Comments on Treatment of Combined Heat and Power in EPA's Proposed Clean Power Plan Rule
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Southwest Energy Efficiency Project (SWEEP)
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Background

Combined heat and power (CHP), which includes waste heat to power (WHP), produces useful heat and power from a single fuel source. CHP is significantly more efficient than central power generation, and is a proven and demonstrated approach to lower emissions, make U.S. manufacturers and other large facilities more competitive, and enhance electrical reliability. The Obama Administration recognizes these benefits and has established a national goal to encourage greater deployment of cost-effective CHP.

The proposed Clean Power Plan Rule discusses how regulated or "affected" (larger than 25 MW) CHP facilities would be treated, and EPA has invited comments on its proposal to credit 75% of the thermal output from these affected units. The proposed Rule also mentions that smaller, unaffected CHP units could be an example of demand-side energy efficiency, and invites comments on whether the Agency should include smaller CHP systems as a potential emission reduction option.[1] The Rule fails to mention waste heat to power (WHP), a type of CHP, which consumes no additional fuel and generates electricity from waste heat. WHP is regarded as a zero emissions, renewable source in several states. However, EPA does not mention WHP or CHP units that burn bio-fuel as potential compliance methods under Building Block 3.

SWEEP recommends several ways that the Clean Power Plan Rule can and should be modified to acknowledge the emissions reduction and other benefits of CHP and to encourage its further deployment. First, EPA should clarify that unregulated, non-major source CHP is an eligible compliance strategy under Block 4, and that WHP and biofuel-burning CHP units are eligible strategies under Block 3. EPA should provide additional guidance to states to enable them to incorporate CHP and WHP into these parts of their compliance plans, including how to account for emissions reductions or equivalent energy savings. Secondly, EPA should modify its proposed methods of accounting for the emissions benefits from affected electric generating units (EGUs) that incorporate CHP.

Clarify Eligibility of Non-Regulated CHP Units

SWEEP recommends that the EPA clarify that CHP and WHP are eligible compliance methods under Building Blocks 3 and 4. Explicit recognition of CHP and WHP will send a signal to states that they can include these technologies in their compliance plans.

[1] "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," Federal Register, https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating, p. 34924.

Natural gas-fired combined heat and power (CHP) is an end-use energy efficiency method with demonstrated benefits. There are accepted methods for calculating the net CO_2 emissions reductions from CHP systems,[2] and seven states currently acknowledge electricity savings from CHP systems as a way to achieve their energy efficiency resource standards.[3]

WHP generates power from waste heat that is would otherwise be exhausted to the environment, and hence involves the consumption of no additional fossil fuel. Burning biofuels in a CHP system is another type of net zero CO_2 emissions generation resource. EPA should allow WHP and biofuel-burning CHP units to qualify as zero-carbon generation resources, along with other renewable energy resources under Building Block 3.

The EPA should also provide guidance to states to help them incorporate CHP and WHP into their compliance plans, including state policies that support further CHP deployment. EPA acknowledges that it "intends to develop guidance for evaluation, monitoring, and verification (EM&V) of renewable energy and demand-side energy efficiency programs and measures incorporated in state plans." This commitment should include guidance on how to value and count emission reductions from CHP. In particular, states will need model rules detailing the best way to include CHP in renewable portfolio and energy efficiency standards and guidance on how to appropriately credit CHP output. These written materials could be supplemented with a CHP webinar for states and other stakeholders involved in developing compliance plans.

Accounting for Benefits of Non-Major Source CHP Systems

New or expanded CHP systems that are not covered by the rule (below the ~25 MW size threshold or below the minimum level of power sales to the grid)[4] could be given credits like energy savings from end-use energy efficiency improvements are given credits, if a state chooses to comply under the CO_2 emissions rate approach. There would be no credits for these CHP units if a state chooses to comply under the mass-based approach, because the energy savings from these smaller CHP units would result in reductions in measured and reported emissions from regulated EGUs, and hence their emission reductions would already be accounted for. However, we recommend that an adjustment (negative credit) be made for the increase in the on-site CO_2 emissions at the CHP facility. This adjustment is described in Appendix A and illustrated with several examples.

[2] For example by using the EPA CHP Partnership's, "CHP Emissions Calculator," available at http://www.epa.gov/chp/basic/calculator.html.
[3] "The 2013 State Energy Efficiency Scorecard," ACEEE, November 2013. http://www.aceee.org/research-report/e13k.
[4] The actual definition of an affected EGU is "any boiler, integrated gasification combined cycle (IGCC), or combustion turbine (in either simple cycle or combined cycle configuration) that (1) is capable of combusting at least 250 million Btu per hour; (2) combusts fossil fuel for more than 10 percent of its total annual heat input (stationary combustion turbines have an additional criteria that they combust over 90 percent natural gas); (3) sells the greater of 219,000 MWh per year and one-third of its potential electrical output to a utility distribution system; and (4) was not in operation or under construction as of January 8, 2014 (the date the proposed GHG standards of performance for new EGUs were published in the Federal Register)." See "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," Federal Register, https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating, p. 34854.

Under a rate-based approach, EPA is proposing to give energy efficiency credits to both utility and non-utility energy efficiency policies and programs that are included in state implementation plans. We recommend that a utility that provides CHP incentives or a state that has a CHP incentive, financing or technical assistance program also receive credits. With these utility or state CHP programs in place and included in the state's Section 111(d) compliance plan, states could have the option to credit either emission reductions or electricity savings from a CHP system. Emissions reductions would be applied to the numerator in a state's emissions rate calculation; electricity savings would be added as a credit in the denominator (analogous to other energy efficiency credits proposed by EPA).

As mentioned above, seven states acknowledge electricity savings from CHP systems as a way to achieve their energy efficiency resource standards. However, even among these states there is no consistent or accepted method for accounting for the amount of electricity savings from CHP. Therefore, EPA should provide guidance to states on how to calculate and credit the emissions reductions or energy savings from CHP.

Because the goal of the Section 111(d) rules is CO_2 emissions reductions, EPA should recommend that states first consider providing credits tied to the level of net CO_2 emissions reductions from the CHP system. As an alternative, states could calculate an equivalent amount of net electricity savings from CHP, based on the CO2 emission reductions. Appendix A describes our suggested method for calculating the credited CO2 emission reductions or net electricity savings, and several examples illustrating the method are summarized in Table 1. These examples show that using this method, the percentage of total electrical output of the CHP system that will be credited as savings (the "net electricity savings") is 60-80%. Except for the boiler/steam turbine examples, there is a strong correlation between the net electricity savings and the CHP system efficiency.

Estimating the Potential Electrical Savings from CHP

Policies that encourage CHP as an energy-saving measure under Block 4 (or Block 3 for WHP or biofuel-based CHP) could result in significant energy savings. These policies could include utility or state programs involving incentives, technical assistance, or financing for CHP systems. In a recent study, the American Council for an Energy-Efficient Economy (ACEEE) estimates that about 20 GW of new CHP capacity could be installed in the U.S. by 2030 if states were to adopt moderate CHP policies under the Clean Power Plan.[5] ACEEE's analysis considers both technical potential, based on analyses by ICF, and the likelihood of implementation based on energy prices, estimated payback periods, and other economic factors. Some of ACEEE's other assumptions, which are reasonable yet slightly conservative, include:

- The projections do not include potential WHP installations
- No electricity export to the power grid is considered, which limits the CHP capacity to the on-site electrical demand.

[5] Sara Hayes, et al, "Change is in the Air: How States Can Harness Energy Efficiency and to Strengthen the Economy and Reduce Pollution," ACEEE, April 2014. http://www.aceee.org/sites/default/files/publications/researchreports/e1401.pdf, p. 50.

Table 1 – Example Calculations of Credits for Unaffected CHP Systems

Example (1)	CHP system efficiency	On-site fuel for CHP (MMBtu)	Displaced thermal fuel (MMBtu) (2)	Total electricity output of CHP (MWh)	CO2 emissions reduction with CHP (tons) (3)	Net electricity savings (MWh equiv. to reduced CO2 emissions) (4)	% of CHP elect output credited as savings
Recip. Engine, 0.8 MW	74.7%	50,693	25,155	5,200	3,357	3,849	**74.0%**
Recip. Engine, 3.0 MW	72.4%	184,817	84,094	19,500	12,298	14,104	**72.4%**
Gas Turbine, 5.4 MW	67.0%	421,694	203,361	35,100	19,976	22,909	**65.3%**
Gas Turbine, 10.2 MW	64.3%	785,471	348,587	66,300	36,305	41,634	**62.8%**
Boiler/ST, 3.0 MW	72.2%	959,774	782,438	19,500	7,828	8,977	**46.1%**
Boiler/ST, 15.0 MW	72.5%	3,578,849	2,827,013	97,500	47,009	53,909	**55.3%**

(1) These examples assume 6500 hours per year of operation, and 90% heat recovery. Fuel consumption and electrical and thermal outputs are from specifications for typical CHP systems of the sizes listed. Recip. Engine means reciprocating engine. Boiler/ST means boiler with steam turbine.
(2) Assumes 80% boiler efficiency.
(3) CO2 emissions for displaced electricity include T&D losses, and are based on the U.S. average "all-fossil" electricity CO2 emissions rate.
(4) Net electricity savings are calculated by taking the CHP CO2 emission reductions and dividing by the same electricity CO2 emissions rate noted in the previous step (note 2).

We estimate that this 20 GW of projected new CHP capacity in 2030 translates to 1.5 GW of incremental CHP capacity per year during 2020-2030, which in turn results in about 6.3 TWh of net electricity savings from new CHP capacity each year. This corresponds to an incremental energy savings potential of about 0.15% of retail electricity sales per year.[6] Therefore, with some additional clarification of CHP's role under Blocks 3 and 4, as discussed above; state policies to promote CHP implementation could make a significant contribution towards achieving the Clean Power Plan targets, as long as CHP is allowed as a compliance option.

Accounting for Benefits of Major Source CHP Systems

For affected EGUs that involve CHP, both the CO_2 emissions and energy output would be included in the determination of a state's average CO_2 emissions rate. The proposed rule would credit all of the electricity produced from the CHP system, but would credit only 75 percent of

[6] The calculation of incremental energy savings potential is explained in Appendix B.

the useful thermal output (by adding the thermal output to the denominator in the emissions rate calculation). EPA has invited comment on "a range of two-thirds to 100 percent credit for useful thermal output in the final rule to better align incentives with avoided emissions."

In previous regulations, the EPA has used two approaches to calculate an emissions rate that factors in both the electric and useful thermal energy outputs of CHP: the Equivalence approach and the Avoided Emissions approach.[7] We think the preferred method for calculating CO_2 emissions from CHP under the Clean Power Plan should be the Avoided Emissions approach. The Avoided Emissions approach most accurately recognizes the CO_2 emission reductions offered by the CHP system. Using this approach, states would incorporate the avoided CO_2 emissions from on-site thermal needs into the calculation of the rate-based electricity emissions factor for CHP.

We provide several examples (see Appendix A) to demonstrate this approach. The equivalence approach is to estimate the benefits of CHP by crediting a percentage of the thermal output from the CHP system in addition to the electrical output. The examples in Appendix A, summarized in Table 2 below, show that for the rate-based approach, crediting only 75% of the thermal output slightly undervalues the actual CO_2 emissions benefits from CHP in cases of high CHP system efficiency. On the other hand, 75% thermal credit is a reasonable approximation if EPA prefers to pick a single, fixed percentage.

The equivalence approach does not apply under a mass-based approach, and states using the mass-based approach would need to directly calculate the avoided emissions from the CHP system's thermal output. This is also explained in Appendix A; Table 2 shows the amount of CO_2 emissions credits for several examples.

[7] "Accounting for CHP in Output-Based Regulations," U.S. EPA Combined Heat and Power Partnership, February 2013, http://www.epa.gov/chp/documents/accounting.pdf.

Table 2 – Example Calculations for Affected CHP Facilities

Example	Assumed heat recovery (%)	CHP system efficiency	Total electricity output of the CHP system (MWh/yr) (1)	CO2 emissions from on-site CHP fuel (tons/yr)	CO2 emissions reductions from displaced thermal (tons/yr) (2)	CHP CO2 emissions rate, no thermal credit (lb CO2/MWh)	CHP CO2 Emissions rate, w/ avoided thermal emissions credit (lb CO2/MWh)	Required % of thermal output to credit to equal avoided emissions rate
Gas Turbine, 25 MW	100%	70.6%	162,500	94,321	42,811	1,161	634	**78.5%**
Gas Turbine, 25 MW	80%	63.3%	162,500	94,321	34,249	1,161	739	**67.3%**
Gas Turbine, 40 MW	100%	71.6%	260,000	139,901	60,475	1,076	611	**81.5%**
Gas Turbine, 40 MW	80%	64.7%	260,000	139,901	48,380	1,076	704	**70.7%**

(1) Based on 6500 hr/yr of operation

(2) Assuming natural gas is used for on-site thermal. This is the amount of CO2 emissions credits that should be given to the CHP facility under a mass-based approach.

(3) Fuel consumption and electrical and thermal outputs are based on CHP system specifications for typical gas turbine systems of the sizes shown.

Appendix A

Calculating the Emissions Benefits of CHP: SWEEP's Recommended Approach

Non-Major Source CHP

Calculating CO_2 Emission Reductions and Credits

1. Calculate the on-site fuel consumption for CHP, reduced fuel consumption for on-site thermal needs, and total electricity output from the CHP system (used on-site or sold to the grid) based on the actual performance of the CHP system each year.

2. Calculate the net CO_2 emissions reduction from the CHP system:
   - Calculate CO_2 emissions from fuel consumption of the CHP system;
   - Subtract CO_2 emissions from displaced on-site fuel consumption for thermal needs,
   - Subtract CO_2 emissions from displaced utility electricity generation (including transmission and distribution losses), using the *state or utility-specific all-fossil emission factor* (see below for discussion about emission factors).
   - The net CO_2 emissions reduction from CHP (calculated as described above) is the amount of credit that a state or utility can add to the numerator under a rate-based approach. We think this should be the preferred method.

Calculation of Net Electricity Savings

1. As an alternative, states can calculate an amount of net electricity (MWh) savings and credits from CHP, equivalent to the CO_2 savings. To do this, convert net CO_2 emissions savings from CHP (from above) into net electricity savings (MWh) by dividing by the *state or utility-specific all- fossil emission factor* (the same electricity emissions factor used above in step 2).

2. This is the amount of net electricity savings that a utility or state can add to the denominator in its CO_2 emissions rate calculation, analogous to the addition of energy efficiency credits from energy efficiency policies and programs. Note that this net electricity savings is less than the full electricity output of the CHP system. The net electricity savings typically varies between 60-80% of the total electrical output, depending largely on the overall CHP system efficiency.

The examples in attached spreadsheet, and summarized in Table 1 above, demonstrate these calculations.

These calculations incorporate assumptions about the average grid heat rate, CO_2 emissions rate, and avoided transmission and distribution losses. CHP additions typically displace fossil fuel-fired power generation (typically natural gas and some coal), so the all-fossil average heat rate and CO_2 emissions factors from the EPA eGRID sub-region or state in which the CHP unit is located currently offer the best approximation for the emissions CHP is displacing.[8]

This avoided emissions approach is well-aligned with the methodology used by the EPA's CHP Calculator, which is a useful resource to help CHP owners/operators calculate or estimate emissions reductions. The calculator allows the user to select default values for many inputs, including transmission and distribution losses, which vary by utility, or by state.

This proposed method will ensure that the calculated electricity savings from CHP align with the CO_2 emission reductions from CHP. It is more accurate and valid from a greenhouse gas point of view than other approaches for calculating equivalent energy savings from CHP. In the examples, we also compare the equivalent electricity savings with two other proposed methods for calculating electricity savings from CHP, the ACEEE method and the Massachusetts method. The examples show that the ACEEE and MA methods undervalue and overvalue, respectively, the electricity savings from CHP, compared to the avoided CO_2 approach.

Mass-Based Approach

Under a mass-based approach, the total electricity output from a CHP system will displace that amount of electricity from the utility and the associated CO_2 emissions. To properly account for the net emission reductions from CHP, states should adjust this total emission reduction from the displaced electricity by adding in the net increase in CO_2 emissions from additional fuel consumption at the CHP facility. (Sample calculations of this are also provided in the attached spreadsheet.)

Major Source CHP

CO_2 Emissions Rate

The method for calculating CO2 emissions rate for regulated, major source CHP systems is similar to the method described above, but in this case for step 2 we calculate the CO_2 emissions rate for the CHP system rather than the total emissions benefits.

1. Calculate the on-site fuel consumption for CHP, reduced fuel consumption for on-site heating, and total electricity output from the CHP system (used on-site or sold to the grid) based on the actual performance of the CHP system each year.

2. Calculate the CO_2 emissions *rate* for the CHP system:
   a) Calculate the CO_2 emissions from fuel consumption of the CHP system
   b) subtract CO_2 emissions from displaced on-site thermal
   c) This is the total net CO_2 emissions from the CHP system

[8] Rather than relying on eGrid (which is the best emission factors available currently), we understand that states will determine and provide to EPA state and utility-specific emission factors annually, including the all-fossil emission factors, as part of Section 111(d) compliance. These emission factors will only be one year behind, rather than being four years behind in the case of eGrid's factors. (This year, 2014, the most current eGrid factors are for 2010.)

d) Divide by net kWh output of the CHP system. The net generation should be adjusted for the benefits of reduced transmission and distribution losses, since most of the power from CHP will be consumed on-site. EPA has proposed dividing the net output from CHP systems by 95% to reflect an average U.S. T&D loss rate of 5%. For the percentage of power consumed on-site, we suggest making this adjustment using the utility-specific T&D loss factor for the customer type (i.e., commercial, industrial, or commercial and industrial combined) instead of assuming 5% across the board.

3. As an alternative, one can calculate the equivalent thermal output that should be credited under the equivalence approach as follows:
   a) Calculate the equivalent amount of thermal output, (converted to kWh), which results in the same CO_2 emissions rate calculated under step 2d (using algebra).
   b) Using this equivalent thermal output (converted to MMBtu), calculate the percentage of actual thermal output that should be credited.

These calculation steps are demonstrated in the examples in the attached spreadsheet and are summarized in Table 2 above.

Calculating CO_2 Credits for CHP Under a Mass-Based Approach

Under a mass-based approach, regulated, major source CHP systems would measure and report their actual CO_2 emissions, and would not see any direct benefit from the avoided emissions at the commercial/industrial park or commercial/industrial facility through utilizing the CHP system's heat output to offset fuel consumption for thermal needs on-site. Therefore, under this approach, EPA should allow states to receive credits for these avoided emissions, similar to crediting the net emissions reduction or adjusted energy savings as described for the rate-based approach. In this case, the amount of avoided CO_2 emissions from the CHP thermal output should be calculated and provided to the CHP system owner. This type of calculation is demonstrated in the examples in the "large CHP" tab of the attached spreadsheet.

Existing Major Source CHP

An existing major source CHP system owned by a utility could contribute to emission reductions if the system increases its operating hours or switches to a less carbon-intensive fuel. In these cases states should calculate the associated CO_2 emissions reductions directly as described above and credit them to the regulated entity.

Bio-fuel CHP

If a new major source CHP system burns biofuel (forest or agricultural residues, biogas or dedicated biofuels), it could be considered a renewable source with zero emissions, and thus be part of Building Block 3 in a state's compliance plan. For bio-fuel CHP, we also suggest crediting the avoided emissions from displaced thermal as described above, which could then be applied to either a rate- or mass-based approach.

Appendix B

Calculation of Energy Savings Potential from CHP

Table B-1 shows SWEEP's calculation of potential incremental energy savings, based on the estimate of 20 GW of new CHP capacity added by 2030, with an average of 1.5 GW of new capacity annually during 2020-2030. This is the amount of new capacity that could be added if states were to adopt moderate policies to promote CHP, as explained above and in footnote 6. Based on the assumptions below, we estimate that this new CHP capacity could contribute incremental national energy savings of 0.15% per year.

Table B-1 – Estimate of Electricity Savings Potential from New CHP Capacity

New CHP capacity in 2030 (GW)	Incremental annual CHP capacity added during 2020-30 (GW) (1)	Incremental annual CHP generation (MWh/yr) during 2020-30 (2)	Incremental annual electricity savings (MWh/yr) (3)	Total U.S. retail electrical sales in 2013 (MWh)	Total electrical sales in 2030 (MWh) (4)	Incremental annual energy savings from CHP as percentage of sales
20	**1.5**	**9,750,000**	**6,337,500**	**3,692,000,000**	**4,299,400,000**	**0.15%**

(1) Assumes 82% of the total new capacity is added between 2020 and 2030 (i.e., over 11 years).
(2) Based on 6500 hr per year of operation.
(3) Assumes 65% average "net electricity savings" (percentage of CHP electrical output counted as savings).
(4) Assumes 0.9% per year growth from now thru 2030, based on the U.S. Energy Information Agency's Annual Energy Outlook 2013.