New York State
Renewable Portfolio Standard

Biomass Guidebook

Prepared for
New York State Energy Research and Development Authority

Prepared by
Antares Group, Incorporated

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Notice

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The New York State Public Service Commission (PSC) Orders issued for Case 03-E-0188 are the controlling authority for all determinations of eligibility of projects participating in the NYS RPS. NYSERDA Guidance documents provide Offerors additional information about the application of the Orders to specific projects and methodologies for determining the amounts of power eligible for contract payments as well as guidance on RPS certification procedures for facilities contracting with NYSERDA for the sale of renewable attributes. If there is any question about the application of the guidance to an Offerors project the Orders will take precedence.

The RPS program was designed to evolve as the implementing authorities gain experience with the program and perform a mandated review in 2009. Guidance provided at this time and any time during the program implementation will apply to the current procurement and may change with successive procurements. Offerors are advised to review applicable guidance provided with the announcement of each successive RPS procurement or auction.

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1. INTRODUCTION

The New York State Renewable Portfolio Standard (RPS) program is seeking a portfolio of renewable generation technologies to meet the goal of increasing renewable generation in New York. The rules for eligibility broadly include biomass resources and conversion technologies with some exceptions. This document has been prepared to offer guidance to prospective biomass power project developers on requirements for the eligibility of biomass-based projects to participate in the RPS Program. Special emphasis has been placed on the areas where the RPS program has placed unique constraints on aspects of biomass generation: accounting for RPS program generation in biomass cofiring, constraints on the use of adulterated biomass in power plants, and requirements for the use of forest resources.

The reader should keep in mind several precepts in using this Guide:

1. The application of any guidance contained in this document in no way precludes, supersedes, or relieves project developers from fulfilling the legal obligations otherwise incumbent on developers or plant operators. This includes, but is not limited to, any operating or environmental permits. Although many of the procedures and protocols presented in this document are intended to leverage existing regulatory infrastructure or standard plant operating practice, the specifics of each project permit and operating requirements are still subject to all Federal and State laws and oversight bodies such as the New York State Department of Environmental Conservation. Guidance presented in this document is solely for the purpose of establishing eligibility for the RPS program.
2. In the April 14, 2005 "Order Approving Implementation Plan, Adopting Clarifications, and Modifying Environmental Disclosure Program," the New York State Public Service Commission (PSC) authorized the Office of Electricity and Environment (OEE) of the Department of Public Service to issue advisory opinions, provisional certification, and operational certification for projects. However, the Order also gives the New York State Energy and Development Authority (NYSERDA) a substantial role in collecting/analyzing data and making recommendations to the OEE Director. Final authority for determining eligibility of projects seeking to participate in the RPS program rests with these two parties.
3. The information and protocols provided in this document are presented as guidelines to developers regarding their existing or planned power plant's treatment under the New York RPS program and associated contracting processes.
4. In some instances, a provisional certification may be offered by NYSERDA based on preliminary or design data. However, final approval will be dependent on demonstrating that the design or cost objectives are met. This is especially important to note for projects seeking to use adulterated biomass and in calculating incremental capacity additions.

Relation to Environmental Permits

All projects participating in the RPS must be permitted and in compliance with environmental and operating permits. The facility must first be permitted by DEC (or comparable agency in other states) which requires the facility to meet all current regulations on air emissions including specific applicable limits on criteria pollutants and air toxics for all the fuels they intend to use.

The RPS imposes additional fuel and environmental requirements beyond state and federal regulations. In general there are restrictions on the types of feedstocks that qualify as biomass. In particular there are special rules that apply to the use of adulterated fuels covering both eligible conversion technologies and air emissions.

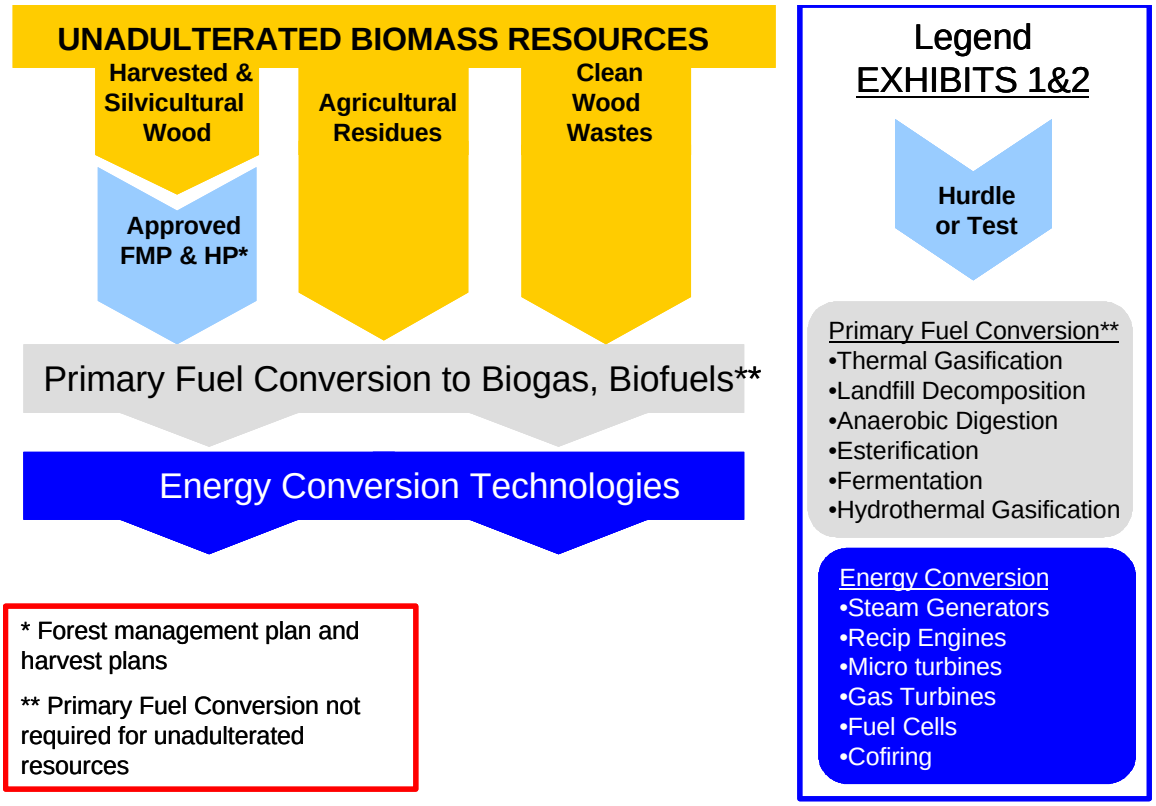
5. Although the authors of this Guide have provided as general a perspective as possible while covering the key issues regarding the participation of biomass projects in the RPS program, special circumstances may arise that fall outside of this document's scope.

2. ELIGIBLE TECHNOLOGY AND FEEDSTOCK COMBINATIONS

The PSC Orders[1] prescribe eligibility requirements in terms of technology and feedstock combinations. These combinations are presented graphically in EXHIBITS 1 and 2. For unadulterated biomass there is always an option to first perform a feedstock conversion step to produce a clean liquid or gaseous fuel prior to the energy conversion step. For the adulterated biomass feedstocks this step is required (see EXHIBIT 2). The EXHIBITS indicate which feedstock and technology combinations are eligible and which ones must meet special hurdles or tests of eligibility.

All of the accepted feedstock and energy conversion technologies may use **unadulterated** biomass to generate RPS program eligible power as shown in **Exhibit 1**. The source-separated, combustible, untreated and uncontaminated wood portion of municipal solid waste or construction and demolition debris qualifies as an unadulterated resource and no special restrictions apply to these biomass fuels so long as the unadulterated biomass is not commingled with other wastes. Note that

Exhibit 1 RPS Eligibility for Unadulterated Biomass

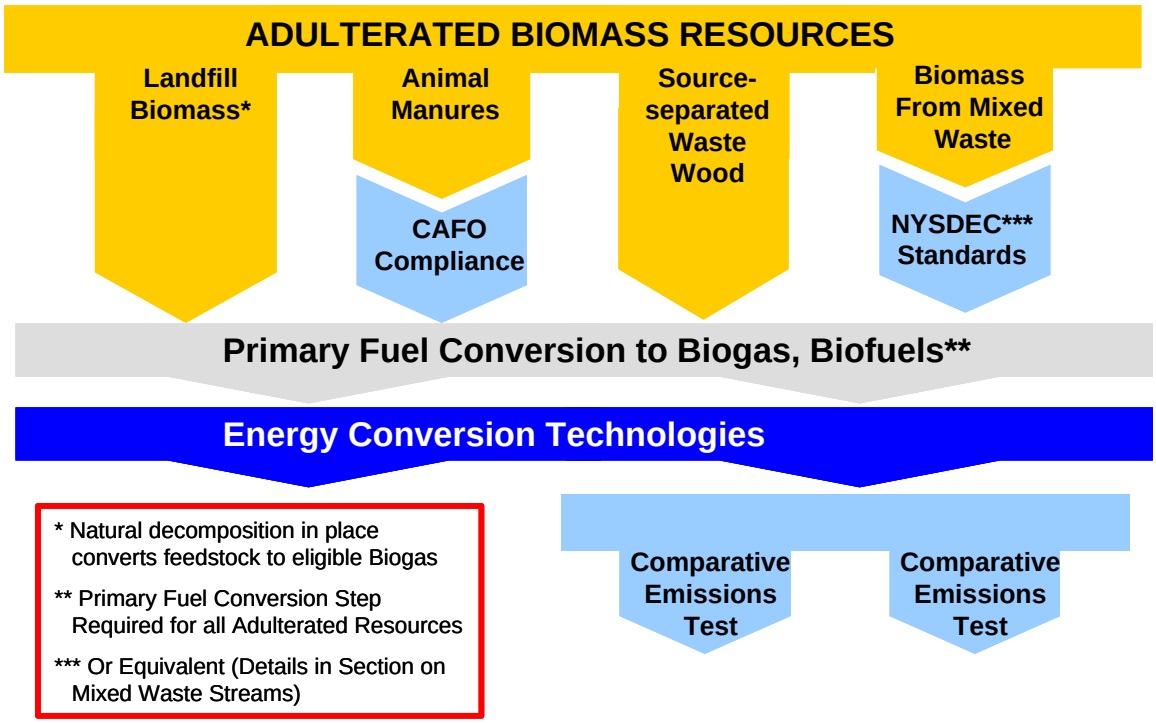


[1] ORDER REGARDING RETAIL RENEWABLE PORTFOLIO STANDARD effective September 24, 2004 and ORDER APPROVING IMPLEMENTATION PLAN, ADOPTING CLARIFICATIONS, AND MODIFYING ENVIRONMENTAL DISCLOSURE PROGRAM, effective April 14, 2005 – Proceeding on Motion of the Commission Regarding a Retail Renewable Portfolio Standard, CASE 03-E-0188, STATE OF NEW YORK PUBLIC SERVICE COMMISSION.

certain restrictions apply to the use of biomass harvested from woodlots. These requirements are detailed in Section 3. These restrictions are designed to ensure the sustainability of the resource. Projects that plan to cofire unadulterated biomass with fossil fuels have additional measurement and reporting requirements to ensure that only the biomass-generated electricity is counted in the RPS program. Those requirements are discussed in Section 4.

EXHIBIT 2 shows that greater feedstock flexibility has been offered to projects that employ technologies that convert adulterated forms of biomass to a gaseous or liquid fuel prior to combustion: natural biological processes, biomass gasification, pyrolysis, or hydrolysis. This is a key provision of the NYS RPS program which allows NY to tap a broader set of biomass resources with important environmental benefits. The most obvious example is the inclusion of landfill gas (LFG) projects which provide a means to capture the biogas generated by the natural decomposition of the biomass portion of municipal solid waste. The benefits of capturing the methane generated from decomposition before it enters the atmosphere and using it to produce energy are well documented. Because the benefits of LFG energy projects have been well demonstrated, there are no special technical requirements for these projects to participate. All other projects electing to use some forms of adulterated biomass must meet additional specified requirements before the energy generated can be considered for eligibility under the RPS program. The following sections detail the eligibility requirements for the technologies that may use adulterated feedstock combinations.

EXHIBIT 2: RPS Eligible Projects - Adulterated Sources



ADULTERATED BIOMASS RESIDUES/WASTES AND ANIMAL WASTES

Adulterated biomass residues and wastes are materials derived from woody or herbaceous biomass where a treatment or coating has been applied, introducing non-biomass materials. This class also includes animal byproducts and wastes even though a chemical treatment process may not be involved. Some forms of adulterated biomass are permitted to be used for power generation under the RPS program with specific restrictions. This Guide provides a roadmap to their use from the feedstock perspective beginning with the least constrained feedstock and conversion combinations.

Landfill Gas Conversion Systems: No special RPS program eligibility requirements are imposed on landfill gas projects that otherwise meet the program's general requirements (refer to page 16 (1.) for certain exceptions).

Animal Manure Digester Gas Conversion Systems: The sole specific requirement for eligibility of these systems is that they demonstrate compliance with NYSDEC or equivalent regulations[2] for Concentrated Animal Feeding Operations (CAFO). If required to have a State Pollutant Discharge Elimination System (SPDES) permit by NYSDEC regulations[3], a power generation facility using the manure must have and be in compliance with its current Comprehensive Nutrient Management Plan (CNMP) developed by a duly qualified Agricultural Environmental Management (AEM) Planner and must be operating in compliance with any applicable SPDES permit. If not required to have a SPDES permit, the CAFO must be operating in compliance with the best management practices for a facility of its size set forth in the Principles and Water Quality Protection Standards specified in the Agricultural Environmental Management (AEM) Framework & Resource Guide developed by the NYS Department of Agriculture and Markets and the NYS Soil and Water Conservation Committee[4].

Source-Separated Urban Wood and Related Biomass Wastes: The source-separated, combustible untreated and uncontaminated wood portion of municipal solid waste or construction and demolition debris qualifies as an unadulterated resource and no special restrictions apply to these biomass fuels so long as the unadulterated biomass is not commingled with other wastes. However, the RPS program provides for the use of source-separated adulterated forms of biomass using advanced conversion technologies with a stringent air emissions standard. Adulterated forms of biomass such as non-recyclable wood (e.g., plywood and particle board), paper, paperboard boxes, textiles, food, leather, yard waste and leaves may be used as a feedstock for Biogas or liquid Biofuels conversion technologies, if it can be demonstrated that the technology employed would produce power with emissions **less than or equal to** emissions produced while using only unadulterated feedstock. The procedure and requirements for conducting the tests necessary to demonstrate compliance with this standard are presented in the next subsection.

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[2] For projects outside of New York, projects must demonstrate that they are operating using equivalent practices and meeting the same environmental requirements as NYSDEC permitted facilities.

[3] See footnote above.

[4] This requirement applies whether or not the project is located in New York State.

Primary Feedstock/Fuel Conversion Technologies, as defined in this Guide, all involve the conversion of biomass to gaseous or liquid fuels prior to use in an energy conversion system. The natural decomposition of landfill biomass to produce methane is the simplest example and is widely used for energy production. Biogas conversion technologies include thermochemical conversion and anaerobic digestion. Liquid Biofuel conversion technologies include: acid or enzymatic hydrolysis to ethanol; esterification to Biodiesel[5]; pyrolysis to Bio-oil; and hydrothermal liquefaction. Biogas production technologies (thermochemical conversion or anaerobic digestion) can produce a fuel gas that will drive a variety of power generation technologies, including gas turbines, micro turbines, fuels cells, reciprocating engines and steam turbines. Conversion to biogas or syngas permits the use of agricultural by-products such as leather and offal and food processing residues, animal manures, sewage gas, and adulterated forms of wood, such as plywood and particle board. Liquid biomass-derived fuels can be produced through a variety of thermochemical and biological conversion processes. As is the case for gaseous fuels from biomass, liquid biomass-derived fuels may be used to fire a wide array of power generation equipment. Conversion to liquid fuels will also permit the use of adulterated forms of wood, such as plywood and particle board, as well as offal and food processing residues.

Biomass Recovered from Mixed Waste Streams: The most stringent requirements for eligibility apply to biomass recovered from mixed waste streams. These facilities must demonstrate that all feedstocks which are not source separated come from permitted solid waste facilities in compliance with all NYSDEC standards for operation (or an equivalent set of state standards for solid waste management). The facility must have a regular independent monitoring program that pays for NYSDEC (or approved third-party[6]) monitors to ensure that its biomass processing is consistently within facility permits and conditions. In addition, these facilities are required to employ sorting techniques that recover the biomass fraction of mixed waste, and must use a feedstock conversion process prior to energy conversion. They are subject to the same requirements that apply to facilities using source-separated adulterated biomass, described above, and also subject to the comparative emissions testing described in the next section.

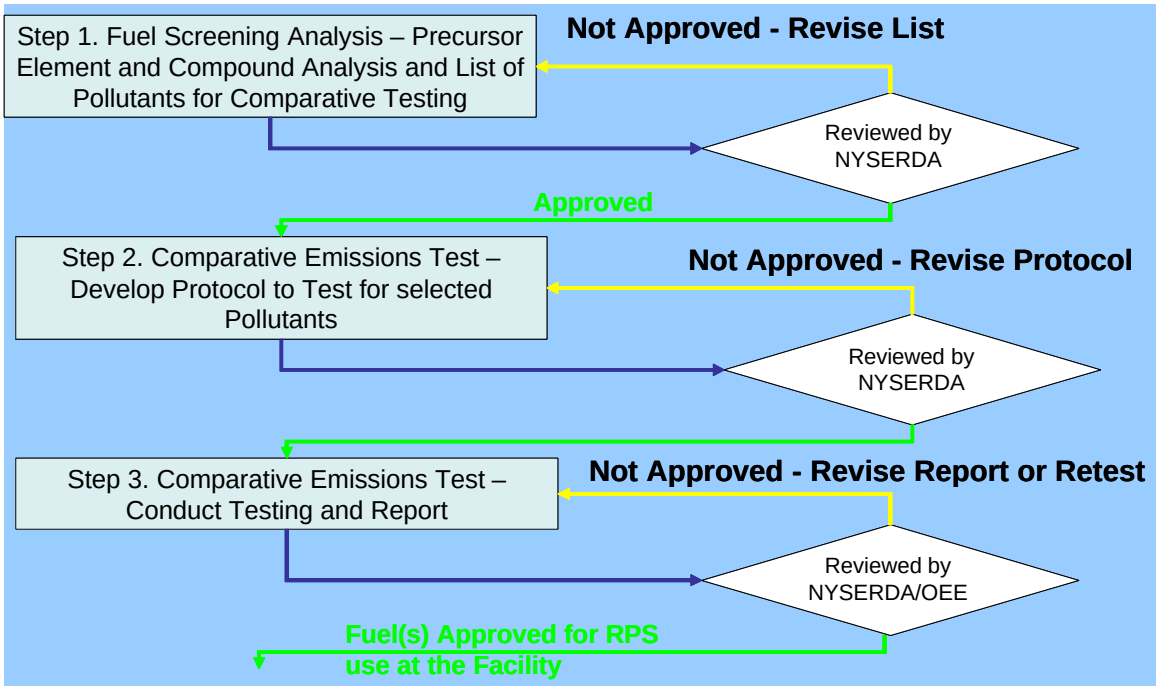
[5] Methanol is an ingredient in esterification and not a product.

[6] Projects located out of state will be required to meet the same standard, but these projects will necessarily rely on monitoring services provided by an approved third party monitor.

REQUIREMENTS FOR FACILITIES USING ADULTERATED BIOMASS

Within the RPS program the use of advanced power generation technologies to convert adulterated biomass will be allowed in certain circumstances (EXHIBIT 3), if it can be demonstrated that the technology employed would produce power with emissions less than or equal to emissions produced while using only unadulterated feedstocks. In this Guide we use the term "comparative emissions testing and analysis." To demonstrate compliance the following procedure must be followed:

EXHIBIT 3: Process for Qualifying Adulterated Biomass



Step 1 Screening Analysis

The facility must submit ultimate and proximate fuel analyses plus a compound and element specific analysis of the alternative fuel. Application to NYSERDA should include a copy of the air permit, listing fuels which the facility is permitted to convert.

At a minimum, the pollutants to be evaluated are those for which the facility was required to test in permitting, plus pollutants listed in the Great Lakes States Air Permitting Agreement, 1988, which is incorporated into NYSDEC Guidelines for the Control of Toxic Ambient Air Contaminants (DAR 1). An excerpt from DAR-1 listing the current pollutants of concern is provided in EXHIBIT 4. In addition, any air toxics that were required to be tested for the facility air permits will be automatically added to the list to be screened for comparative testing. To determine the environmental testing which will be required, the chemical analysis for screening must include the components of the fuel that, under the combustion conditions present in the proposed biomass facility, could produce any of the seven pollutants listed. For

purposes of this methodology they will be called "precursor" compounds and elements. They include: lead, aromatics, chlorine and mercury. A definitive list of precursor compounds and elements will be developed for the RPS program and will be available upon request to any facility planning to implement this procedure. If any of these "precursor" elements or compounds is found in greater concentration than in the unadulterated biomass, then comparative emissions tests must be performed. Comparative emission testing requires that emissions for both the unadulterated fuels and the adulterated fuel be measured and the results compared. The facility will submit to NYSERDA the results of the compound analysis accompanied by a proposed list of pollutants to be measured. NYSERDA will review and then either recommend approval of the report and pollutant list to OEE or return the report to the facility with a list of deficiencies noted. The facility may choose to resubmit a revised analysis and list or withdraw the application.

EXHIBIT 4: Targeted Pollutants

- The seven contaminants listed are targeted for stringent control by an interstate compact amongst the governors of the states surrounding the Great Lakes:
  - Alkylated Lead Compounds
  - Benzo-a-pyrene
  - Hexachlorobenzene
  - Mercury
  - 2,3,7,8 -Tetrachlorodibenzo-p-dioxin
  - 2,3,7,8 -Tetrachlorodibenzofuran
  - Total Polychlorinated Biphenyl
- All sources of these contaminants within the Great Lakes watershed shall be assigned an "A" Environmental Rating; all sources of these contaminants are required to be equipped with "Best Available Control Technology" (BACT).

Step 2 Test Protocol Development

Based on the prescribed list of pollutants to be tested, the facility will develop a test plan for comparative emissions measurement. Wherever available the protocol will use EPA- and DEC-approved test methods. Minimum requirements for the plan are listed in EXHIBIT 5. A protocol for measuring each pollutant must be provided. The facility owner's test plan is required to specifically address the issue of fuel variability so that the full range of permitted fuel compositions is evaluated. Developers who properly structure the air permit testing to include a full range of fuels (which necessarily requires collecting data on criteria pollutants and dealing with other air toxics) will go a long way in collecting the data needed to address the additional requirement imposed for the RPS. Sufficient repetitions should be included to permit a statistical analysis for certain pollutants that are not easily measured (i.e., expected emission quantities are near detection limits or measurement techniques are sensitive to a variety of test conditions). The facility will submit the proposed test plan to NYSERDA with the approved list of pollutants to be measured. NYSERDA will review the plan and then either recommend approval to OEE or return it to the facility with a list of deficiencies noted. The facility may choose to resubmit a revised plan or withdraw the application.

EXHIBIT 5: Test Plan Requirements

- Identify facility, owner, permits
- Provide approved pollutant list for testing
- For each pollutant describe the protocol to be used in testing identifying the full test procedure by citation
- Identify the Contractors and laboratories who will conduct each aspect of testing and chemical analysis
- Provide Schedule for testing

Step 3 Comparative Emissions Testing and Analysis

The facility must make all arrangements to conduct the comparative emissions test. NYSERDA may send a test monitor (either contractor or other state agency) to observe the tests and report any deviations from the test plan. A full report including statistical analysis, as required for measurement of certain pollutants, must be submitted to NYSERDA. No statistical analysis is required for the pollutants that are measured and are consistently under the unadulterated biomass emission levels. Pollutants that are measured and are consistently greater than the unadulterated biomass emission levels will be deemed in excess of the RPS program emissions standard. When pollutant measurements for adulterated biomass fall both below and above the levels for unadulterated biomass, an analysis for statistical significance will be necessary. That analysis will be conducted by a qualified consultant selected from a list maintained by NYSERDA and paid for by the facility.

NYSERDA will review the report. Upon completion of the review, NYSERDA and OEE have three choices:

- Approve the fuels that meet the standard for use at the facility for RPS program eligible generation;
- Return the report to the facility with a list of deficiencies noted requiring a revised analysis; or
- Return the report to the facility with a list of deficiencies noted requiring a retest for certain pollutants for which results were inconclusive or for which a deviation from the test plan occurred during the test that voided the test results.

For the latter two cases the facility may choose to submit a revised report, conducting a retest if required or withdraw the application.

3. BIOMASS HARVESTED FROM FOREST RESOURCES

New York State has an abundant supply of wood that can be used to help achieve the RPS program targets. There are over 15.4 million acres of timberland in the state and the annual growth rate on this land is three times greater than what is currently being harvested. Biomass harvested from timberland that is used to meet the targets of the RPS program is defined in the Order as either "Harvested Wood" or "Silvicultural Waste Wood." Mechanisms have been set up as part of the RPS program to ensure that the biomass in these categories is managed so that it provides a sustainable feedstock. This portion of the Guide outlines the procedures required to use this biomass as part of the plant's RPS program eligible fuel supply. This includes providing a framework for developing forest management and harvest plans.

The Order states that biomass facility owners must have and be in compliance with an approved forest management plan (FMP) to make use of biomass that fits under the definitions of "Harvested Wood" and/or "Silvicultural Waste Wood." The FMP should address the overall management goals and performance standards that need to be used during the procurement of the biomass resource for the facility. The FMP plan is required to include: standards and guidelines for sustainable forest management and requires the adherence to management practices that conserve biological diversity, productive forest capacity, and promote forest ecosystem health. The FMP must be completed by a professional forester and approved by the Department of Public Service. The pathways for approval are outlined in EXHIBIT 6.

The approved FMP needs to be provided to each of the biomass suppliers for the biomass facility. Suppliers need to be in compliance with the FMP for the facility or the customers of their biomass fuel but they are not required to have their own forest management plan. However, suppliers are required to prepare harvest plans for each parcel where harvested biomass is supplied to an RPS program eligible generator. This requirement should be clearly stated in the FMP.

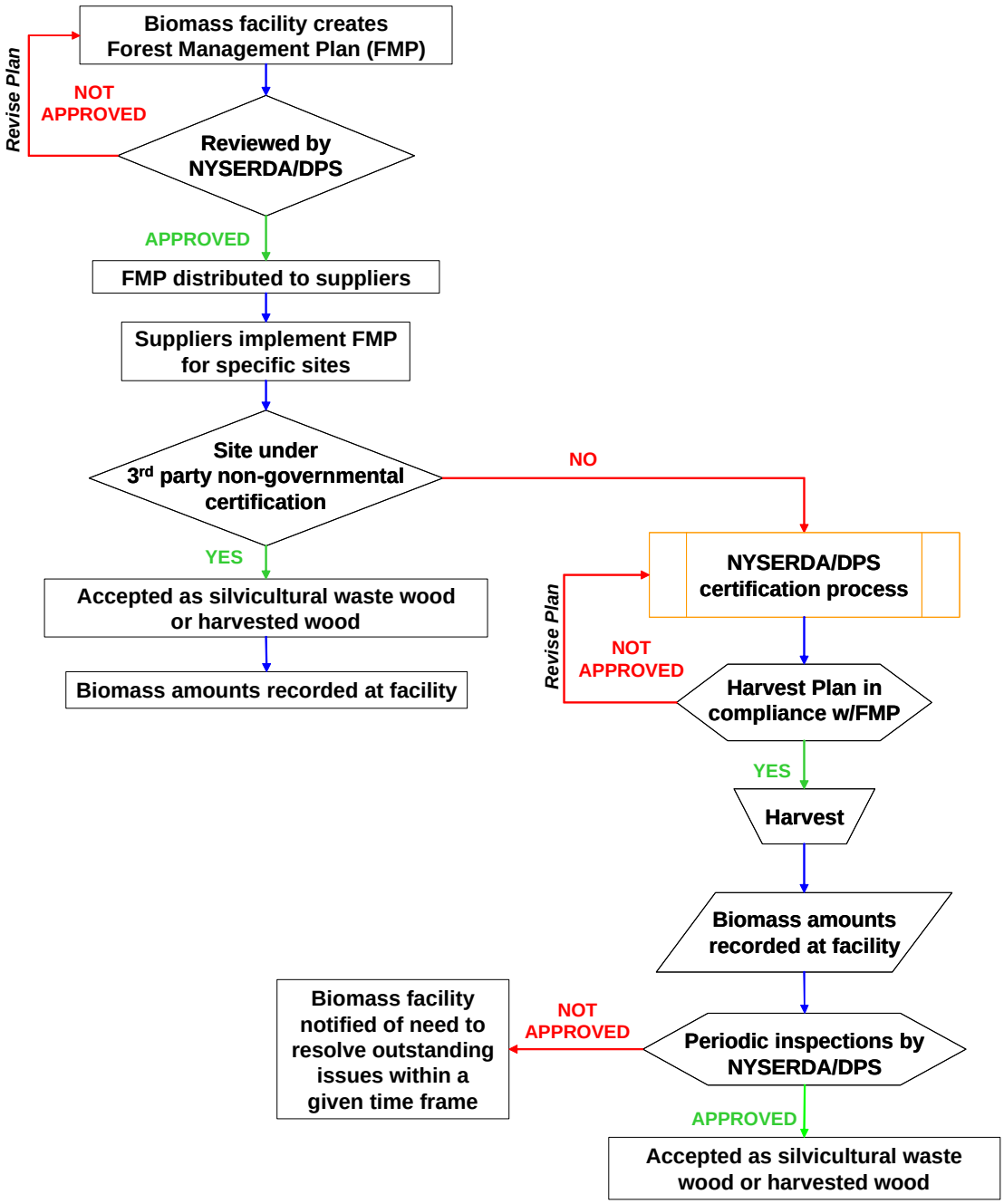
Once a FMP has been approved, there are two processes that can be used to ensure that harvest operations conform to the FMP and harvest plans: 1) the non-governmental certification process, and 2) the state approval process.

NON-GOVERNMENTAL CERTIFICATION PROCESSES

Three non-governmental forest certification bodies, Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), and Tree Farm[7] are recognized under the RPS program. NYSERDA will accept certification of harvest compliance, under an approved FMP, from any of these three bodies. Certified parcels will be available for monitoring and inspection according to the policies of the certification body. The harvest plan template provided below clarifies what information is required for parcels certified by one of the three non-governmental certification bodies.

[7] SFI www.afandpa.org/Content/NavigationMenu/Environment_and_Recycling/SFI/SFI.htm
FSC www.fscus.org/ Tree Farm www.treefarmsystem.org/

EXHIBIT 6: Pathways for Approval of Harvested / Silvicultural Wood



State Approval Process

The second mechanism is the state approval process. Under this process the harvest plan needs to include landowner objectives; a map of the area to be harvested; skid road layout; locations of all streams, wetlands and water bodies; forest type designation, anticipated volume of wood to be harvested; silvicultural techniques and best management practices to be implemented. As part of this process, provisions need to made by the biomass facility owners so that the biomass facility forester can meet with DPS staff, DEC personnel or a qualified private consultant hired by the state at least once a year to conduct on-site inspections of active or recently completed harvesting operations to ensure that they are in compliance with the FMP and harvest plans.

FOREST MANAGEMENT PLAN GUIDE

Provided below is a section-by-section guide for the development of a forest management plan as described in the Order, and a template for the harvest plan.

Section 1 - Introduction

In this section the owner and operators of the biomass facility should be identified. Basic information describing the facility should be summarized including the production capacity of the facility, location of the power plant, anticipated sources and amounts of fuel that will be used at the facility.

The FMP should state that the biomass facility's goal is to acquire fuels using sustainable forest management practices and guidelines and make use of management practices that conserve biological diversity, productive forest capacity and promote forest ecosystem health. Additional goals and objectives that are important for the biomass facility can be included in this section.

Section 2 - Procurement Policy: Harvest Wood & Silvicultural Waste Wood

This section of the FMP should state that suppliers of the fuel would be required to have a copy of the FMP, be in compliance with its principles, and develop and submit a harvest plan for all parcels where biomass is harvested for use at the biomass facility. The contents of the final harvest plan developed by the biomass facility should be summarized in this section. A copy of the harvesting plan template that will be used by the suppliers should be included in the FMP.

The contents of the harvest plan will vary depending on whether the land to be harvested is certified by FSC, SFI or Tree Farm. For land that is not certified by one of these non-government organizations, the harvest plan needs to include as a minimum the items listed in the Order including: landowner objectives; a map of the area to be harvested; skid road layout; locations of all streams, wetlands and water bodies; forest type designation, anticipated volume of wood to be harvested; silvicultural techniques and best management practices to be implemented. The FMP should state that when biomass is acquired from land that is certified by FSC, SFI or Tree Farm using an independent third party mechanism, the harvest plan will identify the certification organization and certification number. The harvest plan template, included in Appendix A, can be used for either situation.

The FMP should state that provisions will be made for the monitoring and periodic inspections of harvesting operations by state authorities or approved non-

governmental forest certification bodies to ensure that harvest operations conform to the FMP standards. Harvest plans for the biomass that has been supplied should be maintained by the biomass facility to facilitate periodic inspections.

The FMP should note that development of specific silvicultural guidelines for each parcel to achieve the management goals of the FMP and the landowners will require the professional judgment of the participating forester and recognized guides. The FMP should list the guidelines and standards that will be used to guide the management of forestland where biomass is harvested for the facility. While good forest management practices follow general principles, guidelines are often specific for a given region or forest type. The ones that are applicable for the region where the facility will source its fuel should be listed in the FMP. A listing of recommended guidelines is provided below:

- New York State Forestry Best Management Practices for Water Quality. BMP Field Guide. 2000.
- Leak, W.B., D.S. Solomon and P.S. DeBald. 1987. Silvicultural Guide for Northern Harwood Types in the Northeast (revised). U.S. For. Serv. Res. Pap. NE-603.
- Marquis, D.A., R.L. Ernst, and S.L. Stout. 1992. Prescribing silvicultural treatments in hardwood stands of the Alleghenies (Revised). U.S. For. Serv. Gen Tech. Rep. NE-96.
- Frank, R.M. and J.C. Bjorkbom. 1973. A silvicultural guide for spruce-fir in the northeast. U.S. For. Serv. Gen Tech. Rep. NE-6.
- Lancaster, K.F.; W.B. Leak. 1978. A silvicultural guide for white pine in the northeast. U.S. For. Serv. Gen. Tech. Rep. NE-41
- Chunko, S.E. (Compiler). 2001. Best Management Practices for Pennsylvania Forests. The Pennsylvania State University.
- The New Hampshire Forest Sustainability Standards Team. 1997. Good Forestry in the Granite State. Society for the Protection of New Hampshire Forests.

The FMP should state that suppliers will comply with all applicable federal, state and local laws, ordinances and regulations. The steps that will be taken by the biomass facility if the suppliers are not in compliance with these items or others aspects of the FMP should be summarized.

Section 3 - Potential Ecological Impacts

The FMP should list the general measures that will be taken to minimize the ecological impact of harvesting on water quality, wildlife, aesthetics and recreation. These measures should be applicable across a wide range of sites. Since each site is unique, the potential impacts and actions to minimize the impact should be listed on the harvest plan.

4. MULTI-FUEL POWER GENERATION TECHNOLOGIES

Multi-fuel power generation systems are subject to power production measurement and accounting rules that are designed to ensure that only the renewable portion of power generation is purchased under the RPS program procurements. In principle, this requires accurate accounting of the renewable or green portion of the power production at the plant based on the following:

1. An accurate measurement and accounting of the RPS program eligible fuel source's heat input to the conversion device; and
2. An apportionment of total electricity generation based on the fraction of the total conversion device heat input provided by the RPS program eligible fuel source.

Most power generating plants use control systems that measure and log data important to operations, regulatory compliance, and electricity sales. The measured and logged data includes both fuel flow rates and net power output of the plant generator. Coupled with chemical composition data of the fuel, this data is sufficient to describe the total energy input and output of a power generation cycle.

Tracking the relative heat contributions of multi-fuel systems requires some additional complexity. These guidelines offer several approaches including options for solid, gaseous and liquid fuel firing scenarios. In general, all of the methods primarily rely on accurate record keeping of biomass eligible fuel use, and sampling and characterization of a few key fuel properties. Other plant operational data is used to ensure practical and accurate renewable generation accounting.

EXHIBIT 7: Cofiring Principle

The amount of renewable generation from the plant (or generation unit) is proportional to the amount of input energy provided by the renewable fuel to that generation unit.

Although some details must be addressed in the context of each specific fuel type, the underlying principle for calculating the renewable fraction of the total electricity generated at a cofiring facility is listed in EXHIBIT 7.

In other words, if 10% of the heat input (energy or BTUs) to a boiler/generator is provided by the RPS program eligible biomass fuel (over the same time period), then 10% of the total net electricity generated can be designated as renewable or green power.

SOLID FUEL BIOMASS COFIRING SYSTEMS

Solid fuel biomass cofiring systems can generally be described as either blended fuel feed systems (the fossil fuel, typically coal, and the biomass are blended prior to injection into the boiler) or separate injection systems (biomass is injected through dedicated burners separately from the fossil fuel). The guidelines presented below are applicable to both applications, but measurement points will differ for the two systems.

Recognizing that the total heat input to the generating unit will be derived from multiple fuels, the cofiring percentage is generically calculated as expressed in the following equations:

Equation 1

$$\text{Cofiring Percentage} = [\text{Heat-Input}_{biomass} / \text{Heat-Input}_{total}]; \text{ where}$$

$$\text{Heat Input}_{total} = (\text{Heat-Input}_{Biomass} + \text{Heat-Input}_{Fossil})$$
$$\text{Heat Input}_{Biomass} = (\text{HHV}_{Biomass} * \text{Mass Flow Rate})$$
$$\text{Heat Input}_{Fossil} = (\text{HHV}_{Biomass} * \text{Mass Flow Rate});$$
$$\text{Where, HHV} = \text{High Heating Value (Btu/lb)}$$

Similarly the cofiring percentage can be used to apportion the total generation as follows:

Equation 2

$$\text{Generation}_{Renewable} = \text{Generation}_{Total} * \text{Cofiring Percentage};$$

Where the cofiring percentage is calculated as an average across the same time frame as the total generation component.

Appendix B provides a guide of acceptable methods for calculating the cofiring percentage and consequently apportioning the total generation as *Renewable* and *Non-Renewable*.

GASEOUS AND LIQUID BIOMASS FUEL COFIRING

In general, the concepts and principles outlined for solid fuel cofiring also apply to gaseous fuels. For the purposes of this document, biomass-derived gaseous fuels include the following:

- Landfill Gas (LFG) or Renewable Pipeline Gas (RPG)[8]
- Biomass syngas derived from pyrolysis or gasification processes
- Gas generated by anaerobic digesters

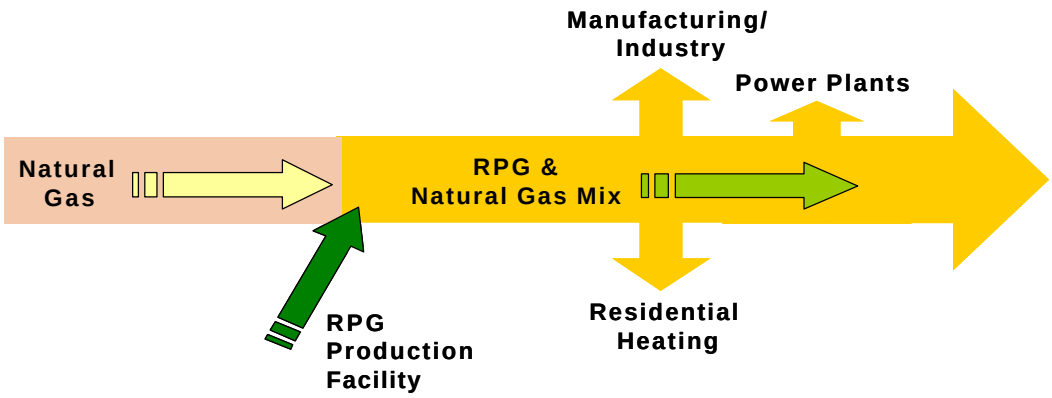
Generally, the treatment of gaseous fuel cofiring follows the rules outlined above. Appendix B provides a guide to acceptable methods for calculating the cofiring percentage and consequently apportioning the total generation as *Renewable* and *Non-Renewable*. However, fungible products can be practically derived from at least one of these gaseous sources - there is the potential to use natural gas pipelines as common carriers and pipe RPG to power generation facilities. For this reason, this section includes additional details concerning cofiring gaseous fuels via common carrier pipelines.

[8] Renewable Pipeline Gas (RPG) will refer to pipeline quality gas derived from upgrading landfill gas resources. In contrast, Landfill Gas (LFG) refers to landfill gas treated to remove contaminants harmful to conversion or use, but not upgraded to pipeline quality.

Conversion of Common Carrier Pipeline Gas

The use of common carriers (natural gas pipelines) to transport RPG for subsequent conversion is a special case for gaseous cofiring. In this special circumstance certain issues associated with the variable chemical composition of biomass fuels are alleviated. Use of a common carrier requires that biomass derived fuels meet the same rigid gas compositional requirements as the rest of the gas being transported through the pipeline. Most notably, this means that the heating value of the fuel will meet very narrow tolerances. Additionally, to use a common carrier for transport, the gas pipeline owner will also impose very strict metering requirements. Therefore, measuring the potential heat input rate of RPG into a project can be readily accomplished using standard heating values for pipeline gas and regular meter readings associated with the injection volumes. Given that the model for contracting for the use of this gas is likely to follow industry standards, sufficient information should be available to verify that contracted volumes (and associated heating value) were delivered.

EXHIBIT 9: Common Carrier Illustration



In a technical sense, every user downstream of a RPG production/injection facility is using a blended fuel and relative to a total pipeline volume, the RPG volumes are likely to be very small. In a physical sense a power generation facility is always using a blend of renewable and natural gas with natural gas being the primary component. The intent of the RPS program will be met by counting the full value of new RPG contracts based on new RPG resources and entered into specifically for the purpose of RPS participation by the power generation facility as new renewable generation. New RPG resources include new RPG production sites, expanded collection and processing systems at existing sites. In all cases, the physical production of new RPG (either through new development or expansion) must be equal or greater to the volumes contracted by the generator. At facilities that already collect and flare the gas adding new facilities to clean and upgrade the gas to pipeline quality will also be treated as new resources.

Based on discussions and information collected during the development of this Guide, the following guidelines have been established for calculating qualified RPS program generation at facilities using RPG:

1. Common carrier RPG resources will be considered eligible only if sourced and used in the same state to generate power delivered to New York.

2. Sufficient metering is in place at the landfill collection/processing facility or other RPG production facility to allow accurate accounting of gas produced, collected, upgraded and injected as RPG into the common carrier;
3. The generator must keep and provide sufficient records on physical delivery from common carrier, gas consumption, and gas quality to pro rate the facilities monthly electrical generation based on the ratio of the total RPG contract gas energy and the total gas energy used.
4. To be RPS eligible, contracts for RPG transported over common carrier must be new contracts. The buyer must notify the gas producer as part of the new RPG contract or modification that the gas contract is being purchased for conversion to RPS eligible power and is subject to the accounting rules of the RPS program. The RPG producer must certify that the gas delivered under contract is produced from new resources, i.e. new or expanded RPG production systems.

Appendix B provides a guide of acceptable methods for calculating the cofiring percentage and consequently apportioning the total generation as *Renewable* and *Non-Renewable*.

Liquid Fuel Cofiring

Although the technical and economic feasibility of this option has not been commercially demonstrated, cofiring liquid biofuels in boilers, combustion turbines, or reciprocating engines is possible. Renewable-based fuels such as ethanol and biodiesel are being primarily viewed as transportation fuels, but as the production costs of these fuels decline, they may become a source of renewable fuel for power generation as well.

Guidance for using these fuels in cofiring operations parallel what has previously been described for solid and gaseous fuels. Project developers should review the suggested approaches and, to the extent that these techniques are applicable, consider these as the preferred approaches in calculating their potential renewable power generation. If special circumstances exist within their project, they should seek additional guidance.

5. INCREMENTAL CAPACITY ADDITIONS

Many developers are considering options that will increase biomass power output at existing power plants. In some cases, these expansions may be as a result of retrofitting with new, more efficient technologies that will be accompanied by incremental gains in output (repowering). In others, the expansion may simply be a function of adding new processing equipment to increase biomass conversion rates. An example of the latter would be adding more equipment to increase a plant's biomass cofiring capacity.

Projects seeking to increase renewable capacity at an existing site should use the following guidelines in calculating the "new renewable generation component" of their output. Two different methodologies are presented: 1) Facilities increasing biomass power generation by more fully utilizing existing biomass power generation capacity and 2) facilities making substantial investments to increase renewable biomass capacity. Although designed for different situations biomass power generators have the option to choose between the methodologies offered depending on their particular circumstances.

OPTIONS FOR CALCULATING INCREASED GENERATION/CAPACITY

This Guide provides for two mechanisms for generation facilities to determine their incremental renewable generation. It will be up to project developers to choose the approach they will use and provide supporting documentation to NYSERDA at the time of their application to the RPS program.

Option 1: Incremental Generation above the Average Baseline

For facilities that plan to more fully utilize existing renewable biomass capacity, the increase in biomass power generation will be calculated on an energy basis with the baseline generation calculated using prior year energy production. For purposes of determining a baseline, only RPS eligible biomass fuels are included in the baseline calculation. In addition, a requirement to track the amount of ineligible fuels consumed will be imposed on projects that wish to continue to use such fuels. Details for calculating the baseline generation, averaging period, and incremental generation are provided below:

RPS Program Generation = Total Renewable Generation – Baseline Renewable Generation

Averaging Period – The averaging period for calculating the baseline will require facilities to provide the monthly production figures for the five most recent years prior to January 1, 2003.

Baseline Biomass Generation – The baseline will be calculated by averaging the renewable generation (kWh) from eligible biomass fuels for the plant during the two highest years during the averaging period.

Baseline Biomass Fuel Use – The amount (in tons) of eligible biomass fuels used to generate power during the averaging period.

RPS Program Generation – RPS program generation (the incremental renewable generation above the baseline) will be calculated by subtracting the Baseline Biomass Generation from the plant's renewable generation output while participating in the RPS program. In order to ensure the project's benefit, periodic true-ups may be performed to ensure RPS program premium payments result in a net annual increase in eligible renewable generation.

Independent Analysis Report: Facilities will provide an audit report endorsed by independent CPA or professional engineer of its baseline analysis. The analysis report must be supported by a listing of facility biomass fuel purchases identifying the vendor/source, physical description of the fuel, quantity, energy content, RPS fuel eligibility status, date of delivery, approximate period of use, conversion efficiency and energy produced (in MWH).

An additional requirement is placed on projects with biomass power generation that includes conversion of any biomass fuels ineligible for the RPS. Only the net energy content[9] of eligible biomass fuels will be counted in the calculations of the ***Baseline Biomass Fuel Use*** and ***RPS Program Generation*** defined above. These projects will be required to account for the use of all fuels (by type, tonnage, and net energy content). Projects will be required to maintain and provide records sufficient to demonstrate that the facility is in compliance with this requirement, including an annual tally of the type and amounts of biomass fuels used. Periodic true-ups, as described above, will be performed to ensure RPS program premium payments result in a net annual increase in eligible renewable generation. *At a minimum the biomass fuel data requirements for facilities using both eligible and ineligible fuels include the source, weight and fuel composition for each delivery.*

Option 2: Incremental Capacity above Baseline

Facilities making a substantial investment in new processing or conversion equipment may find it advantageous to calculate their incremental capacity in an alternative manner. For this option, renewable generation output from the plant will be determined by the capacity ratio[10]:

RPS Capacity Ratio: The ratio of the incremental renewable generation capacity to the total renewable generation capacity at the plant; where the total renewable generation capacity is defined as the sum of the average baseline capacity plus the incremental renewable capacity.

> *Total Renewable Generation* – defined as the Baseline Renewable Generation Capacity plus the Incremental (New) capacity added through investment. This value will be expressed in megawatts (MW).
>
> *Baseline Renewable Generation Capacity* - Baseline Capacity will be determined and documented by either the nameplate capacity of the biomass generation equipment or operational tests conducted at full load measuring the biomass generation capacity. This value is expressed in MW.

[9] Based on the Lower Heating Value of the fuel to ensure proper weight is given to fuel ratios based on actual energy converted to electricity.

[10] In multifuel operations where the predominant fuels are non-renewable the baseline and incremental capacity calculations are based solely on the equipment and power production associated with the biomass fuels.

RPS Program Generation Capacity – This figure is nameplate renewable generation capacity of new assets or respectively calculated value of the new biomass capacity addition based on operational testing at full load. This is also expressed in MWs.

Therefore, the RPS Capacity Ratio = Incremental Renewable Generation / (Total Renewable Generation). This ratio will then be applied to all renewable energy generated (in MWh) from the facility to calculate the incremental generation eligible under the RPS program so that a facility always receives credit in proportion to the new renewable capacity.

RPS Capacity Investment: The incremental investment must be properly documented and may only include costs directly associated with the engineering and installation of the new equipment.

Independent Analysis Report: Facilities will provide an audit report endorsed by an independent CPA or professional engineer of its baseline and incremental capacity analysis. The analysis to establish the baseline and incremental capacity must be supported by documentation of either the nameplate capacity or operational tests at full load capacity of the biomass power generated before and after plant modification or upgrade to increase biomass generation capacity. The report must also document the investment in renewable plant equipment for the modification or upgrade.

An additional requirement is placed on projects with baseline generation that includes conversion of any biomass fuels ineligible for the RPS. Specifically, in any given month, the ratio of eligible to ineligible generation (i.e. electricity generated using eligible and ineligible fuels) must be greater than or equal to either of the ratios defined under Option 2. This provision ensures that attributes purchased under the RPS are derived solely from eligible fuels. Projects will be required to maintain and provide records sufficient to demonstrate that the facility is in compliance with this requirement, including an annual tally of the type and amounts of biomass fuels used. Periodic true-ups may be performed to ensure RPS program premium payments result in a net annual increase in eligible renewable generation.

6 VALIDATION/VERIFICATION PROCEDURES

Throughout this document, validation and verification procedures have been described in context of the nuances associated with various technology/feedstock combinations. The exact agencies, timing, and ongoing audit requirements for ensuring RPS program compliance will be included in the renewable attribute purchase contracts. For biomass projects, these are likely to vary somewhat from project to project. However, a few additional general comments are offered below:

1. A substantial portion of planned and future validation/verification processes will be based on documentation kept by project operators. Failure to keep adequate records such as fuel receipts, fuel supplier contact information and source information, fuel flow data, maintenance records, or any other information that is required to ensure compliance with RPS program related contracts may impact a project's ongoing eligibility.
2. Similarly, fuel end-users are ultimately responsible for ensuring that their fuel supplies are in compliance with the RPS program eligibility rules.
3. Since the renewable generation of cofiring projects is a calculated valued based on other data instead of a metered quantity as it is in single fuel biomass plants, operators of these plants have a special burden to maintain adequate records.

Lastly, as stated in the opening section of this document, the RPS program will be willing to consider variances from the protocols described in this document. However, adherence to the guidance will streamline contracting processes. Developers seeking a variance from these guidelines should expect a thorough review and some delay as petitions will be carefully weighed for their impact on existing and future projects.

APPENDIX A: HARVEST PLAN TEMPLATE

The Harvest Plan Template provided on the next page, when properly completed, provides all the information required by the RPS program. The biomass facility should include a copy of the final version of their harvest plan template in the FMP.

HARVEST PLAN TEMPLATE

Landowner Information		
Landowner:		
Address:		
City/Town:	State:	Zip Code:
Phone:		

Total Property Acreage: _____

Acreage of Area to be Harvested: _____

Total Estimated Volume of Harvest: _____

Proposed Harvester: _____

Proposed Harvest Date: _____ through _____

Harvest Plan Prepared by: _____

Phone: _____

Date Prepared: _____

Is this property certified under an approved non-governmental certification program?

Yes No

If yes, identify which program and record certification number.

If no, continue to second page and complete harvest plan.

Forest Stewardship Council, Certification # _____

Sustainable Forestry Initiative, Certification # _____

Tree Farm, Certification # _____

A map that shows areas to be harvested, topography, skid road layout, locations of all streams wetlands and water bodies and forest type designation is attached.

Landowner's Objectives for the Property:

_____
_____
_____
_____
_____
_____

Potential Impact from Harvesting on the Ecology of the Site:
(Summary for entire site and actions to minimize the impact should be noted)

Water Quality:

_____
_____
_____
_____

Wildlife:

_____
_____
_____
_____

Aesthetics:

_____
_____
_____
_____

Recreation:

_____
_____
_____
_____

Note: A parcel owned by a single landowner may have several forest stands that require different management prescriptions. Information for each stand where biomass will be harvested should be recorded separately.

Stand Number: _____ Forest Type:

_____

Size (acres): _____ Age Distribution:

_____

Size Class[1]: _____

Dominant Species[2]:

_____

_____

General Vigor:

_____

_____

Insect/Disease Problems:

_____

_____

Harvest History:

_____

_____

Average Basal Area: _____ Average Number Trees/acre: _____

Relative Stocking: _____

Estimated Volume to Harvest: _____

Harvest Objective:

_____

_____

_____

Type of Harvest:

_____

_____

Silvicultural Techniques to be Used:

_____

_____

_____

Best Management Practices (BMPs) to be Implemented:

_____
_____
_____
_____
_____

[1] Size Class Legend	
SS	Seedling/sapling (1-5" DBH)
SP	Small pole (6 – 8" DBH)
LP	Large pole (9 – 11" DBH)
SST	Small Saw Timber (12- 14" DBH)
MST	Medium Saw Timber (15 – 17" DBH)
LST	Large Saw Timber (17+" DBH)
ST	Saw Timber (12 – 17+' DBH)

[2] Tree Species Codes			
Hardwoods		Softwoods	
AS	Aspen	BF	Balsam fir
BA	Basswood	BS	Black spruce
BE	Beech	ERC	Eastern red cedar
BC	Black cherry	HE	Hemlock
BO	Black oak	JP	Jack pine
BW	Black walnut	LA	Larch
BO	Bur oak	NWC	Northern white cedar
CO	Chestnut Oak	NS	Norway spruce
D	Dogwood	OS	Other softwoods
EL	Elm	PP	Pitch pine
HM	Hard maple/sugar maple	RP	Red pine
HA	Hawthorn	RS	Red spruce
HI	Hickory	SP	Scotch pine
OH	Other hardwoods	TK	Tamarack
PB	Paper birch	WP	White pine
RM	Red maple	WS	White spruce
RO	Red oak		
SBHI	Shagbark hickory		
SVM	Silver maple		
SB	Sweet birch		
WA	White ash		
WO	White Oak		
YB	Yellow birch		
YP	Yellow poplar		

APPENDIX B: COFIRING CALCULATIONS

SOLID FUELED COFIRING CALCULATIONS OF RENEWABLE GENERATION

Two measurements are required to calculate the total heat input of solid biomass into the energy conversion system over time: 1) the mass flow of biomass and 2) the energy content per unit mass. Multiplying these data will provide total biomass heat energy flows. For example:

*5 tons per hour of biomass * 12 million BTUs (MMBtu) per ton = 60 MMBtu per hour*

Given that this calculation is multiplicative, preserving measurement accuracy for the heating value and flow rate of the biomass is imperative. Additionally, the calculation shown above has been conducted on an hourly basis. These calculations can be conducted over a longer time period, but at a maximum, heat input accounting will be required on a daily basis.

Biomass Mass Flow Measurements

Regardless of the type of system, tracking the mass flow of biomass fuel into the boiler(s) is a critical component of accounting for the relative contribution of the renewable resource to the unit(s) output. Therefore, the biomass feed system must be designed to meter biomass fuel flows accurately. Acceptable strategies include:

1. The use of differential weighing devices such as loss-in-weight feeders or weigh hoppers properly equipped with devices to track changes in weight over time. These devices can be an accurate and reliable means of measuring biomass fuel flow. If a single vessel-batch type system is employed, provisions must be made to maintain accurate flow measurements during refill periods. In addition, handling or fuel injection systems that employ less sophisticated weighing processes (truck scales or scoop scales) may be used provided that such systems are accompanied by detailed records of when each batch was weighed and introduced into the system for firing. In all cases, evidence from field calibration tests and/or manufacturer data for handling biomass materials such as those used on-site for fuel will be required to demonstrate that a high degree of accuracy can be maintained throughout the duty cycle of the equipment. Upon request, projects employing these scales must provide certification that the equipment has been installed by a qualified installer according to the manufacturer's specification and that recommended calibration and maintenance schedules are being followed in accordance with the type of material being weighed.
2. The use of belt scales (integrating weighing device) are also acceptable provided that precautions are taken to ensure continued measurement accuracy. Belt scales make continuous measurements over an extended period of time and it may be difficult to detect measurement drift or the impact that material build-up is having on the readings. External forces such as wind, changes in belt tension and physical interference may introduce measurement errors. Upon request, projects employing these scales must provide certification that the equipment has been installed by a qualified installer according to the manufacturer's specification and that recommended calibration and maintenance schedules are being followed in accordance with

the type of material being weighed. This includes, but is not limited to, routine testing for "zero" weight.

Regardless of the individual technology employed, it is imperative that projects demonstrate accurate measurement of the as-fired fuel flow rates. Plant operators employing batch technologies that rely on infrequent mass measurements upstream of the fuel injection system, must demonstrate that they know how much fuel was introduced into the boiler across a discrete time frame. For example, if a fuel conversion rate is based on fuel withdrawals from a day bin which is being filled on an as-needed basis over a 16-hour period, the project must employ additional system monitoring and operation protocols that will allow independent verification of the following:

1. All of the fuel delivered to the day bin was consumed; and
2. When biomass fuel conversion started and when it was completed (via an auditable record either through boiler plant controls or signed data log).

Ultimately, the mass flow measurement data must be recorded and converted into a fuel firing rate, such as tons/hour. Note that projects providing fuel injection measurements on a near-real-time basis are preferred, but daily accounting of total biomass fuel consumed will be considered acceptable provided the proper tracking protocols are in place. In cases where day bins may not be completely emptied in a 24-hour period, visual or non-instrument based measurements of fuel delivery rates will not be acceptable. It will be incumbent on plant operators to manage fuel processing in a manner that allows quantitative analysis of fuel flow rates over accurate time frames.

Biomass Fuel Energy Content

Accounting for the biomass fuel's heating value is an equally critical component to measuring fuel heat input. Although some real-time heating value measurement systems are entering the market, they are cost prohibitive and have a limited track record. Commonly, fuel heating values are determined via laboratory analysis of batch samples.

It is also important to recognize that fuel moisture content is the single most likely indicator of a biomass fuel's energy content. This fact is easily illustrated by comparing the "bone dry" and "as-received" heating values of different biomass fuels.

EXHIBIT 8: Heating Value Comparison

Fuel Type	As Received Moisture (Weight %)	As Received Higher Heating Value (Btu/lb)	Bone Dry Higher Heating Value (Btu/lb)
Green Wood	50.0%	4,390	8,780
Willow	10.2%	7,478`	8,330
Bark	50.0%	4,185	8,370
Refuse-Derived Fuel (RDF)	20.0%	6,450	8,063
Switchgrass	7.9%	7,370	8,000
Sawdust	52.6%	4,150	8,760

Note that despite the very different nature of the fuels above, the "bone dry" heating values are far less disparate than the differences in the "as received" heating values at the varying moisture levels. In fact, the heating value variance is directly proportional to the moisture in the fuel, so a 50% decrease in moisture content will increase a fuel's heating value by 50%. The effect is similar for ash content, however, non-RDF sources of biomass (especially woody resources[11]) tend to be relatively low in ash, and variations in heating value due to ash content tend to be less dramatic.

Given this data, the following guidelines are offered for establishing baseline heating values using complete fuel analyses and more frequent sampling and testing for fuel moisture content verification and use in ongoing heat input calculations.

Fuel Supplier/Type Baseline Chemical Analysis

Establishing a baseline fuel composition is important for several reasons. First, since project eligibility is dependent both on the combination of fuel resource and conversion technology, the chemical analyses provide documentation of fuel eligibility. Second, both proximate and ultimate fuel analyses provide heating value information, a critical parameter in calculating the total energy contribution of the renewable resource.

Projects seeking to participate in the RPS program should perform either an ultimate or proximate analysis on each type of fuel from each supplier on a semiannual basis for the purpose of documenting each fuel's dry heating value. In addition, as noted elsewhere in this document, specific chemical analyses may be required to demonstrate that the fuel is either unadulterated, or to identify potential contaminants of concern.

Any methodology that relies on infrequent and small samples extracted from large fuel flows assumes that the incoming material is relatively homogenous in chemical composition. When considering biomass fuel supplies, this is a valid assumption if the fuel is being sourced from a reliable broker/supplier with quality control measures and a contractual obligation to provide a relatively homogenous product of a particular type or blend. In addition to the chemical fuel analyses, plant operators are required to keep fuel supply contracts and other documentation on hand to demonstrate that fuels being converted at the facility are consistent with the RPS program eligibility requirements.

On-site Batch Sampling/Operations Protocol

Coupled with the more rigorous chemical property testing (outlined above) to determine each fuel's dry heating value, regular grab samples analyzed for moisture content provide a practical method for estimating the heating values of the biomass fuels on an as-fired basis. Moisture analysis can be accomplished with relatively low-cost, bench-scale equipment which is often part of the fuel laboratories located at larger power plants. Heating values for as-fired fuels can be calculated from the ultimate or proximate analysis as follows:

[11] To reiterate discussions from prior sections, solid fuel cofiring projects are limited to using unadulterated biomass resources.

Equation 3

$HHV_{AS\text{-}FIRED} = HHV_{DRY} * (1\text{-}MCW_{AS\text{-}FIRED})$; *where*

HHV = Higher Heating Value

MCW = Moisture Content Wet Basis

Grab samples from the as-fired biomass fuel stream should ideally be taken on an hourly basis[12]. However, less frequent sampling may be possible depending on the delivery method of the fuels, storage/pile management, and diversity of supply. Introduction of "like-fuels" into the system in large batches may make less frequent sampling acceptable. However, projects employing less frequent sampling will be required to demonstrate handling protocols that ensure like-fuel aggregation and sufficient records to audit their handling methodology upon request.

Calculation of Total Plant Heat Input

Another key variable in calculating the cofiring percentage is the plant's total heat input while cofiring (shown in the denominator of Equation 1.) This Guidebook contemplates two methods of determining the plant's total heat input, both of which are consistent with industry practices. However, each method's applicability is determined by the availability of a continuous emissions monitoring system (CEMS).

Facilities with CEMS or CO2 Emissions Monitors

Most large power plants are required, as a condition of their operating permits, to install and maintain CEMS. The data from these systems are used to report key power plant emissions such SO_2 and NO_X to regulatory agencies such as the EPA or state air quality organizations. However, these systems are also used to track the total heat input of fuel into the plant. This is useful in measuring the plant's overall efficiency (Plant Heat Rate) and allowing for emissions output to be converted into a rate (lb-pollutant/MMBtu.) Although these heat input calculations rely on fuel chemical characteristics, they depend on measurements of the plant's CO_2 emissions (not fuel flow rates) to determine how much fuel is being consumed. Since these systems are tied to plant environmental performance monitoring, they are also required to be regularly calibrated.

It is also possible that plants not otherwise required to maintain CEMS could install a stack CO_2 emissions monitoring system. Provided that the system and its installation meet the requirements specified for CEMS, the information collected from this type of instrumentation could be used synonymously for the CEMS CO_2 data discussed below.

In addition to being used in single-fuel plants, the underlying EPA methodology also offers guidance on multi-fuel systems. While other methodologies may offer some advantages in calculation simplicity, they do not tie all of the regulatory and plant operational data elements together, and offer less precision in measuring renewable generation.

[12] Note that the grab samples do not have to be analyzed on a real-time basis, just collected, and tagged with the time and date. Actual moisture analysis can take place all at one time within 24 hours of collection and used in downstream calculations accordingly.

Calculation mechanics for calculating total plant heat input using plant stack CO_2 emissions relies substantially on a key variable known as a fuel factor or F-Factor for short. There are different values for the F-Factor, but it is primarily dependent on a fuel's carbon content and the way in which CO_2 emissions are being measured at the plant. Assuming the plant CEMS provides CO_2 stack flow data in standard cubic feet (scf) per hour, the F-factor is determined by either (1) multiplying the percent carbon in the fuel by 321,000 and dividing by the gross calorific value of the fuel or (2) using the tabulated values set by EPA for the fuel types. To calculate the total heat input of fuel into the boiler over a given time period, the total measured CO_2 flow in the stack is divided by the F-Factor (F_c) with units of scf-CO_2 per MMBtu of fuel input.

Equation 4

$$\textit{Total Heat Input (MMBtu/hr)} = \frac{\textit{Total Measured } CO_2 \textit{ flow (scf/h)}}{F_c \textit{ (scf/MMBtu)}}$$

Note that the time frame used in the Equation 4 is based on hourly flow rates. Longer periods are acceptable provided that the guidelines for calculating the composite F-Factor for multi-fuel firing are consistent with the selected time frame. Projects calculating heat input on an hourly rate are preferred, but daily rates will be acceptable if all other data tracking required to support the calculation on this basis are accurate on a daily basis.

Tabulated F_c values for bituminous coal and wood are 1,810 and 1,840 scf per MMBtu, respectively[13]. Therefore, a cofiring application with 90% bituminous coal and 10% wood has a composite F_c value of 1,813 scf per MMBtu (see Equation 6 below). The proposed method of calculating total heat input during cofiring uses a composite value for F_c based on daily coal and biomass usage. The composite F_c will then be used to determine the total heat input using stack CO_2 flow data. If an hourly cofiring rate (heat basis) is desired, then it can be calculated using hourly biomass heat input data (collected from fuel sampling and mass flow rate data) divided by the total boiler heat input as calculated from the composite F_c-based calculation. Equations for the process are illustrated below.

Equation 5

$$\text{Coal \% Heat In} = \frac{\text{Coal HHV * Coal Flow (lb/day)}}{\text{Coal HHV * Coal Flow (lb/day) + Biomass HHV * Biomass Flow (lb/day)}}$$

; where HHV = Higher Heating Value (Btu/lb)

Equation 6

$$F_{c,}\ \text{Composite} = \text{Coal \% Heat In} * F_{c,\ coal} + \text{Biomass \% Heat In} * F_{c,\ biomass}$$

After determining these values, the total boiler heat input can be calculated using Equation 4.

[13] Procedures for Preparing Emission Factor Documents, Environmental Protection Agency, Table I. F Factors for Various Fuels, November, 1997.

Facilities without CEMS or CO2 Emission Monitors

The primary issue of universal application of the method described above is that plant CEMS are not required on older (installed prior to EPA's Acid Rain program) fossil fuel-fired boilers under 25 MW. As it would represent an unreasonable burden to impose the installation of such equipment (these systems can be expensive to install and maintain), an alternate heat input apportionment method is offered for facilities not otherwise required to have a CEMS. Although not as precise or rigorous[14], the use of fuel receipts and regular chemical composition data offers a verifiable and analytical measurement technique for determining the total boiler heat input.

Plants not equipped with CEMS or CO_2 emissions monitoring equipment must demonstrate an alternate method of measuring total heat input that accurately accounts for the combined fuel heat contribution of the biomass and fossil fuels. One acceptable procedure is to combine the biomass mass flow and heating value data with similar information collected for the fossil fuels used. In other words, regular fuel sampling of the fossil fuel portion combined with mass flow measurements across discrete time frames will provide a consistent and practical means of measuring total heat input.

For example, calculation of the total heat input to a boiler over an 8-hour period would be based on feeder weight totalizer readings, sample HHV data for the coal plus the same data for the biomass heat input. However, it will be incumbent on plant operators to demonstrate that their fossil fuel sampling and mass flow measurement protocols are accurate enough to provide a high degree of certainty that the total heat input to the boiler is being calculated. Projects without CEMS employing this methodology are strongly encourage to use steam condition and production information coupled with recent boiler efficiency data[15] to cross check results and ensure that total heat input calculations are reliable.

Equation 7

Total Heat Input = Coal HHV * Coal (lb/ (8-hours)) + Biomass HHV * Biomass (lb/ (8-hours))

[14] Biomass cofiring, particularly at high heat input levels, does have a small but measurable impact on boiler efficiency which is not captured if calculations rely on existing boiler efficiency data.

[15] There are several methods of measuring boiler efficiency data. However, this reference does not imply calculated values based on estimates of heat loss taken from original boiler commissioning data. If the heat loss method is employed, operators should provide recent supporting data provided by third-party measurements of boiler performance.

Solid Fuel Cofiring-CEMS Calculation Example

New York Boiler 1, with a current net output of 435 MW, consumes 200 tons/hr of bituminous coal and is interested in cofiring 10 tons/hr of clean wood waste. The coal and wood waste have HHV of 12,500 Btu/lb and 6,500 Btu/lb, respectively. The CO_2 stack gas flow at full load is 9,050,000 scf per hour during both co-firing and coal only operation. The calculations below show the potential renewable power generated.

%Coal Heat Input (Daily Average) $= \dfrac{12{,}500 \text{ Btu/lb} * 400{,}000 \text{ lb/hr} * 24 \text{ hr/day}}{(12{,}500 \text{ Btu/lb} * 400{,}000 \text{ lb/hr} + 6500 \text{ Btu/lb} * 20{,}000 \text{ lb/hr}) * 24 \text{ hr/day}}$

$= 0.975$ or 97.5%

$F_{c,}$ Composite $= 0.975 * 1810 + 0.025 * 1840$
$= 1811$ scf CO_2 / MMBtu

Total Heat Input (MMBtu/hr) $= 9{,}050{,}000 / 1811$
$= 4{,}997$ MMBtu/hr

Cofire % biomass $= \dfrac{6500 \text{ Btu/lb} * 20{,}000 \text{ lb/hr}}{10^6 \text{ Btu/MMBtu} * 4{,}997 \text{ MMBtu/hr}}$
$= 2.6\%$

Renewable Generation $= 2.6\% * 435$ MW
$= 11.3$ MW

GAS-FUELED DIRECT CONVERSION CALCULATIONS

The principles for calculating the biomass generation from direct cofiring in a gas-fueled plant at the landfill mirror those outlined for a solid fuel plant. The key variables for calculating the renewable generation component remain the heating value of the fuel, fuel flow rate, and total boiler heat input. However, gas fuels can be used in a wider array of conversion devices, which introduces some additional complexity.

Calculation of Biomass Heat Input

As with solid biomass fuels, the chemical composition of biomass gas fuels (LFG, biomass syngas, and gases generated from anaerobic digesters) can vary substantially. For example, gasification will yield different gas compositions based on feedstock type and design, LFG compositions will vary based on the contents of the landfill, landfill conditions, and the level of gas clean-up required prior to energy conversion. Digesters will yield different gas compositions according to the material being digested and digester conditions. However, some consistency is offered when assuming that many projects will likely be designed around a given set of circumstances and available feedstocks. Depending on the project, this may substantially dampen any gas compositional variability.

However, if a high degree of variability is encountered, it will be difficult to quantify on a real-time basis. Assessing the heating value analysis of gases requires specialty equipment and expertise that may not be economically available to project developers. Therefore, the sampling regimen suggested for solid fuel projects is likely to be prohibitively expensive.

Therefore, projects should consider project start-up and operational strategies that allow the use of initial project commissioning data, feedstock compositional data (or waste in place data), and semiannual or annual sampling tests to demonstrate that heating value of gas fuels can be consistently predicted. If stability can be demonstrated either across a variety of feedstocks or by feedstock type, several methods for estimating heat input are appropriate. If gas quality and specifically gas heating values cannot be demonstrated, project developers should be prepared to present an approach and metering technologies sufficient to take this variation into account in their calculations of the renewable energy output of their facility.

Facilities with CEMS or CO2 Emissions Monitors

Gaseous-fired facilities equipped with CEMS can use the same F-Factor-based methodology presented for the solid fuel cofiring case. Readers should refer to that section for a detailed explanation of this procedure. However, the composite F-Factor required to complete this calculation for gaseous fired projects will vary in three ways.

1. The F-Factors for the fossil-fired fuel (most likely natural gas) will be different and the F-Factor value for the biomass-derived gaseous fuel will have to be calculated (there are no tabulated F-Factors for biomass syngas-derived fuels) using EPA guidelines;
2. The exact formula for back-calculating the plant's total heat input from the composite F-Factor may be different based on differences in the way CO_2 is measured in the CEMS.
3. Biomass heat input will be based on volumetric or mass flow meters for the biomass-derived gas and estimates of the gas heating value.

As with the solid fuel cofiring case, operators of these plants will still be required to maintain sufficient records about the amounts and times when they are cofiring fuels. Similarly, hourly estimates of the cofiring rate and renewable generation output are preferred, but daily apportionment may be acceptable if gas compositional variability can be demonstrated to be minimal and repeatable either by management of like feedstock conversion or gas production conditions.

In all cases, facilities should conduct semiannual testing to verify ongoing consistency in fuel composition. More frequent testing may be required if variability is indicated.

Facilities without CEMS or CO2 Emission Monitors

In some circumstances, the application of the methodology described above may be impractical or impossible. Under such circumstances, alternatives to measuring the total plant heat input and renewable generation are offered below.

Biomass-derived gas cofiring projects that use gas generated and cleaned for on-site conversion, which also demonstrate minimal variation in the gas heating value, should use daily gas flow meter readings and natural gas flow meter readings to

calculate total heat input to the conversion device. Renewable generation can then be apportioned on a daily basis using Equations 1 & 2.

If the use of meters is impractical (high temperatures or other concerns), projects are encouraged to develop calibration curves. This method requires project prequalification testing using different fuels at different load levels. The testing protocol will require holding the fossil heat input into the conversion device steady, while progressively introducing more biomass-derived gas across the entire cofiring heat input range. Using data from multiple loads and fuels, a correlation curve can be developed to directly calculate renewable power generation from biomass heat input levels which properly accounts for changes in conversion efficiency. However, before considering this methodology, project developers should seek additional guidance and alternatives will be considered.

RPG-FUELED COFIRING CALCULATIONS OF RENEWABLE GENERATION

This is based on the full quantity of biomass-derived fuel heat input based on the RPG volumes newly contracted for the RPS. Assume the same RPG flow rates as shown above and for a 70 MW combined cycle plant with an average daily gas consumption of 13,440,000 cf/day. The contracted cofiring percentage (average daily basis) would be calculated as follows:

$$\text{Contracted Cofiring \%} = \frac{100{,}000 \text{ cf/day) * (1{,}000 Btu/cf)}}{13{,}440{,}000 \text{ cf/day * (1{,}000 Btu/cf)}} = 0.7\%$$

Using the 70MW base-loaded plant as an example, the renewable generation output calculated using these two different values is as follows:

Renewable Generation Actual = 70,000 kW * 24 hours/day * 0.1% = 1,680 kWh
Renewable Generation Contractual = 70,000 kW * 24 hours/day * 0.7% = 11,760 kWh

Additionally, unless the power plant is consuming most of the common carrier volume, the difference in the renewable generation calculation has the potential to be even more disparate.