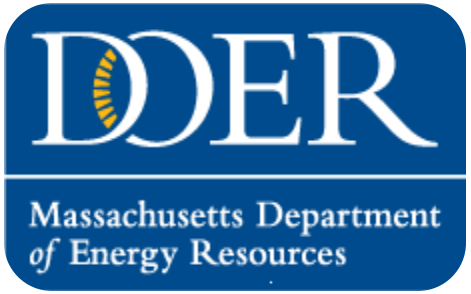
Creating A Cleaner Energy Future For the Commonwealth



COMMONWEALTH OF MASSACHUSETTS

Charles D. Baker, Governor
Karyn E. Polito, Lt. Governor
Matthew A. Beaton, Secretary
Judith Judson, Commissioner

Massachusetts Renewable Thermal Stakeholder Sessions

Sessions 1 & 2

January 11, 2018

DOER
Massachusetts Department of Energy Resources

Session 1: Air and Ground Source Heat Pumps

Agenda

- APS overview recap
- Eligibility, metering, and reporting procedures
- Application process and requirements
- APS next steps
- Question and answer opportunity

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APS Overview

Alternative Energy Portfolio Standard (APS) Background

- The APS was established as of January 1, 2009, under the Green Communities Act of 2008
- Supports alternative energy technologies that increase energy efficiency and reduce the need for conventional fossil fuel-based power generation
- The Green Communities Act specifically included the following as eligible technologies:
  - Combined Heat and Power
  - Flywheel Storage
  - Gasification with Carbon Capture and Permanent Sequestration
  - Paper Derived Fuel
  - Efficient Steam Technology
- Eligible technologies are able to generate one Alternative Energy Certificate (AEC) for each MWh of electricity or 3,412,000 Btus of Useful Thermal Energy produced

What is the APS?

- State program requiring a certain percentage of the in-state electric load served by Load Serving Entities (LSEs) come from renewable energy
- LSEs meet their yearly obligations by procuring Alternative Energy Certificates (AECs)
- One AEC = 1 MWh (or 3,412,000 Btus)
- Obligation typically expressed as percent of total electric load

Example:

Utility serves 1,000,000 MWh of load in 2017 and has an obligation to procure 4.25% of that through the purchase of AECs

1,000,000 MWh x 0.0425 = 42,500 MWh (number of AECs they must procure)

Summary of MA Portfolio Standard Programs

RPS Class	Sub Class	Technology	Minimum Standard	2017 ACP Rate, $/MWh
Class I		Wind, LFG, Biomass, Solar PV, Small Hydro, AD, etc.	12% in 2017; increases by 1% each year	$67.70; increases with CPI
	Solar Carve-Out	Solar PV; 6 MW or less, in MA	1.6313% in 2017; set by formula annually	$448; reduced annually per 10-year schedule
	Solar Carve-Out II	Solar PV; 6 MW or less, in MA	2.8628% in 2017; set by formula annually	$350; reduced annually per 10-year schedule
Class II	Renewable	same as Class I	2.5909%; increases per schedule in regulation	$27.79; increases with CPI
	Waste Energy	Waste to Energy Plants, in MA	3.5%; stays constant	$11.12; increases with CPI
APS		CHP in MA, flywheels, storage, etc.	4.25% in 2017; increases to 5% in 2020	$22.23; increases with CPI

Program Participants

- Generation Unit Owners
- Installers
- Authorized Representatives
- Independent Verifiers
  - MassCEC will be the Independent Verifier for all small renewable thermal systems
- Aggregators
  - DOER encourages all Generation Unit owners to work with an aggregator

AEC Pricing

- Market driven
- State sets two variables:
  - Minimum Standard
  - Alternative Compliance Payment (ACP) Rate
- Minimum Standard refers to yearly percentage obligations placed upon compliance entities
- ACP rate is the price LSEs must pay for every MWh they are short of meeting their obligation

2014 and 2016 Statutory Changes

Chapter 251 of the Acts of 2014 required DOER to make changes to the existing APS regulations, including:

- Adding the following generation and fuel sources as eligible renewable thermal technologies:
  - Ground Source Heat Pumps (GSHP) and Air Source Heat Pumps (ASHP)
  - Solar Hot Water (SHW) and Solar Hot Air
  - Biomass, Biogas, and Biofuels
- Removing the following technologies as eligible:
  - Gasification with Carbon Capture and Permanent Sequestration
  - Paper Derived Fuel

Chapter 188 of the Acts of 2016 further required DOER to make changes to the APS regulations, including:

- Adding the following generation and fuel sources as eligible technologies:
  - Fuel Cells
  - Waste-to-Energy Thermal

Rulemaking Process

- Stakeholder meetings were held in late 2014 and early 2015 to discuss implementation of statutory changes
- Regulation initially filed on May 19, 2016
  - Public hearings were held on June 15, 2016 and June 17, 2016 in Amherst and Boston
  - Written comments were accepted through June 30, 2016
  - Over 50 sets of comments received
- Second draft of the APS Regulations incorporating 2016 statutory changes and changes in response to the first public comment period was filed on June 2, 2017
  - Public hearings were held on July 14, 2017 and August 7, 2017 in Boston and Holyoke
  - Written comments were accepted through August 7, 2017
  - Over 75 sets of comments received
- On October 13, 2017, DOER filed with the Clerk of the House of Representatives the amended draft with changes in response to public comments. It was referred to the Joint Committee on Telecommunications, Utilities, and Energy on October 16, 2017.
- After receiving no comments from the Joint Committee, DOER filed the final regulation with the Secretary of State's office on December 15, 2017
- Final regulation was promulgated and became effective on December 29, 2017

New Eligible Fuel and Technology Types

- Renewable thermal technologies:
  - Heat pumps (air source and ground source)
  - Solar thermal
  - Liquid biofuels
  - Biomass
  - Biogas
  - Compost heat exchange systems
- Non-renewable fuel cells (e.g. natural gas)
- Waste-to-energy thermal

Small, Intermediate, and Large Generators

- All renewable thermal generators are divided into three size categories as follows:

	Size Classification			
	Small	Intermediate		Large
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 thermal: evacuated tube and flat plate solar hot water	Collector surface area less than or equal to 660 sq ft	Collector surface area between 660 and 4,000 sq ft	-	Collector surface area greater than or equal to 4,000 sq ft
Solar thermal: solar hot air	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	All
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
Air source heat pump: electric motor or engine driven	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Ground source heat pump	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Deep geothermal	-	-	-	All

- Classification determines whether the generators must directly meter thermal output
- No small and some intermediate systems are required to meter their thermal output, but instead receive AECs per formulae established in DOER Guidelines

Pre-Minting and Forward Minting

- Small heat pumps and solar hot water and air systems may choose to pre-mint or forward mint AECs
- **Pre-minting** of AECs allows certain generators to receive 10 years of AECs upfront in the first quarter of operation
- **Forward minting** of AECs allows generators to receive a pre-determined number of AECs each quarter over a period of 10 years
- Both options allow generators to receive AECs without directly metering their thermal output
- If the APS market is **more than** 25% undersupplied, **Pre-minting** is the default option available
- If the APS market is **less than** 25% undersupplied, **Forward minting** is automatically triggered for new generators
- Biomass, biogas, and liquid biofuel generators may not pre-mint or forward mint their AECs

Certificate Multipliers for Non-Emitting Renewable Thermal Technologies

- The statute allows for DOER to establish certificate multipliers for "non-emitting renewable thermal technologies", which results in more AECs being earned for the same 3,412,000 British thermal units of net useful thermal energy
- DOER has established the following multipliers for non-emitting renewable thermal technologies:

		APS Renewable Thermal Generation Unit Multiplier		
	System Size	**Small**	**Intermediate**	**Large**
Technology Type	Active solar hot water systems used for domestic hot water	3	3	3
	Active solar hot water systems used for domestic hot water, space conditioning or process loads	1	1	1
	Active solar hot air systems	-	5	5
	Solar sludge dryer	-	-	1
	Ground source heat pumps	5	5	5
	Deep geothermal	-	-	1
	Air source heat pumps (electric or engine driven) – supplying less than 100% of building heating load	2	-	-
	Air source heat pumps (electric or engine driven) – all other	3	3	3
	Compost heat exchange system	-	-	1
	Biomass, biofuels, biogas	N/A	N/A	N/A

Heat pumps installed in highly energy efficient homes, passive homes or zero net energy buildings are eligible to receive an additional multiplier of 2, added to their base multiplier in the table above

Massachusetts Department of Energy Resources

Eligibility, Metering, and Reporting Procedures

Size Classification

	Size Classification			
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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**
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Solar thermal: solar hot air	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	All
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
Air source heat pump: electric motor or engine driven	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Ground source heat pump	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Deep geothermal	-	-	-	All

GSHP- Size Classification

	Size Classification			
	Small	**Intermediate**		**Large**
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**
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Solar thermal: solar hot air	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	**All**
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
Air source heat pump: electric motor or engine driven	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Ground source heat pump	**Output capacity less than or equal to 134,000 Btu per hour**	-	**Output capacity between 134,000 and 1,000,000 Btu per hour**	**Output capacity greater than or equal to 1,000,000 Btu per hour**
Deep geothermal	-	-	-	All

ASHP- Size Classification

	Size Classification			
	Small	**Intermediate**		**Large**
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**
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Solar thermal: solar hot air	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	**All**
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
Air source heat pump: electric motor or engine driven	**Output capacity less than or equal to 134,000 Btu per hour**	-	**Output capacity between 134,000 and 1,000,000 Btu per hour**	**Output capacity greater than or equal to 1,000,000 Btu per hour**
Ground source heat pump	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Deep geothermal	-	-	-	All

Small GSHP- General Requirements

- Certified to the International Organization for Standards Standard
- COP equal to or greater than the following:

Small ground source heat pump system type	Cooling energy efficiency ratio	Heating coefficient of performance
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

EER = (full load EER + part load EER)/2
COP = (full load COP + part load COP)/2

- Installed by licensed contractors and/or plumbers. Meet National Electric Code and manufacturer's specifications. Conform with all regulations.
- have blowers that are multi-speed or variable-speed, high-efficiency motors.
- use compressors that are two-stage, multi-speed, or variable-speed drives, unless they are water-to-water units. Single-stage water-to-water systems are eligible with additional provisions
- Minimum depth of 150 per 12,000 Btu/hr if vertically bored closed-loop systems
- Grout conductivity equal to or greater than anticipated earth conductivity of the drill site up to 1 Btu per hour-foot-degree Fahrenheit if closed-loop system

The above is a summary of the regulation requirements. For full requirements please review the APS regulations and metering guidelines.

Small GSHP- General Requirements (cont.)

- have at least 15 feet of separation between closed-loop bore holes
- must comply with MassDEP Guidelines For Ground Source Heat Pump Wells, and Underground Injection Control Program
- open-loop system wells must comply with MassDEP Private Well Guidelines or MassDEP Guidelines and Policies for Public Water Systems
- installed in conformance with 313 CMR 3.00: Registration of Well Drillers and Filing of Well Completion Reports
- standing column wells must include bleed circuits and drywells
- all systems must supply 100% of a building's total annual heating; non-renewable supplemental heat sources are prohibited
- all closed loop systems must be installed and tested in accordance with subsections 4 and 5 in section 1 of the "Closed-Loop/Geothermal Heat Pump Systems, Design and Installation Standards", published by the International Ground Source Heat Pump Association. Pressure testing may also be hydrostatically pressure tested in accordance with ASTM Standard F2164
- Direct exchange heat pumps, which circulate a refrigerant through a closed-loop copper-pipe system, are prohibited

The above is a summary of the regulation requirements. For full requirements please review the APS regulations and metering guidelines.

Small ASHP- General Requirements

- ENERGY STAR™ certified
- meet the Cold Climate Air Source Heat Pump Specification Version 2.0 published by Northeast Energy Efficiency Partnerships effective January 1, 2017 or any version thereafter
- have a variable speed compressor
- be part of an Air-Conditioning, Heating, & Refrigeration Institute matched system
- have a coefficient of performance greater than or equal to 1.9 (Max) at 5 degree Fahrenheit
- have a coefficient of performance greater than or equal to 2.5 (rated) at 17 degree Fahrenheit

Certificate Multipliers for Non-Emitting Renewable Thermal Technologies

The statute allows for DOER to establish certificate multipliers for "non-emitting renewable thermal technologies", which results in more AECs being earned for the same 3,412,000 British thermal units of net useful thermal energy

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	Active solar hot water systems used for domestic hot water, space conditioning or process loads	1	1	1
	Active solar hot air systems	-	5	5
	Solar sludge dryer	-	-	1
	Ground source heat pumps	5	5	5
	Deep geothermal	-	-	1
	Air source heat pumps (electric or engine driven) – supplying less than 100% of building heating load	2	-	-
	Air source heat pumps (electric or engine driven) – all other	3	3	3
	Compost heat exchange system	-	-	1
	Biomass, biofuels, biogas	N/A	N/A	N/A

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	Active solar hot air systems	-	5	5
	Solar sludge dryer	-	-	1
	Ground source heat pumps	**5**	**5**	**5**
	Deep geothermal	-	-	1
	Air source heat pumps (electric or engine driven) – supplying less than 100% of building heating load	2	-	-
	Air source heat pumps (electric or engine driven) – all other	3	3	3
	Compost heat exchange system	-	-	1
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	Ground source heat pumps	5	5	5
	Deep geothermal	-	-	1
	Air source heat pumps (electric or engine driven) – supplying less than 100% of building heating load	**2**	**-**	**-**
	Air source heat pumps (electric or engine driven) – all other	**3**	**3**	**3**
	Compost heat exchange system	-	-	1
	Biomass, biofuels, biogas	N/A	N/A	N/A

ASHP- Multiplier Requirements- Less than 100% bldg load

- be installed in existing buildings (not allowed in new buildings)
- be used as a primary heat source, providing at least 90% of the total annual heating load
- be integrated to the building's heating distribution system such that the useful thermal output of the RTGU is able to be distributed to all space-conditioned areas of the building
- have a capacity at 5 degrees Fahrenheit that is at least 50% of the name-plate capacity of the existing heating source equipment.

ASHP- Multiplier Requirements- All Other

- Small Generation Units must:
  - provide 100% of a building's total annual heat load
  - if installed in an existing building, the non-renewable heat source must be removed

GSHP and ASHP- Multiplier Requirements- Additional

- Any air source heat pump installed in a building shall be eligible for an additional multiplier of 2 (added to the base multiplier) if the building meets any of the following criteria:
  - achieves Home Energy Rating System (HERS) rating of 50 or less
  - meets the Department of Energy definition of "Zero Energy"
  - achieves PHIUS+ Certification by the Passive House Institute US (PHIUS)
  - registers as a Certified Passive House Building or an EnerPHit Retrofit by the International Passive House Association (iPHA)

More information on these multipliers can be found in the Guideline on Multipliers for Renewable Thermal Generation Units.

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Metering Requirements and Production Reporting

GSHP- Small Generation Units- AEC Formulas

<u>If conditioned building area is less than or equal to 1,500 sf:</u>

Useful Thermal Energy = 4.6 MWh/year

Example:

Useful Thermal Energy = 4.6 MWh/yr * 10 (years) = 46 MWh

Apply multiplier:

46 MWh * 5 = 230 AECs

GSHP- Small Generation Units- AEC Formulas

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

$$Useful\ Thermal\ Energy = \left(4.6 + (3.1 * \left(\frac{A - 1{,}500}{1{,}000}\right)\right)$$

Where:

- Useful Thermal Energy = MWh/year
- A = Conditioned space in square feet (sf)

Example: 2,000 sf building

Useful Thermal Energy = $\left(4.6 + (3.1 * \left(\frac{2{,}000-1{,}500}{1{,}000}\right)\right)$= 6.15 MWh

6.15 MWh * 10 (years) = 61.5 MWh

Apply multiplier:

61.5 MWh * 5 = 307 AECs

61.5 MWh * [5 (base) + 2 (Eff. Bldg)] = 430 AECs

ASHP- Small Generation Units- AEC Formulas

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

Useful Thermal Energy = 3.0 MWh/year

Example

Useful Thermal Energy = 3 MWh/yr * 10 (years) = 30 MWh

Apply multiplier:

Option 1: 30 MWh * 2 (ASHP, < 100%) = 60 AECs

Option 2: 30 MWh * 3 (ASHP, all other) = 90 AECs

Option 3: 30 MWh * [3 (ASHP, all other) + 2 (Eff. Bldg)] = 150 AECs

ASHP- Small Generation Units- AEC Formulas

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

$$Useful\ Thermal\ Energy = \left(3.0 + (2.0 * \left(\frac{A - 1{,}500}{1{,}000}\right)\right)$$

Where:

- Useful Thermal Energy = MWh/year
- A = Conditioned space in square feet (sf)

Example: 2,000 sf building

Useful Thermal Energy = $\left(3.0 + (2.0 * \left(\frac{2{,}000-1{,}500}{1{,}000}\right)\right)$= 4MWh

4MWh * 10 (years) = 40 MWh

Apply multiplier:

Option 1: 40 MWh * 2 (ASHP, < 100%) = 80 AECs

Option 2: 40 MWh * 3 (ASHP, all other) = 120 AECs

Option 3: 40 MWh * [3 (ASHP, all other) + 2 (Eff. Bldg)] = 200 AECs

Small Generation Unit-
Production Reporting Procedure

- Generation Unit submits a Statement of Qualification Application to DOER
- DOER reviews and approves the application and submits the calculated number of AECs to the MassCEC
- MassCEC verifies the calculation and reports the number of AECs to NEPOOL GIS
- The AECs are minted in the next quarterly minting

GSHP Metering- Intermediate and Large Generation Units

- Systems typically include:
  - Controls
  - A closed refrigerant sub-system
  - An air side sub-system
  - Well field
  - Well field to heat pump circulation water loop

- Must work with an Independent Verifier
- Must install a BTU Computer and Data Acquisition System
- Intermediate Generation Units: Useful Thermal Energy is determined via direct metering using thermal meter and electricity meter
- Large Generation Units: Useful Thermal Energy is determined via direct metering using thermal meter, electricity meter and flow meter

More information is available in Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units- Part 2

ASHP Types- Intermediate and Large Generation Units

- Direct Expansion- typically a self-contained unit with a warm forced air output. The major components of a typical DX ASHP include, but are not limited to the following:

- Split and Variable Refrigerant Flow (VRF)- typically a split system consisting of an outdoor unit which generates hot refrigerant coupled with an indoor distribution system connected with one or more air handler or fan coil terminal units

- Systems typically include:
  - Controls
  - A closed refrigerant sub-system
  - An air side sub-system

ASHP Metering- Intermediate and Large Generation Units

- Must work with an Independent Verifier
- Must install a BTU Computer and Data Acquisition System

- Intermediate Generation Units: Useful Thermal Energy is determined via direct metering
  - DX Systems- thermal meter, fuel meter
  - Split or VRF System- thermal meter and an electricity meter

- Large Generation Units: Useful Thermal Energy is determined via direct metering
  - Dx Systems- thermal meters, flow sensor, fuel meter
  - Split VRF System- thermal meters, flow sensor, pressure sensor and an electricity meter

More information is available in Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units- Part 2

Production Reporting Procedure

- Generation Unit submits a Statement of Qualification Application to DOER
- DOER reviews and approves the application
- The Independent Verifier begins recording and verifying energy production
- The Independent Verifier reports the production to the NEPOOL GIS
- The AECs are minted on a quarterly basis

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Application Process and Requirements

Application Portal

- All Statement Qualification Applications must be submitted on-line through application portal
- Hosted by the Massachusetts Clean Energy Center
- Portal and process is similar to the SREC II program
- The application is six steps, with the ability to save and exit after each step
- Includes in-portal communication function and automatic email updates

Application portal going live on January 16th

Renewable Thermal Application

Step 1 | Step 2 | Step 3 | Step 4 | Step 5 | Step 6

System Information

System name REQUIRED

A personalized name for your project

System Address

Street REQUIRED

Apartment or Suite

City REQUIRED

-- specify one --

State REQUIRED

Massachusetts

Zip REQUIRED

Enter five digit zip code (12345) or five digit code with four digit extension (12345-6789)

System Details

Electric Distribution Company REQUIRED

-- specify one --

Gas Distribution Company REQUIRED

-- specify one --

Facility Type REQUIRED

-- specify one --

About this Application

Systems may choose to size up their classification (Small to Intermediate or Large; Intermediate to Large) if they wish to implement additional metering technology. System owners should refer to the Department's Guideline on Metering for further information.

Please complete all required fields prior to moving to the next Step. Changes to this page will not be saved until the 'Save and Continue' option has moved the application to the next Step.

Contact Us

Tel	(617) 626-1180
Email	thermal.doer@state.ma.us

Application Requirements

- Generation Unit location and capacity
- Existing heating system details
  - Annual heat load
  - Primary heating fuel and distribution type
- Generation Unit installation and design details
  - Capacity compared to load
  - Equipment information
  - Rating information
  - System cost
  - Installer
- Contact information
- NEPOOL GIS information

Application Attachments

Small Generation Units:

- AEC Services Agreement- (optional- for aggregators/authorized representatives only)

Intermediate and Large Generation Units only:

- AEC Services Agreement (for aggregators/authorized representatives)
- Independent Verifier Request Form
- Process Flow Diagram with all APS meters shown
- One Line Electrical Diagram with all APS Meters Shown
- Metering Plan
- List of APS Meters
- System Information Data Sheet

Application Attachments cont.

Intermediate and Large Generation Units only (cont.):

- Equipment Arrangement Drawing
- General Site Plan
- Annotated Product Literature for all major equipment, each APS meter, and the Data Acquisition System
- Description of System Controls and Sequence of Operations
- System Performance Workbook
- Certified Performance Data Construct (Intermediate Only)

APS Next Steps

- Statement of Qualification application portal will open on January 16th

- Webinar- January 16th, 10:30am – 12:00pm
  - APS Application Process

Questions?

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Session 2: Solar Thermal

Agenda

- APS overview recap
- Eligibility, metering, and reporting procedures
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- State program requiring a certain percentage of the in-state electric load served by Load Serving Entities (LSEs) come from renewable energy
- LSEs meet their yearly obligations by procuring Alternative Energy Certificates (AECs)
- One AEC = 1 MWh (or 3,412,000 Btus)
- Obligation typically expressed as percent of total electric load

Example:

Utility serves 1,000,000 MWh of load in 2017 and has an obligation to procure 4.25% of that through the purchase of AECs

1,000,000 MWh x 0.0425 = 42,500 MWh (number of AECs they must procure)

Summary of MA Portfolio Standard Programs

RPS Class	Sub Class	Technology	Minimum Standard	2017 ACP Rate, $/MWh
Class I		Wind, LFG, Biomass, Solar PV, Small Hydro, AD, etc.	12% in 2017; increases by 1% each year	$67.70; increases with CPI
	Solar Carve-Out	Solar PV; 6 MW or less, in MA	1.6313% in 2017; set by formula annually	$448; reduced annually per 10-year schedule
	Solar Carve-Out II	Solar PV; 6 MW or less, in MA	2.8628% in 2017; set by formula annually	$350; reduced annually per 10-year schedule
Class II	Renewable	same as Class I	2.5909%; increases per schedule in regulation	$27.79; increases with CPI
	Waste Energy	Waste to Energy Plants, in MA	3.5%; stays constant	$11.12; increases with CPI
APS		CHP in MA, flywheels, storage, etc.	4.25% in 2017; increases to 5% in 2020	$22.23; increases with CPI

Program Participants

- Generation Unit Owners
- Installers
- Authorized Representatives
- Independent Verifiers
  - MassCEC will be the Independent Verifier for all small renewable thermal systems
- Aggregators
  - DOER encourages all Generation Unit owners to work with an aggregator

AEC Pricing

- Market driven
- State sets two variables:
  - Minimum Standard
  - Alternative Compliance Payment (ACP) Rate
- Minimum Standard refers to yearly percentage obligations placed upon compliance entities
- ACP rate is the price LSEs must pay for every MWh they are short of meeting their obligation

2014 and 2016 Statutory Changes

Chapter 251 of the Acts of 2014 required DOER to make changes to the existing APS regulations, including:

- Adding the following generation and fuel sources as eligible renewable thermal technologies:
  - Ground Source Heat Pumps (GSHP) and Air Source Heat Pumps (ASHP)
  - Solar Hot Water (SHW) and Solar Hot Air
  - Biomass, Biogas, and Biofuels
- Removing the following technologies as eligible:
  - Gasification with Carbon Capture and Permanent Sequestration
  - Paper Derived Fuel

Chapter 188 of the Acts of 2016 further required DOER to make changes to the APS regulations, including:

- Adding the following generation and fuel sources as eligible technologies:
  - Fuel Cells
  - Waste-to-Energy Thermal

Rulemaking Process

- Stakeholder meetings were held in late 2014 and early 2015 to discuss implementation of statutory changes
- Regulation initially filed on May 19, 2016
  - Public hearings were held on June 15, 2016 and June 17, 2016 in Amherst and Boston
  - Written comments were accepted through June 30, 2016
  - Over 50 sets of comments received
- Second draft of the APS Regulations incorporating 2016 statutory changes and changes in response to the first public comment period was filed on June 2, 2017
  - Public hearings were held on July 14, 2017 and August 7, 2017 in Boston and Holyoke
  - Written comments were accepted through August 7, 2017
  - Over 75 sets of comments received
- On October 13, 2017, DOER filed with the Clerk of the House of Representatives the amended draft with changes in response to public comments. It was referred to the Joint Committee on Telecommunications, Utilities, and Energy on October 16, 2017.
- After receiving no comments from the Joint Committee, DOER filed the final regulation with the Secretary of State's office on December 15, 2017
- Final regulation was promulgated and became effective on December 29, 2017

New Eligible Fuel and Technology Types

- Renewable thermal technologies:
  - Heat pumps (air source and ground source)
  - Solar thermal
  - Liquid biofuels
  - Biomass
  - Biogas
  - Compost heat exchange systems
- Non-renewable fuel cells (e.g. natural gas)
- Waste-to-energy thermal

Small, Intermediate, and Large Generators

- All renewable thermal generators are divided into three size categories as follows:

	Size Classification			
	Small	Intermediate		Large
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 thermal: evacuated tube and flat plate solar hot water	Collector surface area less than or equal to 660 sq ft	Collector surface area between 660 and 4,000 sq ft	-	Collector surface area greater than or equal to 4,000 sq ft
Solar thermal: solar hot air	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	All
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
Air source heat pump: electric motor or engine driven	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Ground source heat pump	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Deep geothermal	-	-	-	All

- Classification determines whether the generators must directly meter thermal output
- No small and some intermediate systems are required to meter their thermal output, but instead receive AECs per formulae established in DOER Guidelines

Pre-Minting and Forward Minting

- Small heat pumps and solar hot water and air systems may choose to pre-mint or forward mint AECs
- **Pre-minting** of AECs allows certain generators to receive 10 years of AECs upfront in the first quarter of operation
- **Forward minting** of AECs allows generators to receive a pre-determined number of AECs each quarter over a period of 10 years
- Both options allow generators to receive AECs without directly metering their thermal output
- If the APS market is **more than** 25% undersupplied, **Pre-minting** is the default option available
- If the APS market is **less than** 25% undersupplied, **Forward minting** is automatically triggered for new generators
- Biomass, biogas, and liquid biofuel generators may not pre-mint or forward mint their AECs

Certificate Multipliers for Non-Emitting Renewable Thermal Technologies

- The statute allows for DOER to establish certificate multipliers for "non-emitting renewable thermal technologies", which results in more AECs being earned for the same 3,412,000 British thermal units of net useful thermal energy
- DOER has established the following multipliers for non-emitting renewable thermal technologies:

		APS Renewable Thermal Generation Unit Multiplier		
	System Size	**Small**	**Intermediate**	**Large**
Technology Type	Active solar hot water systems used for domestic hot water	3	3	3
	Active solar hot water systems used for domestic hot water, space conditioning or process loads	1	1	1
	Active solar hot air systems	-	5	5
	Solar sludge dryer	-	-	1
	Ground source heat pumps	5	5	5
	Deep geothermal	-	-	1
	Air source heat pumps (electric or engine driven) – supplying less than 100% of building heating load	2	-	-
	Air source heat pumps (electric or engine driven) – all other	3	3	3
	Compost heat exchange system	-	-	1
	Biomass, biofuels, biogas	N/A	N/A	N/A

Heat pumps installed in highly energy efficient homes, passive homes or zero net energy buildings are eligible to receive an additional multiplier of 2, added to their base multiplier in the table above

Size Classification

	Size Classification			
	Small	**Intermediate**		**Large**
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 thermal: evacuated tube and flat plate solar hot water	Collector surface area less than or equal to 660 sq ft	Collector surface area between 660 and 4,000 sq ft	-	Collector surface area greater than or equal to 4,000 sq ft
Solar thermal: solar hot air	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	All
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
Air source heat pump: electric motor or engine driven	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Ground source heat pump	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Deep geothermal	-	-	-	All

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Eligibility, Metering, and Reporting Procedures

Size Classification

	Size Classification			
	Small	**Intermediate**		**Large**
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**
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Solar thermal: solar hot air	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	All
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
Air source heat pump: electric motor or engine driven	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Ground source heat pump	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Deep geothermal	-	-	-	All

Size Classification

	Size Classification			
	Small	Intermediate		Large
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 thermal: evacuated tube and flat plate solar hot water*	Collector surface area less than or equal to 660 sq ft	Collector surface area between 660 and 4,000 sq ft	-	Collector surface area greater than or equal to 4,000 sq ft
Solar thermal: solar hot air*	-	Collector surface area less than or equal to 10,000 sq ft	-	Collector surface area greater than 10,000 sq ft
Solar sludge dryer	-	-	-	All
Eligible Biomass Fuel	-	-	Capacity less than or equal to 1,000,000 Btu per hour	Capacity greater than 1,000,000 Btu per hour
Compost heat exchange system	-	-	-	All
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Ground source heat pump	Output capacity less than or equal to 134,000 Btu per hour	-	Output capacity between 134,000 and 1,000,000 Btu per hour	Output capacity greater than or equal to 1,000,000 Btu per hour
Deep geothermal	-	-	-	All

*Based on Gross Area

Certificate Multipliers for Non-Emitting Renewable Thermal Technologies

The statute allows for DOER to establish certificate multipliers for "non-emitting renewable thermal technologies", which results in more AECs being earned for the same 3,412,000 British thermal units of net useful thermal energy

		APS Renewable Thermal Generation Unit Multiplier		
	System Size	**Small**	**Intermediate**	**Large**
Technology Type	Active solar hot water systems used for domestic hot water	3	3	3
	Active solar hot water systems used for domestic hot water, space conditioning or process loads	1	1	1
	Active solar hot air systems	-	5	5
	Solar sludge dryer	-	-	1
	Ground source heat pumps	5	5	5
	Deep geothermal	-	-	1
	Air source heat pumps (electric or engine driven) – supplying less than 100% of building heating load	2	-	-
	Air source heat pumps (electric or engine driven) – all other	3	3	3
	Compost heat exchange system	-	-	1
	Biomass, biofuels, biogas	N/A	N/A	N/A

Certificate Multipliers for Non-Emitting Renewable Thermal Technologies

The statute allows for DOER to establish certificate multipliers for "non-emitting renewable thermal technologies", which results in more AECs being earned for the same 3,412,000 British thermal units of net useful thermal energy

		APS Renewable Thermal Generation Unit Multiplier		
	System Size	**Small**	**Intermediate**	**Large**
Technology Type	**Active solar hot water systems used for domestic hot water**	**3**	**3**	**3**
	Active solar hot water systems used for domestic hot water, space conditioning or process loads	**1**	**1**	**1**
	Active solar hot air systems	**-**	**5**	**5**
	Solar sludge dryer	-	-	1
	Ground source heat pumps	5	5	5
	Deep geothermal	-	-	1
	Air source heat pumps (electric or engine driven) – supplying less than 100% of building heating load	2	-	-
	Air source heat pumps (electric or engine driven) – all other	3	3	3
	Compost heat exchange system	-	-	1
	Biomass, biofuels, biogas	N/A	N/A	N/A

General Requirements

- Must be an active system
- All systems must have a performance certification to
  - OG-100
  - OG-300
  - Other (as approved by DOER)
- Rating Entities include:
  - Solar Rating and Certification Corporation (SRCC)
  - International Association of Plumbing and Mechanical Officials (IAPMO)
  - Other (as approved by DOER)
- Unglazed flat plate collectors for pool heating are not eligible to qualify

Small Generation Units

- AECs are calculated based on a formula using the following components:
  - OG-100 or OG-300 rating
  - Number of solar thermal collectors (if using OG-100)
  - Surface Orientation Factor, calculated based on the azimuth and tilt of the solar thermal collectors, see section below
  - Annual, average solar access

OG-100 and OG-300 Rating

- ICC 901/SRCC 100 Solar Thermal Collector Standard
- ICC 9010/ICC-SRCC™ 300 Solar Thermal Systems Standard
- Should be based on:
  - Boston, MA for OG-300
  - Medium Radiation, Category D for OG-100

OG-300 Rating

SINGLE DAY RATING CONDITIONS	SI Units	Inch-Pound Units
System Set Temperature	57.2 °C	135 °F
Environmental Temperature	19.7 °C	67.5 °F
Ambient Temperature Profile Average	14.4 °C	58 °F
Water Mains Temperature	14.4 °C	58 °F
Delivered Load	43.3 MJ/day	41,045 Btu/day
Solar Irradiance	4,733 Wh/m^2-day	1,500 Btu/ft^2-day

41,045 Btu/day = 4,391 kWh/year

OG-100 Rating

COLLECTOR THERMAL

Kilowatt-hours (thermal) Per Panel Per Day			
Climate -> Category (Ti-Ta)	High Radiation (6.3 kWh/m².day)	Medium Radiation (4.7 kWh/m².day)	Low Radiation (3.1 kWh/m².day)
A (-5 °C)	13.5	10.2	6.9
B (5 °C)	12.9	9.6	6.3
C (20 °C)	11.9	8.6	5.3
D (50 °C)	10.0	6.7	3.5
E (80 °C)	7.9	4.7	1.7

A- Pool Heating (Warm Climate) **B**- Pool Heating
D- Space & Water Heating (Cool Climat

Surface Orientation Factor

The SOF of a system is used to adjust the predicted thermal yield (collector rating) due to a decrease in production efficiency based on the tilt and orientation of the system's solar thermal collectors

		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

AEC Formula Using OG-300

$$\textbf{Useful Thermal Energy} = \frac{\mathbf{R}}{\mathbf{1{,}000}} * \mathbf{SOF} * \mathbf{S} * \mathbf{t}$$

Where:

R = OG-300 Rating for (kWh/year)

SOF = Surface Orientation Factor

S = Annual, average solar shading

t = Time, 10 years

AEC Formula Using OG-300

Example:

Useful Thermal Energy = 4,391(kWh/year) / 1,000 * 1.0 * 1.0 * 10 (years)

Useful Thermal Energy = 43.9 MWh equivalent

Apply multiplier:

43.9 MWh * 3 (DHW only) = 131 AECs

AEC Formula Using OG-100

$$\textbf{Useful Thermal Energy} = \frac{\mathbf{R}}{\mathbf{1{,}000}} * \mathbf{C} * \mathbf{SOF} * \mathbf{S} * \mathbf{t}$$

Where:

R = OG-100 Solar Collector Rating (kWh/panel/day)

C = Number of solar thermal collectors

SOF = Surface Orientation Factor

S = Annual, average solar shading

t = Time, 3650 days

AEC Formula Using OG-100

Example:

Useful Thermal Energy = 2,445 (kWh/year) / 1,000 * 3 (collectors) * 1.0 * 1.0 * 10 (years)

Useful Thermal Energy = 73.35 MWh equivalent

Apply multiplier:

73.35 MWh * 3 (DHW only) = 220 AECs

Pool Heating

Systems with a useful thermal load that is dedicated to heating a pool are eligible so long as they do not use unglazed flat plate collectors. If the pool is located indoors the same methodology as a typical domestic hot water load should be used. If the pool is located outdoors the same methodology should be used, but with the OG-100 Category B rating.

COLLECTOR THERMAL F

Kilowatt-hours (thermal) Per Panel Per Day			
Climate -> / Category (Ti-Ta)	High Radiation (6.3 kWh/m².day)	Medium Radiation (4.7 kWh/m².day)	Low Radiation (3.1 kWh/m².day)
A (-5 °C)	13.5	10.2	6.9
B (5 °C)	12.9	9.6	6.3
C (20 °C)	11.9	8.6	5.3
D (50 °C)	10.0	6.7	3.5
E (80 °C)	7.9	4.7	1.7

A- Pool Heating (Warm Climate) **B**- Pool Heating
D- Space & Water Heating (Cool Climat

Production Reporting Procedure

- Generation Unit submits a Statement of Qualification Application to DOER
- DOER reviews and approves the application and submits the calculated number of AECs to the MassCEC
- MassCEC verifies the calculation and reports the number of AECs to NEPOOL GIS
- The AECs are minted in the next quarterly minting

Intermediate and Large Generation Units

- Must work with an Independent Verifier
- Must install a Data Acquisition System (DAS)
- Intermediate Generation Units: Useful Thermal Energy is determined via indirect metering, using electric meters and a pump curve
- Large Generation Units: Useful Thermal Energy is determined via direct metering, using electric meters, hot water Btu meters, and cold water Btu meters

More information is available in Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units- Part 2

Intermediate and Large Solar Hot Water Generation Units

Intermediate and large solar hot water RTGUs include, but are not limited to, the following major components:

(a) A solar thermal energy collector system

(b) One or more unfired water storage tanks that supply water, pre-heated by solar energy only, to a primary (fired) heating system

(c) Heat exchanger(s) which transfer energy from the solar collector heat transfer fluid circulating loop to the volume of water in the pre-heat storage tank (not shown in Figure 2 below)

(d) Electric motor driven pump(s) which circulate a heat transfer fluid in a closed loop between the solar collectors and the collector fluid-to-unfired storage tank heat exchanger

(e) Automatic pump controller(s) which start and stop the circulating pumps based on a pre-set temperature difference between the temperature of the un-fired storage tank and the temperature of the solar collectors

Intermediate and Large Solar Hot Air Generation Units

Major system components for both intermediate and large solar hot air Generation Units include, but are not limited to, the following major components:

(a) Transpired Solar Air Collector(s)

(b) Ducting from collector to ventilation unit

(c) Bypass Air intake to ventilation

(d) ON/OFF Solar Air Collector Damper and ON/OFF Bypass Air Damper

(e) Automatic Controls

(f) Ventilation Unit (Typically an existing Air Handling Unit, Make-Up Air Unit, In-Line Supply Fan

Production Reporting Procedure

- Generation Unit submits a Statement of Qualification Application to DOER
- DOER reviews and approves the application
- The Independent Verifier begins recording and verifying production
- The Independent Verifier reports the production to the NEPOOL GIS
- The AECs are minted on a quarterly basis

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Application Process and Requirements

Application Portal

- All Statement Qualification Applications must be submitted on-line through application portal
- Hosted by the Massachusetts Clean Energy Center
- Portal and process is similar to the SREC II program
- The application is six steps, with the ability to save and exit after each step
- Includes in-portal communication function and automatic email updates

Application portal going live on January 16th

Renewable Thermal Application

Step 1 | Step 2 | Step 3 | Step 4 | Step 5 | Step 6

System Information

System name REQUIRED

A personalized name for your project

System Address

Street REQUIRED

Apartment or Suite

City REQUIRED

-- specify one --

State REQUIRED

Massachusetts

Zip REQUIRED

Enter five digit zip code (12345) or five digit code with four digit extension (12345-6789)

System Details

Electric Distribution Company REQUIRED

-- specify one --

Gas Distribution Company REQUIRED

-- specify one --

Facility Type REQUIRED

-- specify one --

About this Application

Systems may choose to size up their classification (Small to Intermediate or Large; Intermediate to Large) if they wish to implement additional metering technology. System owners should refer to the Department's Guideline on Metering for further information.

Please complete all required fields prior to moving to the next Step. Changes to this page will not be saved until the 'Save and Continue' option has moved the application to the next Step.

Contact Us

Tel	(617) 626-1180
Email	thermal.doer@state.ma.us

Application Requirements

- Generation Unit location and capacity
- Existing heating system details
  - Annual heat load
  - Primary heating fuel and distribution type
- Generation Unit installation and design details
  - Capacity compared to load
  - Equipment information
  - Rating information
  - System cost
  - Installer
- Contact information
- NEPOOL GIS information

Application Attachments

Small Generation Units:

- AEC Services Agreement- (optional- for aggregators/authorized representatives only)

Intermediate and Large Generation Units only:

- AEC Services Agreement (for aggregators/authorized representatives)
- Independent Verifier Request Form
- Process Flow Diagram with all APS meters shown
- One Line Electrical Diagram with all APS Meters Shown
- Metering Plan
- List of APS Meters
- System Information Data Sheet

Application Attachments cont.

Intermediate and Large Generation Units only (cont.):

- Equipment Arrangement Drawing
- General Site Plan
- Annotated Product Literature for all major equipment, each APS meter, and the Data Acquisition System
- Description of System Controls and Sequence of Operations
- System Performance Workbook
- Certified Performance Data Construct (Intermediate Only)

APS Next Steps

- Statement of Qualification application portal will open on January 16th

- Webinar- January 16th, 10:30am – 12:00pm
  - APS Application Process

Questions?