



## Protocol Comment Form

Date: May 6, 2004  
Name: Kathleen Spees  
Company Name: Battelle, Pacific Northwest National Laboratory  
Mailing Address: PO Box 999 K6-10  
SIGMA2/410  
Richland, WA 99352  
Phone: (509) 372-4778  
Fax: (509) 372-4370  
Email: kathleen.spees@pnl.gov

### What is the issue or problem with the current Protocol?

Please select one:  General Reporting Protocol  Certification Protocol

Subject: Combined Heat and Power Plant Emissions Division Between Electricity and Steam

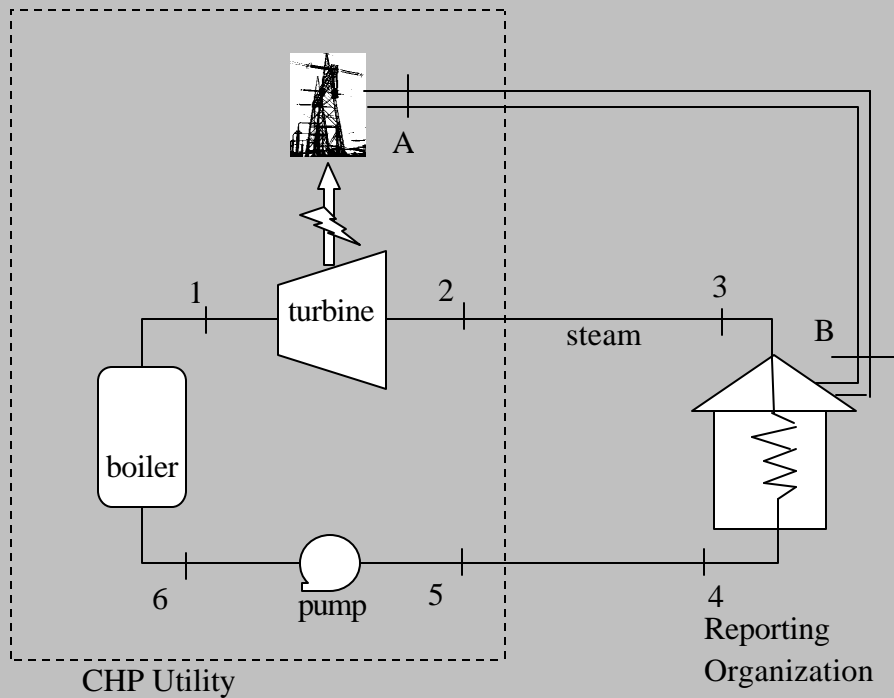
The assignment of percentage emissions output between district heat and electricity in CHP utilities skews data to favor electricity over steam.

Adding kWh electricity generated to Btu "total usable heat" and dividing emissions as directed in equations 8a-8c assigns more emissions to the steam generated and less to the electricity than it should because the electricity at plant and the steam heat at plant do not have equivalent associated emissions. The higher inefficiencies involved in converting the raw heat into the more organized form of power electricity is inherently less efficient than using it directly as heat. (These additional efficiency factors include turbine efficiency, heat loss, and generator efficiency - none of which are present for district heating.)

### What solution or alternative approach would address this?

I'm modeling the CHP utility as a simple Rankine cycle. Resulting equations will be more complicated in practice when adding reheat, etc., but the approach will be the same\*.

Diagram and variables for clarity:



Variables:

Variable subscripts  $i$  represent the state of steam/electricity as identified in the figure

$h_i$  is the specific enthalpy of steam  $\frac{Btu}{lbm}$

$E_i$  is the electric energy generated or delivered per unit mass steam  $\frac{kWh}{lbm}$

Heat/Enthalpy Drop Values:

In  $\frac{Btu}{lbm}$

Steam enthalpy drop associated with district heat:  $q_{dh} = h_2 - h_5$

Heat delivered to building via district heat:  $q_{ddh} = h_3 - h_4$

Steam enthalpy drop associate with electricity generation:  $q_{eg} = h_1 - h_2$

Total usable heat  $q_{tot}$  to include that used for *both* electricity generation and district heat:

$$q_{tot} = h_1 - h_5 = q_{eg} + q_{dh}$$

Efficiencies:

*T&D efficiency associated with district heat:*

$$e_{dh} = \frac{h_3 - h_4}{h_2 - h_5}$$

*Conversion efficiency associated with electricity generation:*

$$e_{ceg} = \frac{E_A}{h_1 - h_2}, \text{ this efficiency will require unit conversions.}$$

*T&D efficiency associated with electricity generation:*

$$e_{t\text{deg}} = \frac{E_B}{E_A}, e_{ideg} \text{ is assumed a nominal 92\% elsewhere in the protocol.}$$

Associated Emissions:

GHG emissions rate from utility  $G$  per month  $\frac{\text{kgCO}_2e}{\text{month}}$

Final Values:

Monthly emissions associated with district heat consumption  $G_{dh} = \frac{q_{dh}}{q_{tot}} \cdot G = \frac{q_{ddh}/e_{dh}}{q_{tot}} \cdot G$

Monthly emissions associated with electricity consumption

$$G_{eg} = \frac{q_{eg}}{q_{tot}} \cdot G = \frac{E_B / (e_{ceg} e_{tdeg})}{q_{tot}} \cdot G$$

This approach allows heat, pressure, and work losses involved with the boiler and pump to be carried proportionally by the steam and electricity end uses. However, the heat and pressure loss inefficiencies associated solely with steam distribution will be assigned solely to steam end use. Likewise, the electric T&D losses, and heat to electricity conversion losses will be attributed solely to electricity.

\*In adding a feedwater heater or other reheat option out of the turbine(s), the equations will be very different, but the approach should still be to assign the emissions output proportionally based on the relative magnitudes of steam enthalpy drop associated with (1) electricity generation, and (2) district heating.

\*\*I used a per unit mass basis, but some combination of per unit mass and per unit time (s, hr, month) will be necessary in practice and depend largely on available reported units. Unit complications might be simplified with careful setup, but I have not addressed these issues.

**How will this proposed solution continue to meet the general spirit and purpose of the Protocol and the Registry, as outlined in the Protocol itself, policies adopted by the Board of Directors and enabling legislation?**

This would more accurately assign emissions to the end use.

Return completed form by email, fax or mail to:  
California Climate Action Registry  
help@climateregistry.org  
Fax: (213) 623-6716  
515 S. Flower St., Suite 1305, Los Angeles, CA 90071

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