New England Geothermal Professional Association
1053 Kittredge Road
Danville, VT 05828
Phone 800-236-8215
Email: Info@negpa.org

www.negpa.org

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Ms. Samantha Meserve
Department of Energy Resources
100 Cambridge Street
Suite 1020
Boston MA 02114

Delivered via email to: Samantha.Meserve@state.ma.us

Dear Ms. Meserve,

On behalf of the New England Geothermal Professional Association Board of Directors, I have attached our comments regarding the revisions to the Massachusetts Alternative Energy Portfolio Standard (APS) and associated metering guidelines.

While these comments focus on the ground-source heat pump technology, we also point out some inconsistencies in the treatment of different technologies, that, if unaddressed, may lead to further delay in adoption of these rules and associated guidelines.

We have tried to be clear and constructive in our comments. If you have any questions or would like any clarifications, please don't hesitate to contact us.

Sincerely,

J. Matthew Davis, PhD
Board of Directors, Member

cc: NEGPA Board of Directors

New England Geothermal Professional Association (NEGPA) comments on 225 CMR 16.00 and associated metering guidelines

The New England Geothermal Professional Association commends the Commonwealth of Massachusetts on incorporating renewable thermal energy into the APS and value the opportunity to provide comments on the draft rules (225 CMR 16.00) and associated metering guidelines that bring the Acts of 2014, Chapter 251 ("the Act") into practice.

Our main points of concern revolve around the following three themes.

- The definition of 'net useful thermal energy' and proper accounting thermal energy from non-renewable sources of useful thermal energy.
- The consistency in the application of the Acts to different renewable technologies.
- Use of a 2.27 multiplier on electricity used by an RTGU is inconsistent with the Act, unjustified, and results in erroneous calculations of AECs.
- Requirement to exclude air-conditioning but without a practical methodology to do so.

The specifics of these concerns are detailed below and we offer recommendations where appropriate.

A. Comments on 225 CMR 16.00

1. On the definition of "net useful thermal energy"

Section 1 of the Act defines "Useful thermal energy" as:

> *energy in the form of direct heat, steam, hot water or other thermal form that is used in production and beneficial measures for heating, cooling, humidity control, process use or other valid thermal end use energy requirements and for which fuel or electricity would otherwise be consumed.*

As defined in the Act, the definition of Useful thermal energy does not stipulate that it be generated entirely from a renewable source but instead stipulates (Section 2(a)) that "alternative energy credit shall be earned for … net useful thermal energy produced".

The language in the Act differentiates between 'Useful thermal energy' as the total energy that is produced and the 'net useful thermal energy' that is renewable and thus eligible for alternative energy credits.[1]

225 CMR 16.05(1)6.a defines the eligible APS renewable thermal generation unit technologies and, in paragraphs (i) and (ii), correctly characterize heat pumps as technologies that use compression and evaporation to transfer thermal energy from the environment (air, ground, and/or water) to a thermal load as Useful Thermal Energy. The electricity used for the operation

[1] In contrast, the State of New Hampshire defines useful thermal energy as "renewable energy that is delivered from a Class I source…." where Class I source can include thermal energy from the ground, but not energy from a compressor.

of a heat pump is converted to thermal energy and included in the definition of Useful thermal energy.

However, in determining the Earned APS Alternative Energy Attributes, 225 CMR 16.05(1)6.b.iii is ambiguous in that it stipulates that "any fossil fuel energy and electrical input to the APS Renewable Thermal Generation Unit necessary for its operation" shall be subtracted from the generated Useful Thermal Energy. 225 CMR 16.02 defines Generation Units as: "A facility that converts a fuel or an energy resource into electrical energy or thermal energy, or both." Furthermore, 225 CMR 16.05(4)a envisions Generation Units as potentially having more than one eligible technology. The definitions and usage of "a Generation Unit" through 225 CMR 16.00 suggest a property, building, or complex with many energy uses, both renewable and non-renewable. Electrical and fossil fuel energy may well be necessary to operate a Generation Unit but may not be at all related to the production of Useful thermal energy.

Recommendation: Calculation of net useful thermal energy as stipulated in the Acts should only subtract the portion of total Useful thermal energy that is directly attributable to non-renewable source; for example, the electrical energy that is converted to thermal energy by a heat pump compressor.

2. On the exclusion of cooling from the calculation of AECs

Per the Act, "Useful thermal energy" is defined as "energy in the form of direct heat, steam, hot water or other thermal form that is used in production and beneficial measures for heating, **cooling, humidity control**, process use or other valid thermal end use energy requirements **and for which fuel or electricity would otherwise be consumed**." 225 CMR 16.05(1)6.a.i and ii state that "heat pumps are provided APS Alternative Energy Attributes only when operating in a heating mode". The Department should provide justification for this contradiction from the Acts.

B. Comments on Guidelines on Metering and Calculations

1. Part I (Formulas for Small Generation Units)

1. On p. 4, the Guidelines put forth the "General Formula for Output Projections for All Small RTGUs"

$$\frac{\text{AECs}}{\text{yr}} = \text{Eth, net} = \text{M} * \text{HC} * \text{t} * \text{P} * \text{O}_{\text{source}}$$

This equation is confusing as it lumps the multiplier (M) into the calculation of net useful thermal energy load (Eth,net). The multiplier, M, should be included explicitly with Eth,net.

Clarification of the equation notwithstanding, the formula is then applied inconsistently to develop specific equations for the difference RTGU technologies.

a. For solar thermal, the Guidelines develop an equation based on equipment capacity, surface orientation, and solar access for the specific location. The Guidelines go on to assume that solar panels are operating at full capacity at all times (t=365 days). It is simply not realistic to assume that a solar hot water system is operating at full output capacity at all times.

b. For heat pump technologies (both ASHP and GSHP), the General formula is applied so that, for buildings less than or equal to 1,500 square feet, the $HC*t*P*O_{source}$ is equal to 2.5 and 4.5, respectively. The rationale for the different multipliers is clearly justified as GSHP will operate at a higher average COP and thus deliver a greater proportion of renewable thermal energy than similarly sized ASHP systems. However, the justification for the value of 4.5 $MWh_{thermal}$ per year for GSHP is not clear. Based on available data, it appears to be low.

Recommendation: To insure that equations being used appropriately reflect renewable thermal energy production, the Department should document the studies on which these equations are based and compare projected production with actual data.

*2. Part II (Metering for Intermediate and Large Generation Units_*

1. On p. 5, it is stated that "The Department has determined that is appropriate, practical, and non-burdensome to require that Large RTGUs be fully and directly metered and that a reduced level of direct metering combined with indirect metering is required for Intermediate sized RTGUs". While we agree that direct metering in itself may not be burdensome, *there are several aspects of the Guidelines that are burdensome.* These will be pointed out below. NEGPA agrees that indirect metering is an attractive solution for Intermediate systems and will meet the objectives with appropriate level of on-site verification.

2. The DRAFT of 225 CMR 16 (Alternative Energy Portfolio Standards), that is also currently open for comment, has the provision (16.05(1)(a)6.b.iii) for the Department to net 'fossil fuel energy and electrical energy input' that is necessary to operate the renewable energy generation unit[2]. There are three major concerns related to this provision. In the Draft Guidelines, the netting of non-renewable fuels

    a. is applied inconsistently to different technologies,

    b. appears to be applied towards GSHP's in a manner that is not the intent of the 225-CMR-16, nor per 3. A) (4) of these guidelines. An example of this is apparent in the Large GSHP AEC formula where the RH (renewable heat) directly from the ground is measured and the NRF (non-renewable fuel energy) is subtracted. In this example, it would be appropriate to subtract the NRF from the **total heat energy** supplied to the building, but NOT from the RH as defined in the guideline. The NRF should be subtracted from the 'net useful heat' transferred to the facility, but not from the RH (renewable heat) which already does not account for the NRF of the system.

[2] 16.05(1)(a)6.b.iii. Earned APS Alternative Energy Attributes shall be for the generation of Useful Thermal Energy, net of any fossil fuel energy and electrical energy input to the APS Renewable Thermal Generation Unit necessary for its operation, however, the Department may exclude small energy uses, including but not limited to, fans, pumps, meters, controls, and data collection. The Department shall prescribe the calculations for netting energy input from the Useful Thermal Energy in the Department's *Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units*.

c. as written in the Guidelines, the 'netting' inappropriately devalues the AECs that may be earned for the production of useful thermal energy from the ground for large geothermal systems.

3. Definition of "Net useful heat" (p. 7) uses the concept of enthalpy to define heat transfer with the Net useful heat being the difference between the thermal energy (enthalpy) supplied to the load minus the thermal energy (enthalpy) returned to the source[3]. The definition of Net useful energy, as stated, does not indicate whether the difference in enthalpies shall be positive or negative. In addition, the definition of 'load' is unclear. Is it delivery upstream of the heat pump (as suggested in metering diagrams) or downstream of the heat pumps (as suggested in the description of Net Useful Heat in 3. A) (4))? This apparent inconsistency seems to be the root of the concern mentioned above in 2. b. of these comments. Also, the term Renewable Heat (RH) in sections 3. I) (12), (17) & (21) seems to intend the same as the 'Net useful heat' in some circumstances, but not in others.

   The definition of Non Useful Heat (p. 9), however, uses the concept of heat transfer (difference in enthalpy) in that it states that energy rejected to a heat sink (e.g. cooling mode of GSHP system?) is not considered Useful Thermal Energy. As defined, the "Net useful heat" will be negative when heat is being rejected to the ground. This can be a large problem in the practical aspects of installing the metering devices for both GSHP and ASHP systems. This is mainly due to the fact that both of these system types can change their operation from heating to cooling at the individual heat pump level. Furthermore, a multi heat pump system could have some heat pumps operating in cooling mode while others are operating in heating mode.

   For a geothermal system with equal heating and cooling loads, the total annual "Net useful heat" will be zero unless the energy transferred during operation of heat pumps during cooling mode is not totalized. While rejecting heat to a ground loop is arguably not qualified for renewable energy credits, the beneficial heating should not be discounted for also operating the system in cooling mode. The currently unclear definition of "Net useful heat" combined with the explicit discounting of "Non useful heat" *would result in most geothermal systems resulting in negative AECs.* According to equation used to calculate AECs (p. 10).

$$AEC = \left(UH - NUH - P_e - P_{th} - \frac{G}{0.44}\right) * M$$

   Where the heat of rejection (NUH) is subtracted from the "Net useful energy", which is already near zero for a geothermal system with an annual balanced load. Even if UH only counted for heating (as was likely intended), the subtraction of NUH (rejected heat) offsets benefits of heat extracted during heating mode.

   Recommendation: 1) Clarify the definitions of 'Net Useful Heat' and RH (Renewable Heat), which appear to be the same concept at times, but different in others, 2) Define UH as energy

[3] Use of the word 'source' here is intended to help clarify definition of net useful heat where 'source' is the source of the renewable energy (ground, air, biomass). The Guidelines actually use RTGU which, as discussed in Comments A.1, above is ambiguous.

transfer during heating mode only (entering temperature > leaving temperature), and 2) do not meter or subtract NUH.

This recommendation would also alleviate the confusion arising from the requirement to install a separate meter to record heat rejected to a sink (p. 9). Such a requirement is highly impractical (and burdensome) for a geothermal system that uses a single pair of supply return pipes.

As noted above, the so-called "netting of energy use" by subtracting G/0.44 is inconsistent with the Acts. Its impact on AEC calculations is discussed in comments below.

4. General Guidance for Locating Btu Meters (p. 9). NEGPA concurs with clause (a) that states that meters should be located on the RTGU side and not on the load side. This clause indicates that the metered heat energy from the RTGU does not include the NRF component of the total energy delivered to the building, therefore the NRF should not be subtracted from the RH for the large geothermal system AEC calculations in 3. I) (21) For a geothermal system, this would be interpreted as metering geoexchange (heat of extraction) on the ground-loop side of any and all heat pumps. Such placement of a meter would prevent it from recording any thermal energy produced by the heat pumps as well as the need for "netting of energy use" (more on this below).

5. Figure 1 is unclear, particularly as it relates to "General Guidance for Location Btu meter" as no meters are shown.

6. Use of Non-Renewable Fuels which are blended (3(B)(3). It is unclear how a geothermal system that uses a gas-fired boiler as emergency backup would use the equation provided. There is no 'renewable fuel' used in such a system. We suggest that the location of the injection of the boiler heat, in conjunction with the location of the electricity meter (for intermediate systems) or heat meter (for large systems) is located, impacts whether the non-renewable fuel needs to be factored out of the net useful heat. It would only need to be factored out if the measurement of the electricity to the heat pump or the heat meter from the RTGU included the heat injected by the boiler. In most GSHP systems, the boiler heat would be on the load side of the heat pumps or the heat meter from the RTGU, so the non-renewable fuel should not need to be factored out in those cases.

7. Thermal (Btu) Energy Meters for "Hot Water". It appears that Table 3 applies to geothermal systems though fluid is typically not "hot".

    a. What is the justification for excluding turbine meters? The Onicon F-1100 and F-1200 are high quality highly accurate flow meters that maintain excellent accuracy over a wide range of flows. They meet the requirements for heat meters in Europe and Canada and are not excluded from ASTM standards. They are highly appropriate for closed loop geothermal systems and should be permitted.

    b. How are accuracies of Btu meters to be documented? Because accuracy depends on operating conditions, most heat meter manufacturers only report the accuracy of individual components and not the entire meter. *Recommendation: Specify accuracy of*

individual components so they are consistent with ENE 1425 (Class 5K temperature sensors, Class 2 flow meters, etc.).

8. Electric (kWh) Meters (p. 15). The Guidelines require that electric meters be 'revenue grade'. However, the Guidelines also use 'indirect metering' for intermediate systems. The benefit of 'revenue grade' kWh is unclear when an indirect method is used to compute AECs. Given the inherent errors in indirect metering for intermediate systems, measurement of volt-amps is sufficient when indirect metering is used. As noted below, one of the most practical ways to discern Useful Heat from heat being rejected is to measure the entering and leaving water temperatures on a heat pump. Currently, the Guidelines require the exclusion of rejected heat but don't provide mechanism for doing so.

9. AECs for Intermediate GSHP systems.

    a. Figure 10.

        i. What is the Btu Computer? Is it computing AECs? If so, shouldn't the NRF meter be input to the Btu Computer? What is the meaning of arrows and dashed lines.

        ii. Should time stamped "q/o" should be "I/O"?

        iii. Typo on circulating pumps (two l's)

        iv. The NRF meter states to include the circulating pumps. We feel that including the circulator pumps is inappropriate due to the method of calculating the AEC's based on the COP_w of the heat pump by the manufacturer. Adding the energy from the circulating pumps with falsely inflate the AEC for the intermediate geothermal system.

    b. The equation to calculate AECs for Intermediate GSHP systems uses the heat pump COP and the energy consumed (NRF = G/0.44):

$$AEC = \left((COP_w * NRF) - NRF\right) * M$$

While the Guidelines require that heat of rejection be excluded for AEC calculations, the equation provided has no mechanism for doing so. The metered electricity usage (G) will include both heating and cooling, unless somehow the cooling mode usage is subtracted out or ignored. In order to determine whether a heat pump is producing Useful or Non-useful thermal energy, it is necessary to measure the entering and leaving water temperature on each heat pump, as is currently done for New Hampshire Thermal RECs (small systems).

    c. COPw is defined as being provided by the equipment manufacturer. We are not aware of any such rating for ground source heat pumps. *Recommendation: Use ANSI/AHRI*

13256-1 and -2 COP ratings that use conservative (minimum) ground loop temperatures COP and consider both closed- and open-loop systems.

10. AECs for large systems.

    a. It is unclear why there are differences in the calculation of AECs for large ASHP and large GSHP systems – two systems which are very similar in setup except that one extracts heat from air, the other from the ground. In the calculation of AECs for Large DX ASHP systems (p. 24) and large VRF ASHPs (p. 28) there is no 'netting' of non-renewable fuel. However, for large GSHP systems (p. 31) there is. What is the justification for the different formulas for ASHP and GSHP technologies? For both, the metering in the figures shown is on the 'source' side and the metered thermal energy does not include any thermal energy from non-renewable fuels.

    b. Furthermore, the inconsistent 'netting' of non-renewable energy between renewable thermal technologies results in the equation for AECs for large GSHP system assuring that a large GSHP system will generate negligible AECs. The equation for large GSHPs (p. 31) is:

$$AEC = (RH - NRF) * M)$$

Renewable Heat (RH) is the metered renewable component of the thermal energy. Given the equation for RH and the recommended placement of the meter (Figure 11), RH is equivalent to the Heat of Extraction (HE) of a geothermal system. NRF is the adjusted non-renewable fuel calculated from the electricity consumed (G) by the RTGU and is calculated as NRF= G/0.44.

Given the wording in the Guidelines and the manner in which the electric meter is shown to be connected to the heat pump in Figure 11, it appears that G (and NRF) include the electricity consumed by the heat pump. If this is correct, the result is that **a GSHP system with a COP of 3.27 (meeting the minimum requirements for Part 1) would result in a total annual generation 0 AECs.**

$$COP = \frac{RH + G}{G}$$

$$If\ COP = 3.27, \qquad RH = 2.27G$$

$$AEC = \left(2.27G - \frac{G}{0.44}\right) * M = 0$$

It is quite clear that the 'netting' of renewable energy, as shown in the guidelines, is inappropriate and erroneous for the Large GSHP systems, especially when compared to how it is or isn't applied to ASHP and other technologies.

If 'netting' of non-renewable energy is used in the calculation of AECs, it should be done uniformly, for all renewable thermal technologies. Furthermore, as stipulated in the Draft of 225 CMR 16, it should include non-renewable energy other than electricity[4]. For example, the harvesting, processing, and delivery of biomass to an RTGU consumes fossil fuel energy, is necessary for its operation, and should be 'netted' out. However, our recommendation is that it is applied appropriately for all technologies but not for the Large GSHP, therefore the AEC formula for Large GSHP should be

$$AEC = RH * M$$

c. Typo on bottom of p. 31. Should be 'renewable heat transferred from the _ground_' instead of '_air_'.

d. Typo on top of p. 32. SGWF in equation should be GSWF, and the units of GSWF should be (lbs/hr) instead of (lbs)

Recommendation: Remove the definition of NRF in the AEC Formula for Large GSHP section if the formula is modified as suggested above in comment 10. B.

[4] "any fossil fuel energy and electrical energy input to the APS Renewable Thermal Generation Unit necessary for its operation".