APPENDIX C

Supporting Documentation for the Regulatory Design Assessment

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Table of Contents

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Appendix C1

Appropriateness of Megawatt-Hours as Surrogate for Greenhouse Gas Emissions

Introduction

This appendix presents the analysis for supporting the use of megawatt-hour (MWh) as the basis for compliance with the Renewable Electricity Standard (RES) as a surrogate for determining the greenhouse gas (GHG) reductions. This evaluation is based on the GHG benefits expected from RES-eligible renewable energy technologies. If the results of this analysis show that the GHG benefits are similar for most renewable technology, then MWh can be used as the basis for compliance with the RES.

Methodology

The method used to quantify the GHG benefit for each technology is more thoroughly discussed in Appendix D, where the GHG emission reduction expected from each resource or technology is fully explained. The following is an overview of the methodology used to quantify GHG benefits.

The GHG benefits is based upon three elements: 1) the "net" GHG emissions from the renewable generator technology; 2) GHG emissions from the operation of the energy technology; and 3) the GHG emissions associated with the incremental displacement of fossil fuel generation from the grid by renewable energy. The focus of this assessment is to determine the direct emissions from the renewable resource. It is not the intent to conduct a lifecycle analysis for each renewable generator technology.

The net GHG emissions is the difference between the GHG emissions from using the renewable resource in an energy technology, such as an internal combustion engine (engine) generator to generate a MWh of electricity, and GHG emissions from the typical use or disposal of the same amount of renewable resource. The net GHG emissions range from zero for some technologies that do not emit GHGs, such as small hydroelectric generation, to resources that emit GHG emissions, such as geothermal power plants that emit CO_2 that was part of the local geological features accessed by the geothermal facility. Included in this evaluation are any GHGs emitted as a result of fuel conversion (for example, converting biomass to renewable diesel) or biogas-to-energy projects that affects that affect landfill methane emissions.

For operational emissions, staff evaluated GHG emissions from material transport and operation at eligible renewable technologies. Sources included as part of a facility's operation include equipment used in maintenance and support activities. Staff determined that, except for transportation used to deliver

biomass fuel to biomass combustion plants, the GHG emissions related to transportation and operation are minor.

The major benefit from using renewable power is the displacement of power produced by burning carbon-based fuels that would otherwise be used to meet the demand on the utility grid. For this analysis, staff is using 830 lbs CO_2 equivalent (CO_2e) per MWh[1,2,3, a] as an estimate of the GHG emissions associated with the marginal power. This value is based on the marginal generation being provided by combined cycle combustion turbine (CCCT) plants 95 percent of the time and combustion turbine (CT) peaking plants 5 percent of the time.

Results and Discussion

Table C1-1, GHG Benefit Determination for Renewable Sources, provides a summary of the GHG benefits for the renewable energy technologies eligible for the RES. The GHG benefits estimated for the renewable technologies range from 530 to 1,700 lb CO_2e per MWh. The high end of the range is represented by the GHG emissions from municipal solid waste (MSW) conversion. Benefits from MSW conversion is dependent upon the amount of biological waste that can be diverted from the waste stream. The low end of the range is represented by geothermal power plants and electricity generated from biodiesel derived from a biomass feedstock. See Appendix D for a detailed discussion of the development of these GHG benefits.

By 2018, generation from geothermal, solar and wind is expected to represent 85 percent of total renewable generation, assuming that all RPS contracts approved by the California Public Utilities Commission (CPUC) are fulfilled and both the contracts signed by Publicly Owned Utilities (POUs) are fulfilled and the POU's owned generation is constructed as scheduled. The GHG benefits for these three categories range from 530 to less than 830 CO_2e per MWh. Because we cannot yet quantify the GHG emissions associated with natural gas generation used to backup variable renewable generation, the GHG benefits cannot be fully estimated for wind and solar generation. Assuming that backup generation may be needed 10 to 20 percent of the time and that CTs will provide this generation, then the GHG emissions for wind and solar would range between 650 to 740 CO_2e per MWh. Consequently, for the three major categories of renewable generation, the GHG benefits will range between 530 to 650 CO_2e per MWh, if we use the low end of the range for the wind and solar GHG benefits.

[a] CPUC recommends that the heat rate for a new CCCT is 6,917 Btu/KWh (6.9 MMBtu/MWh) and the efficiency for a new CT is 10,807 Btu/KWh (10.8 MMBtu/MWh). Based on these values, the efficiency for the CCCT is 49 percent (3412/6,917) and the CT is 32 percent. The EIA GHG emission factor for natural gas is 53.06 kg CO_2/MMBtu or 181 kg CO_2/MWh. To determine the GHG emissions for the CCCT and the CT, the heat rates for the turbine are multiplied by the GHG emission rate. For the CCCT, the GHG emissions are 366 kg CO_2/MWh (6.9 * 53), and the CT are 572 kg CO_2/MWh. The average GHG emissions, based on CCCTs operating 95 percent of the time and CTs operating 5 percent of the time, is 377 kg CO_2/MWh or 830 lb CO_2/MWh.

Conclusion

Based on a review of the three renewable generation resources that are expected to provide the majority of the renewable generation for compliance with the RES, the MWh metric is an appropriate surrogate for estimating GHG emission reductions.

Table C1-1
GHG Benefit Determination for Renewable Sources

Technology	Potential Avoided GHG Emissions[b] (lb CO_2e per MWh)	Comments
Biogas Injection	830	Benefit based on 100 percent use of biogas pipeline fuel—for existing projects, the biogas represents a portion of fuel used by generator
Biomass Combustion	760	Includes GHG emissions from transportation[c]
Converting Biomass to Renewable Diesel	730	Includes GHG emissions from conversion of biomass to renewable diesel[d]
Geothermal	520	GHG emissions resulting from operation—no emissions if heat stream is re-injected[e]
Hydropower and Conduit Hydropower	830	
Landfill	900	Weighted average for in-state and out-of-state projects[f]
Municipal Solid Waste	1200 to 1700	Includes GHG emissions from conversion of MSW and benefit for conversion of methane; range dependent upon amount of waste separation
Ocean Technologies	830	
Wind and Solar	Less than 830	

[b] Benefit is based on one MWh renewable generation.
[c] GHG emissions for transportation are based upon the operational data from the late 1990's for six California biomass-to-energy plants. The data include the amount of biomass used by each plant and the GWh produced by each plant. Using this information and assuming each truck would carry 20 tons of biomass per trip and the truck would travel 80 miles roundtrip, staff estimated transportation GHG emissions as 70 lbs CO_2e per MWh.
[d] To estimate the energy needed to convert biomass into renewable diesel, staff evaluated the energy needed to use the Fischer-Tropsch (F-T) process to produce renewable diesel. The F-T process is energy intensive, but in addition to producing renewable diesel, electricity and naptha are produced as co-benefits. Information on the process taken from Strategic Assessment of Bioenergy Development in the West. Task 2: Bionenrgy Conversion Technology Characteristics, Antares Group, 2008. For the purposes of the GHG benefit analysis, the benefit was reduced by 1,300 lbs CO_2e per MWh, but electricity co-benefit of 1,200 lbs CO_2e per MWh was added—a net reduction of 730 lbs CO_2e per MWh.
[e] Based on range of emissions for several geothermal generators.
[f] In-state projects provide a benefit of 160 lb CO_2e per MWh and out-of-state projects provide a benefit of 1,500 lb CO_2e per MWh. Based on LMOP data and assuming that 55 percent of projects would occur out-of-state and 45 percent would occur in-state, the average benefit is 900 lb CO_2e per MWh.

REFERENCES

[1] S. Murtishaw, California Public Utilities Commission. "Re: drafts of RES staff report chapters and appendices." E-mail to Amy Baker,G. Chin, Dave Mehl. May 22, 2010.

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[3] Energy Information Administration, 2010. Fuel Emission Factors, http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls

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Appendix C2

California Renewable Electricity Standard
Threshold Determination Survey

Purpose: To determine the threshold level (MWh) at which load-serving entities (LSE) need to comply with the ARB's Renewable Electricity Standard. Seven questions will be asked to determine (estimate) the cost of regulation compliance for each LSE.

Survey Questions

1) What was your total electricity sales revenue for 2007, 2008 & 2009?
2) What was your retail electricity cost (energy and transmission costs) for 2007, 2008 & 2009 calendar/ fiscal year in terms of dollars?
3) How many MWh were sold during these periods of time?
4) What was your overall personnel expense (salaries + benefits) for 2008 & 2009 calendar/fiscal year (in dollars)?
    a. How many staff (full-time, part-time & contractors) did you employ during these periods?
5) What do you estimate the administrative cost of compliance (in dollars) if known?
    a. How many additional staff (full-time, part-time) would be required to comply with the regulation?
    b. If no additional staff is required, how would the administrative requirements of the regulation is handled? (Hire outside entity, use current staff)
        i. If so, how much do you estimate the cost to be?
6) How do you plan to comply with the regulation? (REC Only vs. Bundled Energy)
7) Are there any other costs associated with this regulation that I have not asked directly?

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