56%
Fuel Consumption (MMBtu/year)	823,138	777,608	433,478	452,174	37%
Equal to the annual GHG emissions from this many passenger vehicles:				11,870	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				7,763	

Case Study 2 – City of Milford, CT

Proposal an outcome of CT DEEP Round 2 Microgrid Program (October 2014)

- 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 146 kW natural gas-fired reciprocating engine CHP systems will replace the existing outdated boilers in the Parsons Center.
- A 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 2 – City of Milford Inputs

	CHP System 1
Type of CHP System	**NG Fired Reciprocating Engine**
CHP Electric Capacity (kW)	292 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 2 – City of Milford 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	1.08	1.01	1.90	91%
SO_2 (tons/year)	0.01	1.92	0.01	1.92	100%
CO_2 (tons/year)	1,728	1,796	1,181	1,249	42%
CH_4 (tons/year)	0.03	0.057	0.02	0.047	59%
N_2O (tons/year)	0.00	0.021	0.00	0.020	86%
Total GHGs (CO_2e tons/year)	1,730	1,804	1,182	1,256	42%
Fuel Consumption (MMBtu/year)	29,568	23,296	20,204	13,932	32%
Equal to the annual GHG emissions from this many passenger vehicles:				238	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				156	

PV Results Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	-	0.08	-	0.08	100%
SO_2 (tons/year)	-	0.15	-	0.15	100%
CO_2 (tons/year)	-	136	-	136	100%
CH_4 (tons/year)	-	0.004	-	0.004	100%
N_2O (tons/year)	-	0.002	-	0.002	100%
Total GHGs (CO_2e tons/year)	-	137	-	137	100%
Fuel Consumption (MMBtu/year)	-		-	1,765	100%
Equal to the annual GHG emissions from this many passenger vehicles:				26	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				17	

Case Study 2 – City of Milford 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	1.16	1.01	1.98	91%
SO_2 (tons/year)	0.01	2.07	0.01	2.07	100%
CO_2 (tons/year)	1,728	1,932	1,181	1,385	44%
CH_4 (tons/year)	0.03	0.061	0.02	0.051	61%
N_2O (tons/year)	0.00	0.023	0.00	0.022	87%
Total GHGs (CO_2e tons/year)	1,730	1,941	1,182	1,393	45%
Fuel Consumption (MMBtu/year)	29,568	23,296.36	20,204	15,697	32%
Equal to the annual GHG emissions from this many passenger vehicles:				264	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				173	

Overall Conclusions

- The CHPP Emissions Calculator can be used to determine the CHP emissions benefits
  - CHP energy savings using the calculator has been considered in some states such as New York and Arizona
  - Grid factor choices in other policy decisions have been predicated on the emission calculator
  - The calculator can provide an estimate of emissions from CHP when integrated with renewables in a grid
- Microgrid projects that incorporate CHP with renewables are gaining traction in the U.S.
  - Over the past decade, there has been a steady increase in such projects. Examples in Massachusetts, Connecticut, and New York.
  - There are clear emission reduction and the calculator provides one estimation methodology
  - Area ripe for further work on emission estimation methodologies

Questions and Contact Information

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