Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs
DEPARTMENT OF ENERGY RESOURCES

ALTERNATIVE ENERGY PORTFOLIO STANDARD

GUIDELINE

ON METERING AND CALCULATING THE USEFUL THERMAL OUTPUT OF ELIGIBLE RENEWABLE THERMAL GENERATION UNITS – PART 1

June 8, 2016

Pursuant to the Alternative Energy Portfolio Standard Regulations at 225 CMR 16.00

This Guideline provides the methods by which the projected useful thermal output of small Renewable Thermal Generation Units (RTGUs) and intermediate biogas and biofuel RTGUs shall be calculated and verified. This document is Part 1 of the Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units, Part 2 of the Guideline can be found at the link below.[1]

The purpose of this Guideline is to ensure uniform, accurate, reliable, and verifiable measurements of RTGU performance for determination of Alternative Energy Portfolio Standard (APS) benefits, as appropriate to RTGU size and expense.

This Guideline is effective immediately upon issuance. However, the Department of Energy Resources (Department) may consider exceptions from the Guideline in the case of RTGUs that went into commercial operation prior to the issuance date, but not earlier than January 1, 2015.

1. Provisions in the Statute and Regulations

The APS statute at M.G.L. Chapter 25A, Section 11F½(a) [2], as amended by Chapter 251 of the Acts of 2014, mandates the following as an eligible Alternative Energy Generating Source (emphasis added as italics):

> (iv) any facility that generates useful thermal energy using sunlight, biomass, biogas, liquid biofuel or naturally occurring temperature differences in ground, air or water, whereby 1 megawatt-hour of alternative energy credit shall be earned for every 3,412,000 British thermal units of net useful thermal energy produced and *verified through an on-site utility grade meter or other means satisfactory to the department*;

Pursuant to the verification provision in that language, the APS regulations state the following at 225 CMR 16.05(4):

> (a) Metering Requirements. The net Useful Thermal Energy output from an APS Renewable Thermal Generation Unit shall be metered according to the specifications laid out in the Department's *Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units* and verified by an independent Third Party Meter Reader as defined in Rule 2.5(j) of the NEPOOL GIS Operating Rules and approved by the Department. The APS Alternative Generation Attributes

[1] Part 2 of the Guideline on Metering and Calculation the Useful Thermal Output of Eligible Renewable Thermal Generation Units can be found at http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/renewable-thermal/renewable-heating-and-cooling-alternative-portfolio-std.html

[2] The APS statute is available at https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter25A/Section11F1~2. These were amended by sections 1, 2, 3, and 9 of Chapter 251 of the Acts of 2014.

reported to the NEPOOL GIS by an independent Third Party Meter Reader shall be the amount as specified in 225 CMR 16.05(1)(a)6.b. This amount will be inclusive of any netting of energy use by the APS Renewable Thermal Generation Units prescribed in 225 CMR 16.05(1)(a)6.b.iii., and the application of any multiplier in 225 CMR 16.05(1)(a)6.b.ii.

(i) An APS Renewable Thermal Generation Unit that uses more than one eligible technology in 225 CMR 16.05(1)(a)6.a. is required to use the same independent Third Party Meter Reader for all technologies.

(ii) Each APS Renewable Thermal Generation Unit is required to have its own individual NEPOOL GIS identification. An APS Renewable Thermal Generation Unit that uses more than one eligible technology in 225 CMR 16.05(1)(a)6.a. is required to have a NEPOOL GIS identification for each technology.

(iii) An APS Renewable Thermal Generation Unit that meets the criteria of a small Generation Unit as prescribed in the Department's *Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units* shall be exempt from the metering requirements in 225 CMR 16.05(4)(a) and, instead, be subject to the small Generation Unit Annual Useful Thermal Energy Determination in 225 CMR 16.05(4)(b).

(b) Small Generation Unit Annual Net Useful Thermal Energy Determination. An APS Renewable Thermal Generation Unit that meets the criteria of a small Generation Unit as prescribed in the Department's *Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units* shall have its annual net Useful Thermal Energy generation output determined by a formula or methodology as prescribed in the Department's *Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units*. This approximation shall be a best reasonable determination by the Department to estimate the net Useful Thermal Energy delivered by the APS Renewable Thermal Generation Unit, specifically considering the APS Renewable Thermal Generation Unit's capacity, performance characteristics, and load application being served. The MassCEC will act as the independent verifier for all small Generation Units, and will deploy appropriate and reasonable measures to verify ongoing operation of the small Generation Units in line with their estimated net Useful Thermal Energy generation.

2. Applicability

This Guideline includes definitions of Small, Intermediate, and Large for the different eligible types of RTGUs as provided by the regulations and the methodologies for calculating the output of small RTGUs and intermediate biogas and biofuel RTGUs, as well as provisions to allow for the verification that non-metered qualified RTGUs continue to be in operation.

Table 1 summarizes how RTGUs will be classified based on their capacity and defines the cut-off points for distinguishing between small, intermediate, and large. If an RTGU consists of several individual separate units, their capacities will be summed and the total capacity will be considered against the size threshold. In the case of a combination of solar thermal and other RTGUs, the thresholds will be applied separately to the solar and non-solar RTGUs.

Table 1: APS Renewable Thermal Generation Unit (RTGU) Classification

Classification	Small	Intermediate[1]		Large[2]
AEC Calculation Basis	**Calculated net renewable thermal output**	**Calculated net renewable thermal based on indirect metering**	**Calculated net renewable thermal output based on direct metering of fuel input**	**Metered net renewable thermal output**
Solar Flat Plate / Evacuated Tube	Collector Surface < 660 sq ft	Collector Surface Between 660 & 4000 sq ft[1]	-	Collector Surface > 4000 sq ft
Solar Hot Air / Sludge Dryer	-	-	-	All
Biomass Pellets/Chips	Output Based on Input Capacity < 0.34 MMBtu/h	-	Capacity Between 0.34 & 1 MMBtu/h	Capacity > 1 MMBtu/h
Biogas/Biofuels[3]	-	-	Capacity < 1 MMBtu/h	Capacity > 1 MMBtu/h
Electric Motor Driven Air Source Heat Pump	Output Capacity < 0.134 MMBtu/h [4]	-	Output Capacity Between 0.134 & 1.00 MMBtu/h [4]	Output Capacity > 1.00 MMBtu/h [4]
Ground Source Heat Pump	Output Capacity < 0.134 MMBtu/h [5]	-	Output Capacity Between 0.134 & 1.0 MMBtu/h [5]	Output Capacity > 1.00 MMBtu/h [5]
Engine Driven Air Source Heat Pump	Output Capacity < 0.134 MMBtu/h [4]	-	Output Capacity Between 0.134 & 1.0MMBtu/h [4]	Output Capacity > 1.00 MMBtu/h [4]
Deep Geothermal	-	-	-	All

[1] Submetering of non-renewable fuel (e.g. gas or grid electricity) consumption will be used in conjunction with original equipment manufacturer performance data to calculate net thermal output for intermediate size Air Source Heat Pumps, Ground Source Heat Pumps, and Solar Thermal RTGUs.

[2] The thermal output and non-renewable fuel consumption are metered directly.

[3] All Biogas/Biofuel RTGUs must apply via an aggregator as described in section 4(H) below.

[4] Output heating capacity at entering source air temperature of 5°F

[5] If AHRI Certificate exists, output heating capacity as indicated on the AHRI Certificate at Full Load. If AHRI Certificate does not exist, use manufacturer's rated output heating capacity as indicated below:

(a) For closed loop, water to water heat pumps: capacity at source entering water temperature of 32°F and load entering water temperature of 104°F If multiple ratings are shown under these conditions, use the source water and load water flow rate that results in the largest heating capacity.

(b) For open loop water to water heat pumps: capacity at source entering water temperature of 50°F and load entering water temperature of 104°F. If multiple ratings are shown under these conditions, use the source water and load water flow rate that results in the largest heating capacity.

(c) For closed loop, water to air heat pumps: capacity at source entering water temperature of 32°F and load entering air temperature of 70°F. If multiple ratings are shown under these conditions, use the source water and load air flow rate that results in the largest heating capacity.

(d) For open loop, water to air heat pumps, capacity at source entering water temperature of 50°F and load entering air temperature of 70°F. If multiple ratings are shown under these conditions, use the source water and load air flow rate that results in the largest heating capacity.

For the purpose of this Guideline, the definition of closed loop and open loop are as follows:

Close loop: Any water to air or water to water to water ground source heat pump system having no direct contact between the groundwater and the system fluid used for heat exchange.

Open loop: Any water to air or water to water ground source heat pump system which uses groundwater as the fluid for heat exchange.

3. Small, Biogas, and Biofuel Renewable Thermal Generation Units

A) Size Thresholds

Size thresholds for small, intermediate, and large RTGUs can be found in Table 1 in section two of this Guideline. The size thresholds apply to the total combined capacity of the RTGU(s) serving the thermal load.

B) Small RTGU Monitoring and Verification

All small RTGUs will receive AECs upfront via calculated projected output per the formulas in 3(C) through 3(I).

The Massachusetts Clean Energy Center (MassCEC) will act as the independent verifier of all generation data for small RTGU. In its capacity as independent verifier, MassCEC will verify that small RTGUs remain in operation through audits and run-time monitoring.

There will be no upfront minting for any Biogas or Biofuel RTGUs, regardless of size.

C) General Formula for Output Projections for All Small RTGUs

The AEC output is based on the thermal load served in the building as well as the rated capacity and performance of an RTGU.

$$\mathbf{AECs/yr = Eth,\ net = M * HC * t * P * O_{source}}$$

Where:

Eth, net = net useful thermal energy output

M = the current multiplier for the RTGU technology in question in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

HC = seasonal average heating capacity

t = time (hours/y) * 10 (for 10 years of operation)

P = Capacity Factor

O_{source} = operating energy factor (renewable thermal energy divided by the nonrenewable source energy)

D) Eligibility and Calculation of AECs for Small Solar Thermal RTGUs

(1) Standard Equation for Calculating AEC Output for Small Solar Thermal RTGUs

The AECs from Small Solar Thermal RTGUs, both domestic hot water systems and combined domestic hot water and space heating systems are calculated by using the annual energy estimate provided by the Solar Rating and Certification Corporation (SRCC) OG-100 Solar Collector Rating (or equivalent entity). The calculation of AECs is based on the SRCC OG-100 Solar Collector Rating for Category D, Mildly Cloudy, and Medium Radiation. The equation for the calculation of small solar thermal AECs is as follows:

$$\mathbf{AECs/yr} = \frac{\mathbf{R}}{\mathbf{1,000}} * \mathbf{C} * \mathbf{SOF} * \mathbf{S} * \mathbf{M} * \mathbf{t}$$

Where:

R = OG-100 Solar Collector Rating for Category D, Mildly Cloudy, Medium Radiation (kWh/panel/day)

C = Number of solar thermal collectors

SOF = Surface Orientation Factor, calculated based on the azimuth and tilt of the solar thermal collectors, see section below

S = Annual, average solar access, as determined by a Solar Pathfinder or comparable device

M = the appropriate multiplier for Solar Thermal Hot Water RTGUs in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

t = Time, 365 days

(2) Substituting OG-300 for OG-100

In special cases where the solar thermal RTGU installed has a SRCC OG-300 Solar Water Heating System Rating, this rating may be exchanged for the OG-100 Solar Collector Rating, modeled for Boston, MA. The adjusted formula used to calculate AECs using an OG-300 rating is as follows:

$$\mathbf{AECs/yr} = \frac{\mathbf{R}}{\mathbf{1,000}} * \mathbf{SOF} * \mathbf{S} * \mathbf{M} * \mathbf{t}$$

Where:

R = SRCC OG-300 Solar Water Heating System Rating for Boston, MA (kWh/year)

SOF = Surface Orientation Factor, calculated based on the azimuth and tilt of the solar thermal collectors, see section below

S = Annual, average solar access, as determined by a Solar Pathfinder or comparable device

M = the current multiplier for Solar Thermal Hot Water RTGUs in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

t = Time, 1 year

(3) Surface Orientation Factor

The Surface Orientation Factor (SOF) of a system is used to adjust the predicted thermal yield (SRCC rating) due to a decrease in production efficiency based on the tilt and orientation of the system's solar thermal collectors. The SOF used to calculate allotted AECs for small solar thermal systems is based on Massachusetts geographic location and an ideal collector tilt of 30-39° and azimuth of 170-189°. See figure below:

		Tilt								
		0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-90
True Azimuth	90-99	0.87	0.86	0.84	0.82	0.78	0.73	0.68	0.62	0.56
	100-109	0.87	0.88	0.87	0.85	0.82	0.78	0.73	0.66	0.60
	110-119	0.88	0.90	0.90	0.89	0.86	0.82	0.77	0.70	0.63
	120-129	0.88	0.91	0.92	0.92	0.89	0.86	0.80	0.74	0.66
	130-139	0.89	0.93	0.94	0.94	0.92	0.89	0.83	0.76	0.68
	140-149	0.89	0.94	0.96	0.97	0.95	0.91	0.85	0.78	0.70
	150-159	0.90	0.95	0.97	0.98	0.97	0.93	0.87	0.80	0.71
	160-169	0.90	0.95	0.98	0.99	0.98	0.94	0.88	0.81	0.72
	170-179	0.90	0.96	0.99	1.00	0.99	0.95	0.89	0.82	0.73
	180-189	0.90	0.96	0.99	1.00	0.99	0.95	0.89	0.82	0.73
	190-199	0.90	0.95	0.98	0.99	0.98	0.94	0.88	0.81	0.72
	200-209	0.90	0.94	0.97	0.98	0.96	0.93	0.87	0.80	0.72
	210-219	0.89	0.93	0.96	0.96	0.94	0.91	0.85	0.78	0.71
	220-229	0.89	0.92	0.93	0.93	0.91	0.88	0.83	0.76	0.69
	230-239	0.88	0.90	0.90	0.90	0.88	0.84	0.79	0.74	0.68
	240-249	0.87	0.87	0.87	0.85	0.83	0.80	0.75	0.71	0.66
	250-259	0.86	0.84	0.83	0.80	0.78	0.74	0.71	0.67	0.64
	260-270	0.85	0.81	0.78	0.74	0.71	0.68	0.65	0.63	0.62

E) Eligibility and Calculation of AECs for Small Air Source Heat Pump (ASHP)

(1) Eligibility Criteria

(a) Applicable Technologies

(i) Air-to-air, split system heat pumps

(ii) Air-to-water heat pumps

(iii) Single-head, multi-head, and central systems

(iv) Ducted and ductless systems

The RTGUs that are to be used for cooling only and single-stage heat pumps are not eligible to qualify under the APS.

(b) Equipment Eligibility

Only high-efficiency, cold climate, ASHP RTGU are eligible to qualify under the APS. This is defined as an ASHP RTGU that:

(i) Meets the requirements of the Cold Climate Air Source Heat Pump Specification published by Northeast Energy Efficiency Partnerships and is listed on NEEP's website

(ii) Meets performance requirements listed in 3(E)(1)(c) of this Guideline

The Department shall maintain and publish a list of eligible ASHP RTGUs that can qualify as Small ASHP RTGUs under the APS.

(c) Performance Requirements

In order to qualify, an ASHP RTGU must meet the following requirements:

(i) RTGU must be listed as ENERGY STAR certified

(ii) Compressor must be variable capacity

(iii) Indoor and outdoor units must be part of an Air-Conditioning, Heating, & Refrigeration Institute (AHRI) matched system

(d) Whole Building Heating Requirement

All ASHP RTGUs must be designed to supply 100% of a building's total annual heat load with no non-renewable supplemental heat source.

(2) AEC Formula for Small ASHP RTGUs

If conditioned building area is less than or equal to 1,500 sf:

$$\mathbf{AECs/yr = 2.5 * (M + m)}$$

If conditioned building area is greater than 1,500 sf:

$$\mathbf{AECs/yr} = \left(\mathbf{2.5 + 1.63} * \left(\frac{\boldsymbol{A - 1,500}}{\mathbf{1,000}}\right)\right) * (\mathbf{M + m})$$

Where:

A = Conditioned space in square feet (sf)

M = The base multiplier for ASHP RTGUs in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

m = Additional multiplier for energy efficient homes or zero energy buildings installing heat pumps in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

F) Eligibility and Calculation of AECs for Small Ground Source Heat Pump RTGUs

(1) Eligibility Criteria

(a) Equipment Eligibility

(i) The GSHP RTGU must be Air-Conditioning, Heating, & Refrigeration Institute (AHRI) rated and meet one of the following testing and rating Standards:

1. ANSI/AHRI/ASHRAE/ISO Standard 13256-1 for water-to-air models; or
2. ANSI/AHRI/ASHRAE/ISO Standard 13256-2 water-to-water models.

(ii) GSHP RTGUs must have AHRI-rated Operating Coefficient of Performance (COP) and Operating Energy Efficiency Ratio (EER) equal to or greater than the following:

Type	Cooling EER[1]	Heating COP[2]
Closed Loop Water to Air	17.1	3.6
Open Loop Water to Air	21.1	4.1
Closed Loop Water to Water	16.1	3.1
Open Loop Water to Water	20.1	3.5

[1] EER shall be calculated as EER = (full load EER + part load EER)/2
[2] COP shall be calculated as COP = (full load COP + part load COP)/2
* EER and COP shall be based on AHRI-rated ground loop heat pump figures for closed loop systems and the AHRI-rated ground water heat pump figures for open loop systems.

(iii) All GSHP RTGUs must be installed by licensed contractors and/or plumbers in accordance with the National Electric Code and manufacturer's specifications and must conform to all applicable municipal, state, and federal codes, standards, regulations, and certifications, as well as program requirements.

(iv) Blower motors must be multi-speed or variable-speed, high-efficiency motors. Motors qualify as "energy-efficient" if they meet or exceed the efficiency levels listed in the National Electric Manufacturers Association's (NEMA's) MG1-1993 publication.

(v) All compressors must use two-stage, multi-speed, or variable-speed drives, unless they are water-to-water units. Single-stage water-to-water systems are eligible, provided they include accumulator tanks with the greater of ten gallons of capacity per heating ton or industry/manufacturer recommended best practice.

(vi) Direct exchange heat pumps, which circulate a refrigerant through a closed-loop copper-pipe system, are prohibited.

(b) Well Requirements

In order to qualify, wells drilled as part of a GSHP RTGU must meet the following requirements:

(i) Vertically bored closed-loop GSHP RTGUs must have a minimum depth of 150 feet per 12,000 BTU/hr of heating load served by the system (i.e., the lesser of capacity and peak load).

(ii) Closed-loop bore grouting must have a grout conductivity equal to or greater than anticipated earth conductivity of the drill site up to 1 BTU/hr-ft-°F.

(iii) There must be at least fifteen (15) feet of separation between closed-loop bore holes.

(iv) All GSHP RTGUs must comply with the Commonwealth of Massachusetts Department of Environmental Protection (DEP) Bureau of Resource Protection Drinking Water Program, Guidelines For Ground Source Heat Pump Wells, and Underground Injection Control Program (December 2013) http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/gshpguid.pdf.

(v) All open-loop GSHP RTGU wells shall be installed in conformance with

1. DEP's Private Well Guidelines – http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/prwellgd.pdf (as amended); or
2. DEP's Guidelines and Policies for Public Water Systems – http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/glintro.pdf (as amended), whichever is applicable.

(vi) All GSHP RTGU wells shall be installed in conformance with 313 CMR 3.00: Registration of Well Drillers and Filing of Well Completion Reports – http://www.lawlib.state.ma.us/source/mass/cmr/cmrtext/313CMR3.pdf.

(vii) Standing column wells must include bleed circuits and drywells to maximize thermal efficiency based on available water production

(c) Whole Building Heating Requirement

All GSHP RTGUs must be designed to supply 100% of a building's heat load with no non-renewable supplemental heat source.

(2) AEC Formula for Small GSHP RTGUs

If conditioned building area is less than or equal to 1,500 sf:

$$\mathbf{AECs/yr = 4.5 * (M + m)}$$

If conditioned building area is greater than 1,500 sf:

$$\mathbf{AECs/yr = \left(4.5 + 2.9 * \left(\frac{A-1{,}500}{1000}\right)\right) * (M+m)}$$

Where:

A = Conditioned space in square feet (sf)

M = The current multiplier for GSHP RTGUs in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

m = Additional multiplier for energy efficient homes or zero energy buildings installing heat pumps in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

G) Calculation of AECs for Small Biomass RTGUs

(1) Eligibility Criteria

Small biomass RTGUs must meet all of the eligibility criteria and requirements found in 225 CMR 16.00 and the *APS Guideline on Biomass, Biogas, and Biofuels for APS Renewable Thermal Generation Units.*

(2) Formula for Calculating AEC Output

AECs/yr = (Fuel * COPw * EFC) / 3,412,000 * M

Where:

Fuel = Higher Heating Value of the fuel delivered to the RTGU

COPw = the climate weighted heating coefficient of performance (COP) for the typical meteorological year (TYM) as provided by the Original Equipment Manufacturer (OEM)

EFC = Eligible fuel content (the percentage of the fuel delivered to the RTGU that qualifies as an Eligible Biomass Fuel)

M = The current multiplier for biogas or biofuels in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

H) Calculation of AECs for Small and Intermediate Biogas and Biofuel RTGUs

(1) Eligibility Criteria

All biogas and biofuel RTGUs must meet the eligibility criteria prescribed in 225 CMR 16.00, particularly those in 225 CMR 16.02.

In the case of biogas, the RTGU must also meet the requirements of 225 CMR 16.05(1)6.a.vi.

In the case of biofuel, the RTGU must also meet the requirements of 225 CMR 16.05(1)6.a.vii.

(2) Qualification Process

All biogas and biofuel RTGUs must qualify via an aggregator. The aggregator will be responsible for providing a form to the Department following the close of each quarter that will contain the following information:

(a) A list of all RTGUs in the Aggregation

(b) Details on the make and model of each RTGU

(c) The quantity of fuel delivered to each RTGU in the quarter

(d) The percentage of the fuel delivered to the RTGU that meets the definitions of Eligible Biogas Fuel or Eligible Liquid Biofuel in 225 CMR 16.02

The Department shall publish the form to be used by aggregators on its website in conjunction with the effective date of this Guideline.

(3) Formula for Calculating AEC Output

AECs for Biogas and Biofuel RTGUs will be generated on a quarterly basis according to the following formula:

$$\textbf{AECs/quarter} = (\textbf{Fuel} * \textbf{Eff} * \textbf{EFC}) / 3{,}412{,}000 * \textbf{M}$$

Where:

Fuel = Btu content of the fuel delivered to the RTGU

Eff = The efficiency of the RTGU, established as 85% for boilers and 80% for furnaces.

EFC = Eligible fuel content (the percentage of the fuel delivered to the RTGU that qualifies as either an Eligible Biogas Fuel or Eligible Liquid Biofuel)

M = The current multiplier for biogas or biofuels in the Department's *Guideline on AEC Multipliers for Renewable Thermal Generation Units*

I) Calculation of AECs for Small Hybrid RTGUs

The process for calculating AECs for RTGUs utilizing multiple APS eligible fuels in conjunction with each other will be determined on a case by case basis by the Department.

4. Miscellaneous

The Department may permit an exception from any provision of this Guideline for good cause.