CREDITS FOR COMBINED HEAT AND POWER (CHP) IN OUTPUT-BASED ENVIRONMENTAL REGULATIONS (OBR)

Neeharika Naik-Dhungel

EPA Combined Heat and Power Partnership

May 16, 2012

Presentation Objective

- Output-Based Regulations (OBR) Concept
- CHP OBR Development Process
  - Thermal Credit in an Electricity-Based CHP System
  - Electricity Credit in a Thermally-Based CHP System
- Thermal/Electrical Credit Methodologies
- Current Federal and State CHP Regulations
- Conclusions

EPA CHP COMBINED HEAT AND POWER PARTNERSHIP

OBR Concept

- Output-based environmental regulations (OBR) relate emissions to the productive output of the process.

- OBR based on emissions limits expressed in terms of:
  - Electrical output (lbs/MWh) for electric generators,
  - Thermal output (lbs/MMBtu) for steam boilers, or
  - Mechanical output (gms/bhp-hr) for reciprocating internal combustion engines.

- This is in contrast to the conventional method that is in terms of the heat input of fuel burned or pollutant concentration in the exhaust.

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

OBR Concept and CHP

- OBR are important for recognizing the significant energy and environmental benefits of CHP.
- CHP systems produce both electrical and thermal outputs.
- OBR can be designed to explicitly account for both types of output.
  - How are the outputs credited appropriately ?
  - How do they incorporate CHP system design characteristics ?

EPA CHP COMBINED HEAT AND POWER PARTNERSHIP

How do you credit CHP ?

- The standard measurement unit for an OBR (e.g., pounds per MWh of electricity or pounds per MMBtu of steam) depends on whether the regulated facility is an electric generator or a thermal generator.

- Electric and thermal output must be credited to completely attribute CHP's environmental benefits.
  - Credit electricity output in a thermal-based CHP system
  - Credit thermal energy output in an electricity-based CHP system

- The unit of measurement in which the additional output is credited depends on the type of regulated facility.

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Common Approaches to Credit CHP

- Two common approaches to credit both CHP outputs in OBR.
  - Equivalence Approach
  - Avoided Emissions Approach
- The two approaches can result in different calculated levels of efficiency and different output emissions rates based on the amount of total output considered.
- Which approach to use would be influenced by the overall regulatory structure and objectives

Equivalence Approach

- Involves adding directly the thermal output to the electric output of the CHP system in consistent or equivalent units.
- An output-based emission rate based on this approach can vary substantially based on the ratio of the CHP unit's power and thermal output (commonly referred to as a system's power to heat (P/H) ratio).
- Examples - the Texas distributed generation rule and the California distributed generation certification program.

Avoided Emissions Approach

- Involves giving credit to the CHP system equal to the avoided emissions that a conventional system would otherwise emit had it provided the same electricity or thermal energy output as the CHP system.
- An output-based emission rate based on this approach relates the value of the thermal output or the electric output of the CHP system directly to the emissions actually avoided by the CHP system.
- Examples - Connecticut and Massachusetts small distributed generation standard.

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Credit Electricity Output in a Thermal-Based CHP System

Thermal-Based OBR*	Equivalence Approach	Avoided Emissions Approach
CHP Electric Capacity, MW	1 MW	
CHP Useful Thermal Output , MMBtu/hr	15 MMBtu/hr	
CHP Electricity Output, MWh	1 MWh	
Boiler Emissions, lb/MMBtu $_{\text{fuel input}}$	0.1 lb/MMBtu $_{\text{fuel}}$	
Boiler Fuel Use, MMBtu/hr	23.2 MMBtu/hr	
Boiler Emissions, lb/hr	2.32 lb/hr	
Electricity Thermal Equivalence,MMBtu/kWh	10,000 Btu/kWh	N/A
Avoided Central Station Emissions, lb/MWh	N/A	0.8 lb/MWh
CHP Output-Based Emission, lb/MMBtu $_{\text{steam}}$	**0.093** lb/MMBtu$_{\text{steam}}$	**0.101** lb/MMBtu $_{\text{steam}}$

*The example is based on a 1 MW steam turbine generator that has measured emissions rate of 2.32 lb/hr (based on a fuel input emissions rate of 0.1 lb/MMBtu). In CHP configuration, the system provides 15 MMBtu/hr of process thermal energy (about 15,000 lb steam/hr) and 1 MWh of net electricity output.

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Federal Regulations – OB Limits For CHP

- Re-proposed National Emissions Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial and Institutional Boilers, 2011
- Existing Mercury and Air Toxic Standards for Power Plants, 2011
- Existing reciprocating internal combustion engine NSPS (for both compression ignition and spark ignited engines) (40 CFR 60), 2010
- Existing Utility and Industrial Boiler New Source Performance Standard (NSPS) (40 CFR 60,Subpart D), 2006
- Existing Gas Turbine NSPS (40 CFR 60, Subpart KKKK), 2006

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Federal Example: (Re-proposed) ICI Boiler MACT

- Uses the "**equivalence approach**" for crediting the electricity output of boiler/steam turbine CHP.
- Value the output of the CHP facility at the equivalent heat rate of the avoided central station power, at 10,000 Btu/kWh.
  - Credit CHP systems for the total energy output
    - Total output is the sum of the energy content of the steam exiting the turbine and sent to the process in MMBtu and the energy of the electricity generated, converted to MMBtu at a rate of 10,000 Btu per kilowatt-hour generated (10 MMBtu per MWh)

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Federal Example: Gas Turbine NSPS (Subpart KKKK)

- Subpart Quad K NSPS allowed turbine owners and operators to meet either concentration-based or output-based NOx and SO_2 emissions limits.
- Allows credit for CHP's thermal output using the "**equivalence approach.**"
  - The emissions limits vary based on the combustion turbine type – whether the unit is new, reconstructed, or modified, what fuel is being used, and the location of the turbine. NOx limits for turbines range from 1.3 lbs/MWh up to 8.7 lbs/MWh.
  - The SO_2 limit is the same for all turbines regardless of size and fuel type and is 0.90 lbs/MWh gross energy output for turbines in continental areas.
  - For CHP systems, the thermal output that is not used to generate additional electricity or mechanical output is credited at 100 percent.

State OB CHP Regulations

State	Equivalence Approach	Avoided Emissions Approach
California	Conventional Emissions Limits & Emissions Performance Standard	
Connecticut		Small DG Rule
Delaware		Conventional Emissions Limits
Massachusetts		Small DG Rule & Performance Standards
Rhode Island		Conventional Emissions Limits
Texas	Small Distributed Generation (DG) Rule	

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

State Example: Massachusetts DG Rule

- In 2008, Massachusetts DEP finalized industry performance standards for small distributed generation (310 CMR 7.26) that is based on output-based methods.
- A compliance credit for CHP against its actual emissions based on the emissions that would have been created by a conventional separate system used to generate the same thermal output - the "**avoided emissions approach.**"
- The credit is subtracted from the actual emissions for determining compliance. To qualify for the thermal credit, CHP systems must meet the following criteria:
  - The power-to-heat ratio must be between 4.0 and 0.15.
  - The design system efficiency must be at least 55%.
  - Engine systems must have a rated power output equal to or greater than 50 kW; turbine systems must have a rated power output less than or equal to 10 MW.

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

State Example: Texas DG Rule

- In 2001, Texas TCEQ created a standard permit with output-based NOx emission limits for small generators (<10 MW) installed or modified after June 1, 2001.
- The compliance calculation is based on the "**equivalence approach:**"
  - Accounts for the thermal output of CHP by converting the measured thermal output (Btu) to an equivalent electric output (MWh). It converts all of the energy output to units of MWh and compares the total emission rate to the emission limit.
  - This regulatory method recognizes 100 percent of the thermal output of steam in the compliance calculation, and the greater overall efficiency of a CHP facility results in a lower output-based emission rate. The rule language simply states that the output will be calculated as the electric output plus the thermal output in MW based on the conversion of 1 MWh equals 3.413 MMBtu of heat output.
  - To be eligible, the heat recovered must equal at least 20 percent of the total energy output of the CHP unit.

CHP
EPA COMBINED HEAT AND POWER PARTNERSHIP

Conclusions

- OBR allows for CHP's environmental and efficiency benefits to be factored into compliance with a regulation.
- Policymakers' and rule writers' choice of OBR emissions crediting approach is predicated on several factors (e.g., regulatory development process, regulatory precedent, feedback from stakeholders, ease of approach).
- The two approaches provide different results and, thus, different levels of recognition of the efficiency benefits of a given CHP application.

Additional Information

EPA CHP Partnership (CHPP)

www.epa.gov/chp

CHPP Contact:

Neeharika Naik-Dhungel
Naik-Dhungel.Neeharika@epa.gov

EPA Resources

Output-based Regulations: A Handbook for Air Regulators, August 2004 http://www.epa.gov/chp/documents/obr_final_9105.pdf.

Output-Based Environmental Regulations Fact Sheet, September 2011, http://www.epa.gov/chp/state-policy/obr_factsheet.html.

EPA CHP COMBINED HEAT AND POWER PARTNERSHIP