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

ALTERNATIVE ENERGY PORTFOLIO STANDARD

GUIDELINE

ON METERING THE ENERGY OUTPUT AND CALCULATING THE ALTERNATIVE ENERGY CREDITS GENERATED BY AN ELIGIBLE FUEL CELL GENERATION UNIT

December 29, 2017

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

This Guideline provides the methods by which the thermal output of eligible Fuel Cell Generation Units qualified for the Alternative Portfolio Standard (APS) shall be metered and how the meter readings are to be used to determine the number of Alternative Energy Credits (AECs) generated. A Table of Contents, Table of Figures, and List of Tables can be found immediately following this section.

The purpose of this Guideline is to ensure uniform, accurate, reliable, and verifiable measurements of Fuel Cell Generation Units' performance, and explain the general APS formula for Fuel Cell Generation Units as well as forms of the general formula to be applied in specific cases for the determination of APS benefits.

This Guideline is effective immediately upon issuance. However, the Department of Energy Resources (Department) may consider exceptions from the Guideline in the case of Fuel Cell Generation Units that went into commercial operation prior to the issuance date, but not earlier than January 1, 2017.

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1) **Provisions in the Statute and Regulations**

The APS statute at M.G.L. Chapter 25A, Section 11F½(a), as amended by Chapter 188 of the Acts of 2016, mandates that fuel cells qualify as an eligible Alternative Energy Generating Source under the Alternative Portfolio Standard.

Pursuant to the verification provision in that language, the APS regulations state the following at 225 CMR 16.05(1)(a)7:

> 7. Fuel Cell. A Fuel Cell Generation Unit that produces electricity and/or Useful Thermal Energy may qualify as an APS Alternative Generation Unit, subject to the limitations in 225 CMR 16.05(1)(a)7.
>
> a. Source of Hydrogen. A Fuel Cell Generation Unit that uses hydrogen generated through the use of propane shall be required to certify that the propane was manufactured using only natural gas.
>
> b. Overall Efficiency. To qualify as an APS Alternative Generation Unit, a Fuel Cell Generation Unit shall be more efficient than the current average for emitting locational marginal units as based on the heat rates for these units shown in the most recent ISO-NE Electric Generator Air Emissions Report available in the same year in which a Fuel Cell Generation Unit submits an SQA. A Fuel Cell Generation Unit that generates both electricity and Useful Thermal Energy must have an overall efficiency of at least 55%. The overall efficiency of a Fuel Cell Generation Unit shall be calculated as the sum of the MWh of electricity generated, excluding any electricity utilized for parasitic load, plus the MWh of Useful Thermal Energy, divided by the total higher heating MWh value of fuel consumed by the Fuel Cell Generation Unit. Supporting operating data, confirming that the Fuel Cell Generation Unit continues to meet the Overall Efficiency requirement in 225 CMR 16.05(1)(a)7.b., must be submitted to the Department on an annual basis in order for the Fuel Cell Generation Unit to maintain its Statement of Qualification.
>
> c. Attribute Multiplier. A Fuel Cell Generation Unit shall earn one and a half APS Alternative Energy Attributes for each MWh of electricity and/or 3,412,000 British thermal units of net Useful Thermal Energy generated. A Fuel Cell Generation Unit shall retain the multiplier provided at its time of qualification as long as it continues to meet all other applicable eligibility criteria in 225 CMR 16.05.
>
> d. Metering Requirements. The net energy output from a Fuel Cell Generation Unit shall be metered according to the specifications in the Department's Guideline on Metering and Calculating the Energy Output of Eligible Fuel Cell 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 reported to the NEPOOL GIS by an independent Third Party Meter Reader shall be the amount that is qualified for Alternative Energy Attributes, as specified in 225 CMR 16.05. This amount will be inclusive of the application of any

multiplier provided in 225 CMR 16.05(1)(a)7.c.

This Guideline specifies the manner by which the output of Fuel Cell Generation Units can be verified through on-site meters that meet the minimum APS metering requirements as described in Section 3 of this document, or other means as specifically approved by the Department on a case by case basis.

2) **Applicability**

This document provides general guidance on the type, number, and location of meters specific to Fuel Cell Generation Units eligible under the APS. The Department strongly suggests that information showing the number, type, and location of meters to be installed, be submitted to the Department for preliminary review prior to the issuance of or bid for construction designs and/or before procurement of the meters.

All direct measurements of energy are to be done by meters which comply with the requirements as set forth in Section 3 of this Guideline. The ongoing operation of all Fuel Cell Generation Units will be verified through means appropriate for each.

3) **Metering Requirements and APS Formulae**

A) General

1) Terms and Procedures

- A British Thermal Unit (Btu) is a unit of thermal energy commonly used in the quantification of the capacity of a Fuel Cell Generation Unit.

- A kilowatt (kW) or megawatt (MW) are units of electrical energy that are also commonly used in the quantification of the capacity of a Fuel Cell Generation.

- All of the energy terms in the APS formulae for the determination of AECs are to be expressed in megawatt hours (MWh).

- Conversion of Btus to MWh :

    - 1 Btu = 1/3.412 watt hour; 1 MMBtu = 1,000,000 Btu = 1/3.412 MWh

- Net useful heat is the thermal energy generated by a fuel cell that is transferred to a facility and/or process load and is equal to the thermal energy supplied to the load from the fuel cell minus thermal energy returned from the load to the fuel cell minus any parasitic thermal energy.

- Fuel cells that are Combined Heat and Power (CHP) Systems:

A fuel cell that co-generates electricity and useful heat also meets the definition of an APS CHP generation unit and may qualify for Massachusetts Portfolio Standard Programs and earn credits in one of three different ways:

1) As an APS Fuel Cell Generation Unit, in which case it will generate one and one half AECs per MWh of electric and Useful Thermal Energy output.
2) As an APS CHP system whereby the net MWh of electricity and the net MWh of useful heat generated by the unit earn AECs per the APS CHP formula as shown in the APS regulations and in related Guidelines
3) If some or all of the fuel to be used meets the definition of a RPS Class I eligible fuel, resource, or technology, as prescribed in 225 CMR 14.05(1)(a), a CHP fuel cell system may qualify both as a RPS Class I Renewable Generation Unit and as an APS CHP Generation Unit. In this case the net MWh of electricity generated by the fuel cell may earn Class I RECs and:
   (i) The net MWh of Useful Thermal Energy generated by a Fuel Cell Generation Unit may earn AECs at a rate of one and one half AECs per MWh; or
   (ii) The net MWh of electricity and the net MWh of useful heat generated by the unit may earn AECs per the APS CHP formula.

NOTE: These guidelines apply only to the qualification of a Fuel Cell Generation Unit pursuant to 225 CMR 16.05 and do not pertain to a fuel cell that elects to qualify as a CHP Generation Unit.

- All electricity supplied by the ISO-NE grid to any Fuel Cell Generation Unit auxiliary system must be subtracted from the net useful electricity generated.

  The term auxiliary denotes a component and/or sub-system that does not directly generate Useful Thermal Energy, but whose operation is required in order for the generation of useful thermal energy to occur. Examples of auxiliary components are:

  - Fuel gas compressor;
  - Enclosure ventilation fans;
  - Over temperature protection radiator fans; or
  - The natural gas reformer system.

  In general, components such as pumps, fans, blowers, etc. that may be installed and operated in conjunction with a Fuel Cell Generation Unit whose function is to distribute the thermal energy generated by a Fuel Cell Generation Unit to a useful thermal load, are not considered as auxiliary and the energy required to operate them is not metered or included in the determination of AECs.

  EXCEPTION: If a Fuel Cell Generation is located more than 500 feet from the point of connection with a thermal load or with the thermal hosts' distribution system being supplied by the Fuel Cell Generation Unit, electricity supplied to circulate heat transfer fluid between a central Fuel Cell Generation Unit and the point of connection with each remote building or self-contained load is to be subtracted from the gross electricity generated by the Fuel Cell Generation Unit.

- Parasitic Energy is defined as the electricity or thermal energy generated by the Fuel Cell Generation Unit, which is used to operate any auxiliary component or system of the Fuel Cell Generation Unit.

  Parasitic thermal energy may be applicable to all Fuel Cell Generation Unit; however it is typically limited to motive steam.

2) Quantification of Parasitic Thermal Energy

   All efforts should be made to locate a system's Btu meters such that the consumption of parasitic thermal energy is netted out. In the event that this cannot be accomplished the parasitic thermal energy of any auxiliary system with a demand exceeding 5% of the projected value of the net annual AECs during nominal operating conditions will require either a calculation of the parasitic load or a separate Btu meter. This determination will be at the discretion of the Department.

3) Non Useful Thermal Energy

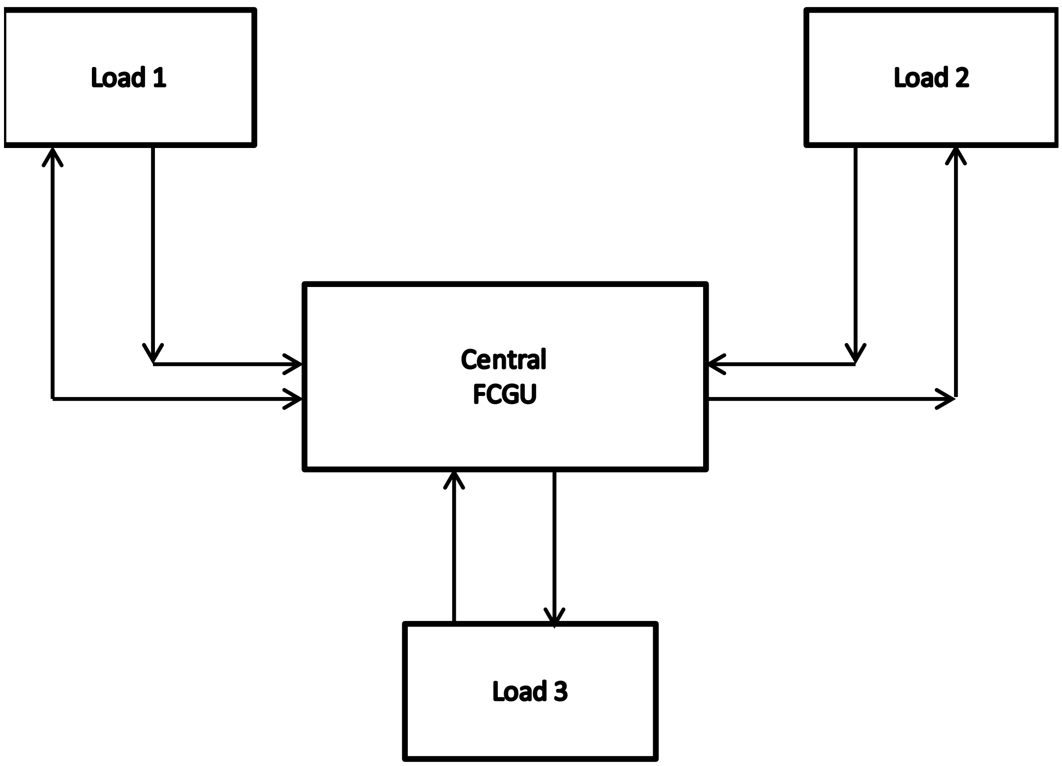
   Renewable thermal energy that is rejected to a heat sink (e.g. the air, ground, surface, or storm water), or in most cases, to heat feedwater is not consideredUseful Thermal Energy and must be accounted for in the location of Btu meter instruments as well as in the determination of the net metered useful energy.

   Wherever possible, the components of Btu meters should be located such that they do not count heat rejected to a heat sink or in most cases to heat feedwater, in the heat being metered as useful. If this is not possible, separate Btu metering will be required to measure the heat rejected to a heat sink and this energy shall be subtracted from the total metered Btus.

4) Locating Btu Meters

   a) Whenever possible, Btu meters should be located at a point before the interconnection with the load's thermal distribution system (i.e. on the Fuel Cell Generation Unit side and not on the load side).
   b) Whenever possible, Btu meters should be located before any point of connection with a non-useful heat load, such as a radiator of cooling tower that rejects excess heat, before delivery to the distribution system, or rejection of excess heating systems.
   c) When a Fuel Cell Generation Unit is located more than 500 feet from the point of connection with a thermal load, the Btu meter(s) must be located within 30 feet from the point of connection to the thermal load.

Figure 1 Diagram of a generic central Fuel Cell Generation Unit with Distributed Thermal Loads



5) <u>Measuring the Thermal Energy Transferred to a Useful Thermal Load</u>

(a) For air or heat transfer fluids (including aqueous mixtures): heat content is based on mass, temperature, and specific heat

B) General Formulae for the Quantification of Useful Thermal Energy

$$\mathbf{UH = (HS - HR - NUH - P_{th})}$$

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

Where:

UH_t = Useful Heat Transferred

HS = Heat Supplied by FCGU to Load

HR = Heat Returned from Load to FCGU

NUH = Non-useful heat

P_{th} = Parasitic thermal energy

C) General Formulae for the Quantification of Net Electricity Generated

Net Elec = (Eg – Ep - Es)

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

Where :
Eg = Gross Electricity Generated

Ep = Parasitic Electricity

Es = Grid Electricity to FCGU auxiliary systems.

D) Minimum Efficiency Standard

Pursuant to 225 CMR 16.05(1)(a)7.b., all Fuel Cell Generation Units must meet an overall efficiency standard. Fuel Cell Generation Units that generate electricity only must be more efficient than the current average for emitting locational marginal units as based on the heat rates for these units shown in the most recent ISO-NE Electric Generator Air Emissions Report available in the same year in which a Fuel Cell Generation Unit submits an SQA.

Fuel Cell Generation Units that generated both electricity and Useful Thermal Energy must have a net overall efficiency of 55% or higher. For the purpose of this standard, the definition of the efficiency shall be:

Efficiency = ((net MWh Electricity) + (Useful Heat)) / (MWh equivalent of fuel consumed for each month of the as-submitted projected average year)

Approval of AECs as submitted to the NEPOOL Generation Information System (NEPOOL GIS) for a given quarter shall be contingent upon achievement of the minimum metered average efficiency, as defined in the definition of efficiency above. The MWh fuel consumed for the given quarter is to be determined pursuant to the method and protocol described in Section 3 of the *APS Guideline on Biomass, Biogas, and Biofuels for APS Renewable Thermal Generation Units*.

E) Acquisition, Recording, Storing, and Transmittal of Metered Data

All Fuel Cell Generation Units must include a Data Acquisition System (DAS) which must meet the following minimum functional criteria:

(a) Input: Input must come from each APS metering system and component, at an interval that does not to exceed 5 minute between inputs.
(b) Storage: 100 days of cumulative input data
(c) Output:
  (i) Have remote electronic access to time stamped data of each input in five minute intervals that can be exported as a comma separated values (.csv) file
  (ii) Data is to be accessible by and transferred directly to the system Independent Verifier and not via a third party.

The DAS may be a stand-alone dedicated unit or be integrated into an existing system.

F) Standards for APS Metering

All meters required by the APS must meet and conform to all applicable laws, ordinances, codes, regulations, and standards, must be of revenue grade accuracy, quality, and reliability, and must have the capability to generate and transmit a signal to the system DAS.

G) Thermal Energy Meters

Table 1. Thermal Energy Meter Requirements for Steam

Line Size	Btu Meter System Components		System Field Accuracy	Re-Calibration Interval	Notes
	Flow Sensor and Btu Computer	Temperature & Pressure Sensors			
All	*Btu Computer*: Automated real-time computation and totalizer	—	—	—	—

≥8"	*Flow Sensor:* Orifice Plate with Differential Pressure Element and Transmitter	Only with superheated Steam	±3%	Annual	1) Perform an annual inspection of the flow sensor orifice plates and check for wear and distortion beyond the OEMs specifications as a part of the annual re-calibration procedure 2) If a significant percentage of flow occurs at flow rates below the flow sensors minimum guaranteed full accuracy flow rate, both the flow and Btus may be undercounted. This can be addressed by installing a two meter manifold with the meters sized to cover the entire expected range of flow rates. Consult the flow meter provider for design and installation details
< 8"	*Flow Sensor:* Vortex Shedding Tube	Only with superheated Steam	±3%	Biennial	—

Table 2. Thermal Energy Meter Requirements for Hot Water

Btu Meter System Components	Btu Meter Field Accuracy	Re- Calibration Interval	Notes
Flow Sensor: In-line Ultrasonic Flow Tube (no strap-on) or Magmeter *Thermal Sensors:* Installed in thermowells *Btu Computer:* Automated real-time computation and totalizer	±3%	Biennial	No turbine or impellor based flow sensors

Table 3. Thermal Energy Meter Requirements for Air

Btu Meter System Components	Btu Meter Field Accuracy	Re-Calibration Interval	Notes
Flow Sensor: a) In-duct Differential Pressure Measuring Airflow Station b) Pitot Tube *Thermal Sensors:* Installed in the air flow stream *Btu Computer:* Automated real-time computation and totalizer	±3%	Annual	Clean and inspect orifices as a part of the annual calibration procedure

Table 4. Thermal Energy Meter Requirements for Refrigerants

Btu Meter System Components	Btu Meter Field Accuracy	Re-Calibration Interval	Notes
Liquid Flow Sensor: Full Flow Ultrasonic (transit time) *Thermal Sensors:* RTD or Thermocouple Installed in thermowells *Btu Computer:* Automated real-time computation and totalizer	±3%	TBD	Care must be taken to avoid flashing of the hot liquid to vapor, which will affect the operation of expansion valves

H) Fuel Meters

Table 5. Fuel Meter Requirements for Natural Gas

Meter Type	Flow rate Range	Accuracy	Minimum Frequency of Calibration	Other
All Meters	2% ≤ Flowrate ≤ 100% Max DF Where Max DF is Maximum System Design Flow Rate	± 2%	Annual	See Notes

Notes:

1) *All diaphragm meters must conform to the current American National Standard Institute (ANSI) B109.2 standard*
2) *All rotary meters must conform to the current ANSI B109.3 standard*
3) *The default Higher Heating Value (HHV) for pipeline natural gas is 1,030 Btu per Standard Cubic Foot (SCF). Alternate HHVs may be proposed as documented by the fuel supplier*
4) *All volumetric measurements must be adjusted to SCF (i.e. they must be temperature and pressures corrected). Meter models that are auto pressure and temperature compensated will meet this requirement. Meters with a settable fixed value pressure compensation may be used if installed downstream of a pressure regulator. The applicant may propose and alternate method for converting the metered flow to SCF units*
5) *Thermal Diffusion Meters (TDM) are not approved*
6) *A pipeline gas meter furnished and installed as part of a dedicated gas line to the Fuel Cell Generation Unit by the site's gas utility will be accepted as an approved natural gas fuel meter*
7) *Submittal of a proposed meter other than as furnished by the site's gas utility should be accompanied by a list of utilities and/or distribution companies that have used the as-proposed meter either for billing or custody transfer.*

Table 6. Fuel Meter Requirements for Biogas

Btu Meter System Components	Btu Meter Field Accuracy	Recalibration & Inspection Frequency	Notes
Gas Flow Sensor: Full Flow Averaging Pitot Real time gas analyzer *Btu Computer:* Automated real-time computation and totalizer.	±3%	Annual	Both tuned laser or infrared based optical gas analyzer technologies are acceptable

I) Electric Meters

Electric (kWh) meters shall be revenue grade and shall:

1) Be certified as meeting American National Standard Institute (ANSI) Standard C12.20
2) Have a kW and kWh remote output signal with an output signal interval of not more than once per minute
3) Have either a non-adjustable or password protected cumulative kWh register

J) Accuracy of Thermal and Fuel Metering

Thermal energy and fuel must be metered per the tables in 3(E) and 3(F) above, with a possible future modification per the issuance of the American Society for Testing and Materials (ASTM) Heat Meter Technology Standard WK37952 that is currently under development under the leadership of the United States Environmental Protection Agency (EPA).

K) Use of non-Eligible Fuels when Combined with Eligible fuels

Possible Fuel Usage Modes

(a) Use of a single eligible fuel
(b) Co-firing of more than one eligible fuel
(c) Co-firing of one or more eligible fuels and one or more non-eligible fuel
(d) Blending of one or more eligible fuels
(e) Blending of one or more eligible fuels with one or more non-eligible fuels

Note: Co-firing denotes switching fuels without blending.

L) Components and Metering Diagrams

1) <u>Components of a Fuel Cell Generation Unit that Generates Electricity and Useful Thermal Energy via a Heat Transfer Fluid</u>

The major components of a Fuel Cell Generation Unit include:

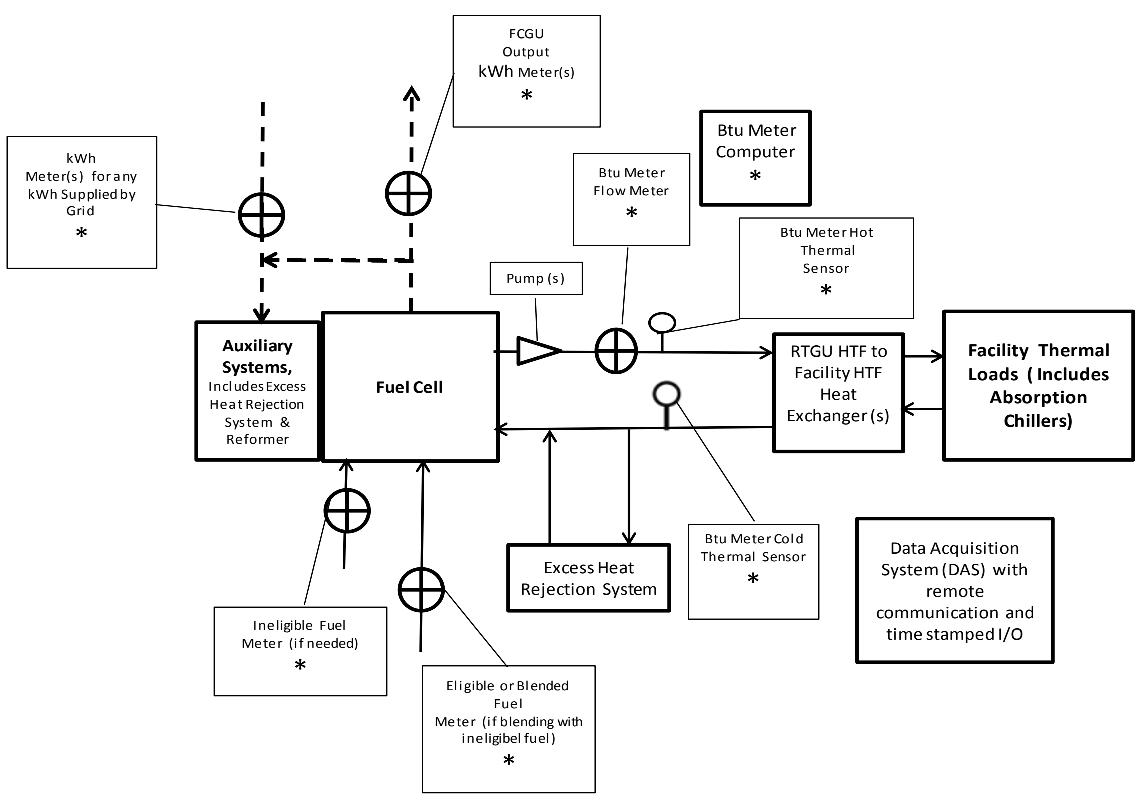
(a) Fuel cell section
(b) Fuel reformer
(c) Fuel storage and delivery system
(d) Heat recovery and transfer system
(e) Over temperature protection system
(f) Controls
(g) Data acquisition system (DAS)

2) Metering for Large, Fired Fuel Cell Generation Units which Generate a Hot Heat Transfer Fluid

The following guidelines are based on a generic basic configuration as shown in Figure 2.

The Department will evaluate metering plans and submittals based on alternative configurations on a case-by-case basis.

Figure 2. Metering Diagram for an Fuel Cell Generation Unit that Generates Electricity and Useful Thermal Energy via a Heat Transfer Fluid



An asteriks (*) indicates an input to the DAS

a) Formulae for APS AECs Generated and Efficiency over an Operating Interval

(*all Energy is As-Metered and all Energy Units are MWH*)

Notation

Eg = Gross Metered Electricity Generated

Ep = Metered Consumption of FCGU Electricity by Parasitic Loads

Es = Metered Consumption of Grid Supplied Electricity by Auxilliary Systems

Fe = Eligible Fuel

Fbe = A blend of two or more Eligible Fuels

Fi = Ineligible Fuel

Fbei = A blend of Eligible and Ineligible Fuels

UH = Useful Heat (Heat Transferred to a Useful Load)

M = the Attribute Multiplier = 1.5

(i) FCGU when Using Only a Single Eligible Fuel

AECs = (Eg- Ep[1] – Es) M

Efficiency = (Eg- Ep[1] – Es + UH) / Fe

(ii) FCGU when Using a Blend of or Co-Firing only with Two Eligible Fuels

AECs = (Eg- Ep[1] – Es) M

Efficiency = (Eg- Ep[1] – Es + UH) /(Fe_1 + Fe_2)

(iii) FCGU when **Co-Firing** Using an Eligible and Ineligible Fuel

AECs = (Eg- Ep[1] – Es) M **only for intervals when an eligible fuel is being used**

Efficiency = (Eg- Ep[1] – Es) UH /(Fe + Fi) – Overt the entire interval including time when an ineligible fuel is being used.

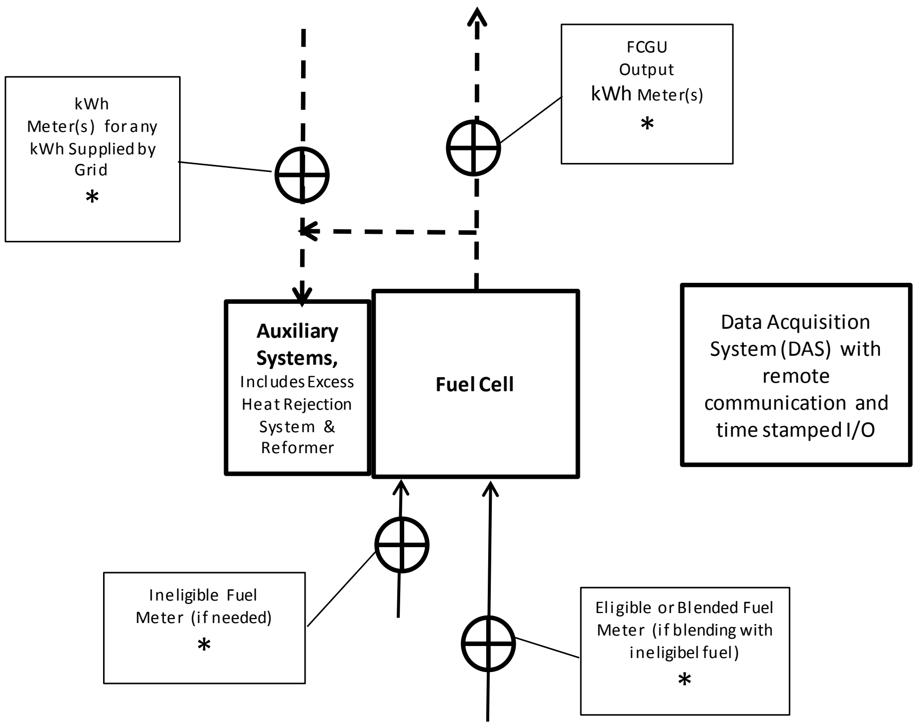
(iv) FCGU when Using a **Blend** of an Eligible with an Ineligible Fuel

AECs = (Fe/(Fbei) (Eg- Ep[1] – Es) M

Efficiency = (Eg- Ep[1] – Es + UH) / (Fbei)

Note(1) *Figure 2 assumes a preferred configuration in which the connection of the Fuel Cell Generation Unit electrical output to all parasitic loads occurs at a point before the main system APS Electrical Meter. In this case Ep = 0. If this is not the case then the nominal parasitic loads must be identified and a method for quantifying Ep over the interval must be submitted to the DOER for review and approval on a case by case basis*

Figure 3. Metering Diagram for a FCGU that Generates Electricity Only



An asteriks (*) indicates an input to the DAS

b) Formulae for APS AECs Generated and Efficiency over an Operating Interval

(*all Energy is As-Metered and all Energy Units are MWH*)

Notation

Eg = Gross Metered Electricity Generated

Ep = Metered Consumption of FCGU Electricity by Parasitic Loads

Es = Metered Consumption of Grid Supplied Electricity by Auxilliary Systems

Fe = Eligible Fuel

Fbe = A blend of two or more Eligible Fuels

Fi = Ineligible Fuel

Fbei = A blend of Eligible and Ineligible Fuels

(i) FCGU when Using Only a Single Eligible or

AECs = (Eg- Ep[1] – Es) M

Efficiency = (Eg- Ep[1] – Es) / Fe

(ii) FCGU when Using a Blend of or Co-Firing only with Two Eligible Fuels

AECs = (Eg- Ep[1] – Es) M

Efficiency = (Eg- Ep[1] – Es) /(Fe_1 + Fe_2)

(iii) FCGU when Co-Firing Using an Eligible and Ineligible Fuel

AECs = (Eg- Ep[1] – Es) M **only for intervals when an eligible fuel is being used**

Efficiency = (Eg- Ep[1] – Es) /(Fe + Fi)

(iv) FCGU when Using a Blend of an Eligible with an Ineligible Fuel

AECs = (Fe/(Fe + Fi)) (Eg- Ep[1] – Es) M

Efficiency = (Eg- Ep[1] – Es) /(Fe + Fi)

Note(1) *Figures 2 and 3 assume a preferred configuration in which the connection of the Fuel Cell Generation Unit electrical output to all parasitic loads occurs at a point before the main system APS electrical meter. In this case Ep = 0. If this is not the case then the nominal parasitic loads must be identified and a method for quantifying Ep over the interval must be submitted to the DOER for review and approval on a case by case basis.*