The following comments were developed by CDH Energy Corp. in a review of the ALTERNATIVE ENERGY PORTFOLIO STANDARD GUIDELINE ON METERING AND CALCULATING THE USEFUL THERMAL OUTPUT OF ELIGIBLE RENEWABLE THERMAL GENERATION UNITS – PART 2 document.

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3) Locating Btu Meters

b) Whenever possible, Btu meters should be located before any point of connection with a non-useful heat load, such as a radiator of cooling tower that rejects excess heat, before delivery to the distribution system, or rejection of excess heating systems.

This criteria is unclear, as it is contrary to most standard system configurations, which are designed to deliver thermal resource at the highest temperature to the useful load point with heat rejection/dump radiators afterwards. We believe the intent of this section is to indicate that <u>useful</u> heat be measured, not <u>total</u> heat (defined as the sum of useful + rejected heat). If this is the case, this section should state:

Locate BTU metering equipment so that the corresponding flow and temperature difference measurements are positioned across the useful heat connection only, excluding any heat rejected at a cooling tower or dump radiator. The BTU meter flow measurement shall be located in sections with the same mass flow as the BTU temperature sensors (e.g. both flow and temperature sensors in main header piping or both flow and temperature sensors in branch piping).

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(a) Input: Input must come from each APS metering system and component, at an interval that does not to exceed 5 minute between inputs.

Most the metering equipment in the guideline incorporates measurements from sensors that have onboard intelligence (e.g. integrating BTU meters, totalizing kWh meters, etc). A 15-minute data interval is sufficient for this type of measurement. For measurements on sensors without onboard intelligence (e.g. system temperatures, flow rates, etc) 15-minute data is suitable if the DAS provides <u>true averages per interval with a high sampling rate (e.g. sample every 30-seconds, record 15-minute average).</u> If the DAS cannot provide true averages for the recording interval, then 1-minute samples should be sufficient. The 5-minute data interval is both insufficient for sampled data, and overly frequent for data from intelligent meters.

For all BTU measurements recorded, the corresponding flow and temperature difference data from the BTU meter or DAS should be also recorded in the data file.

<u>Top of Page 15 of 56 (Table 3)</u>

Insertion flowmeters should be given consideration, as these meters allow for meter servicing without shutting down or draining the RTGU system. Insertion style meters using magnetic sensors and shedding vortex sensors are widely commercially available with the accuracy specification required.

Surface mount (strap-on) flow measurement should be an allowed option for temporary one-time flow measurements.

Page 14-15 (All Tables)

All metering used to verify RTGU performance are typically field installed sensors. The word "re-calibration" implies removing the meter and imposing a fixed and known process load to the meter. This would typically occur in a lab setting, and under not field performance measurement. It is recommended that this wording be changed to "Field Verification" which would have the definition of comparison to another measurement in place, with the results of the comparison documented.

Unify in verification interval on all meter to either annual or biennial would simplify program compliance.

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Measuring refrigerant flow is extremely difficult in the field, and typically only performed in a lab setting using calibrated low pressure drop orifice plates or Coriolis style meters. Installing meters of this type require cutting into the refrigerant piping, which is highly discouraged. We do not know of a non-intrusive measurement (e.g. ultrasonic meter) that will work with refrigerant.

Measuring refrigerant temperature difference will not capture the entire refrigeration effect provided, as the vapor compression refrigeration cycle incorporates phase change also. Measurements of capacity provided by refrigerant systems (typically heat pumps) must be achieved on the secondary fluid portion of the system (e.g. air-side or water-side of system evaporator).

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Note that this block of text:

Determination of RH:
RH for any interval = $RH_{supply} – RH_{return}$

Where:

RH_{supply} = The renewable thermal energy supplied from the RTGU to the useful thermal load(s)
RH_{return}= The renewable thermal energy returned from the useful thermal load the RTGU

Is equivalent to this block:

The rate that RH transferred to the load at any time is:
HTFF * HTF * Cp * (HTFST – HTFRT)

Where:

HTFF = HTF flowrate (gpm)
HTF = The density of the heat transfer fluid that circulates between the collector array and the loop to storage tank heat exchanger (not shown, lbs/gal)
Cp = The constant pressure specific heat of the HTF (Btu/lb-°F)
HTFST = HTF supply temperature (°F)

Both texts describe the heat transfer to the useful thermal load, and the bottom is the more common expression, and is equal to the top when integrated across any interval.

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Figure 4 in Section 3(I)(3) and Section 3(I)(5).
(a) The systems heat transfer supply temperature (HTST) & heat transfer return temperature (HTRT) will be measured directly with thermal sensors located at the collector array and the grid supplied electrical energy (G) must be directly metered.
(b) The heat transfer fluid (HTF) flow will be indirectly metered using the manufacturer's performance data for the specific pump. After the RTGU is commissioned and the HTF flows are balanced and set, the following data will be obtained and recorded for each of the HTF circulating pumps:
(i) The inlet and discharge pressure (psig) (for location of the pressure gauges, see Figure 3)
(ii) The average operating kW over a five minute interval, after full flow is established. A copy of a report issued by the pump supplier on company letterhead showing the system flow rate in pounds of HTF per hour for each pump is to be provided with the statement of qualification application. A copy of the pump performance curve showing the system pump design point (see Figure 4 below) must be included in the report.
(c) Based on the pump supplier's determination of the heat transfer flowrate (HTFF) for each pump, the flow for each pumped HTF loop will be:
HTF flow (lbs) = Sum for all loops
Where the flow for each pump = HTF flow (lbs/hr) * kWh/kW pump
Where:
kW pump = kW pump as recorded in (b) above.
OR
The installer may use an approved temporary flow meter to measure and record the system flow rate for each pumped HTF circulating loop

The purpose of this section is to establish a simplified path for flow measurement on intermediate sized Solar Thermal RTGU. The following issues are noted with section (b):

1) Manufacturers of pumps will resist providing any "certified" flow rate for a field installation, regardless of instrumentation/documentation supplied (section b). This may be determined in the field using the pump curve, pressure readings, and one-time measured pump power, however typically pumps in this size range have a very flat pump curve, resulting in a wide range of flows at any observed pressure drop.
2) Pressure gauge readings are often either inaccurate, or gauge ranges are over broad, providing inaccurate pressure measurement.
3) Systems with multiple parallel pumps will require individual pressure gauges across each pump. The supply and return header pressure may not accurately represent the conditions for each pump.
4) Pump curve often typically states bHP, which is brake horsepower of the pump or mechanical shaft power, not electrical input power that is measured with a power meter.

Allowing for a one-time measurement of system flow using outside equipment (e.g. ultrasonic meter) should be suitable for all circuits where constant speed pumps are employed. An RTGU employing variable speed pumping requires continuous direct measurement of heat transfer flow (HTF).

The intent of section (c) is unclear. The total RH rate is based the combined flow of all pumps, and the measured temperature difference (HTST – HTRT) located at the supply and return header piping for the RGTU. If inferred flow from a pump curve is allowed, section (c) should simply state that the system heat transfer flow rate is calculated using the sum of all inferred flows.

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Note that Section 7 metering methodology could also apply to intermediate sized systems configured in a similar manner. Intermediate sized systems often have cold water makeup and storage tank.

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Note that off the shelf BTU computers are typically set up for wet fluid flow (steam/hot/cold water), and BTU calculations for air side measurements may need to be performed at the DAS itself. As an alternative short time step (1-minute data or faster) readings of air flow and temperature could be recorded.

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Formula for $E_{net,out}$ should be: RH - G/0.44

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Formula for $E_{net,out}$ should be: RH - G/0.44

Page 33 of 56 – Use of the word “Rating”

The guide states “i) The AHRI rating performance data should be used”. Data from manufacturer’s performance tables is not “rated.” The only “rated” values are defined in standards, such as the heating COP at 17F and 47F for air-source HPs (AHRI 210/240). The performance tables are broader that the rating points.

You could ask for the performance tables to also include points at rated conditions so that published ratings can be compared to the values in the tables. Any differences due to fan power assumptions, etc. can then be discerned.

There is a new ASHRAE standard being developed that helps the cause defining the necessary data:

ASHRAE STANDARD 205P, “Standard Representation of Performance Simulation Data for HVAC&R and Other Facility Equipment”. It is now out for advisory public review.

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The word “Outside” and “evaporator” should be omitted from the definition of EAF. I believe this should be “Air flow rate through the indoor coil.”

If you are trying to measure the flow through the outdoor coil (evaporator in the heating mode) this is very hard and it would require additional humidity measurements to determine enthalpy of entering and leaving

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Same comments as on page 33 rating

Page 38 of 56, and Table 5 on page 15

Measuring refrigerant mass flow in the field is difficult and rarely done. Most laboratory measurements use Coriolis meters or low-mass turbines (ASHRAE Standard 37 shows examples of laboratory setups). I have never seen an ultrasonic flow meter used for this measurement.

Page 39 or 56

The formula for net renewable heat transfer is incorrect. The formula must use the enthalpy of the refrigerant. Additional measurements are required:

- hot gas temperature and pressure
- liquid temperature (assuming saturation)

Q = mass_flow * ($H_{in,gas}$ – $H_{out,liq}$)

Where $H_{in,gas}$ = F(Tg,Pg)

$H_{out,liq}$ = F(T_L)

Mass_flow is for the liquid

Calculations like these can be found in ASHRAE Standard 37

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The formula for the "renewable heat transfer to a load" is incorrect. This is the heat transfer from the ground loop. Therefore, the formula at the top of the page should be

$E_{net,out}$ = RH

No value of G is required.

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The equation for the rate of renewable heat transfer to a useful load should be:

RH = GWSF * Cp * (GWST – GWRT) / 3.412E6 (Btu/Mwh)

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Arrow is missing on Heat Rejection diagram block. Need BTU meter symbols across useful HX (for direct **OPTIONAL** measurement of RH).

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The methodology described in Section 4 provides a coarse method for determining RH (and AECs) by setting all energy streams to zero when heat rejection is observed to operate. Even on small systems the preferred method should be to measure RH direct at the useful heat exchanger. The cost of adding thermal metering is small compared to the cost of the required two fuel meters.

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Based position of BTU meter in Figure 15, RH is directly metered, and there NUH and P_t should not be subtracted from the equation.

The equation should be:

$E_{net,out}$ = (RH – G/0.44)

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Due to the definition of RH, the following changes are necessary:

Note: All terms are the cumulative as-metered values. Unless otherwise indicated, all units in MWh

Where:

RH = Renewable heat transferred to a useful load and is directly metered

~~**NUH = Non useful thermal heat rejected to a heat sink**~~

G = Grid supplied electrical energy

~~**Conversion of site to source nonrenewable fuel per MWh grid electricity = G / (0.44)**~~

~~**Pt = Parasitic thermal energy**~~

~~***Note: For systems which includes a system that rejects heat directly generated to a heat sink (e.g. a radiator or cooling tower), the provider must either provide a method by which the heat rejected can be quantified or provide a method, such as a relay or switch which is actuated by the operation of the heat rejection system and will transmits a signal to the data acquisition system to set to zero all AECs generated during any interval during which the heat rejection system has been running. For a CHP RTGU, G does not include any electricity supplied to auxiliary systems by the CHP generator(s)***~~

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RF and NRF definitions listed twice

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Based on the location of the steam meter in Figure 16, this meter represents the net steam flow needed to directly measure RH. Eliminate NUH and Pt from this equation.

If the output steam meter is located before the steam vent or dump condenser, then dumped steam metering is required to calculate the net steam delivered.