December 10, 2010

Attn: Mary Nichols, Chairperson
California Air Resources Board
1001 I Street
Sacramento, CA 95812

Subject: Placer County Air Pollution Control District Comments on Proposed California Cap on Greenhouse Gas Emissions

Dear Ms. Nichols:

Placer County Air Pollution Control District ("District") appreciates the opportunity to comment on the subject proposal. The District has significant and highly productive agricultural and forested land, integrated with urban and rural populations – producing a wide range of biomass wastes. Some of these biomass wastes are burned in three biomass boilers to produce renewable energy. Alternatively, much is disposed of through open pile burning. We thus have a strong interest in the proposal’s impact on biomass energy conversion facilities. Our comments below address four separate aspects of the proposal that may critically impact the future viability of biomass for producing renewable energy in California.

First, we request the implementation of the proposed rule provision that provides for “Voluntary Renewable Energy Allowance Set-asides” under Sub Article 8, Disposition of Allowances, Section 95870 (e), as soon as the cap is implemented. The set-aside allowance pool needs be maintained of sufficient size to encourage and stimulate renewable energy projects. These set-aside allowances should be preferably limited and made available only to renewable energy projects that are determined to be “additional” and surplus, similar to that which must be demonstrated for an “offset” or emission reduction credit project. Projects eligible for the set-asides need to be those that would not have taken place under baseline “business as usual” market conditions. This requires a demonstration that without the value of the set-aside allowance, the renewable energy project economics would not be favorable. Specifically this should include projects which utilize biomass wastes that would have otherwise been open burned. We further recommend the GHG value of the set-aside allowance be determined using the average statewide GHG electricity emissions factor from the previous year (tons GHG per MWh electric).

Second, we suggest that revenues from the cap and trade program, such as allowance auctions, be used directly for the support of renewable energy projects that are additional and beyond business as usual, as described above.

We also support the proposed rule consideration of GHGs from biomass wastes as excluded from allowance requirements. This is consistent with other cap and trade
programs, and recent U.S. EPA guidance which allows permitting authorities to take into account the environmental, energy, and economic benefits of biomass during Clean Air Act Permitting for Greenhouse Gases.

Finally, we request the adoption of our GHG offset protocol for Biomass Waste for Energy projects. A copy of the protocol is attached, including letters of support. The protocol was previously provided to CARB staff responsible for offset protocol development. We have yet to receive a response from CARB.

Thank you for considering these comments. Please call me, at (530) 745-2330, with any questions.

Sincerely,

[Signature]

Thomas Christofk
Air Pollution Control Officer

Attachments:

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1. **Introduction**

This protocol provides accounting, reporting, and monitoring procedures to determine greenhouse gas (GHG) reductions associated with biomass for energy projects.

The protocol is for projects which process and transport biomass for the generation of energy (e.g. electricity and process heat). The protocol is limited to projects where, under baseline, business as usual conditions, at the start of the project, the biomass would have otherwise been disposed of through: (1) open burning, or (2) decay and decomposition in the field. The protocol is also limited to biomass that is the result of sustainable harvesting operations or urban biomass waste generation.

Biomass for energy projects potentially reduce GHG emissions through: (1) avoiding methane (CH₄) and nitrous oxide (N₂O) emissions that occur during disposal through open burning and/or decay and decomposition, and (2) producing renewable energy that displaces GHG emissions from fossil fuel combustion needed for an equivalent energy supply.
2. **GHG Reduction Project – Biomass for Energy**

Biomass is generated from forestry, agriculture, urban landscape, and related industries. Biomass is defined as non-fossilized and biodegradable organic material originating from plant material, and is disposed of through open burning, or decay and decomposition in the field. Biomass includes:

- Forest slash / non-merchantable remains from forest management activities including timber harvesting or forest thinning. These include small trees, brush, tree tops, and branches.
- Defensible space clearing residues (brush, tree branches and trunks, clippings).
- Orchard and vineyard removals and prunings.
- Field straws and stalks.
- Urban prunings/cuttings residues

Biomass has energy content that can be utilized in energy recovery facilities, which include:

- Direct biomass combustion, producing heat and/or electricity.
- Biomass gasification, producing syngas used for heat or electricity production, or conversion into alternative transportation fuels (e.g. biofuels).

Sources of GHG emissions from a biomass for energy project are shown in Table 1.

2.1. **Project Definition**

For this protocol, the GHG reduction project involves the use of biomass for energy recovery, where otherwise under baseline, business as usual conditions, the biomass would have been disposed of through open burning, or left to decay and decompose in the field.

The project developer must provide information defining the project operations, including:

- Location where the biomass is generated.
- Operation for which the biomass is a byproduct, i.e. how is the biomass generated.
- Generation (rate and timing) of the biomass.
- Composition of the biomass.
- Historical, current, and anticipated future, disposal practice for the biomass in the absence of the proposed biomass to energy project.
- Biomass processing operations prior to transport, such as conveyors, grinders, and loaders.
- Biomass transportation method.
- Location of energy recovery facility.
- Type of energy produced (e.g. electricity, heat, fuels).
• Estimated cost of processing and transporting biomass to the energy recovery facility.
• Generation rate of energy from biomass.
• User(s) / purchaser(s) of energy generated from biomass.
• Permitting status of the energy recovery facility.
• Documentation of environmental assessments required as part of the biomass generating activities, such as those for the National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), California Forest Practices Rules and Regulations, Timber Harvest Plans, and Best Management Practices assessments.

This information must be provided in Form A, included as an attachment to the protocol.

2.2. Project Developer

Project developers can include biomass generators, biomass waste energy recovery operators, and/or third party aggregators. Ownership of the GHG reductions must be established by clear and explicit title, where ownership is determined through agreement between project developers. This is important to avoid double counting of reductions by the energy recovery operator, biomass processor, biomass owner (landowner), or third party investor.

2.3. Methane and Nitrous Oxide Global Warming Potential Characterization Factors

Methane (CH\textsubscript{4}) is a GHG that maintains a global warming potential characterization factor of 21, equivalent global warming potential of 21 tons of CO\textsubscript{2e} per ton of methane.

Nitrous oxide (N\textsubscript{2}O) is recognized to have a global warming potential of 310 tons CO\textsubscript{2e} per ton N\textsubscript{2}O.
3. **Eligibility**

Projects must meet the following requirements to be eligible for GHG offset credits under this protocol.

3.1. **Biomass from Qualified Operations**

The biomass material used for energy recovery must be characterized as:

- “Biomass” – The material must be non-fossilized and biodegradable organic material.

- “Excess waste” – The material must be an excess waste byproduct that, in the absence of the project, would be disposed of through open burning, or deposited in the field.

- “Sustainable” – The material must be a byproduct of operations which:
  - Protect or enhance long-term productivity of the site by maintaining or improving soil productivity, water quality, wildlife habitat, and biodiversity.
  - Meet all local, state, and federal environmental regulations, including National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), California Forest Practices Rules and Regulations, Timber Harvest Plans, and Best Management Practices.

3.2. **Additionality**

Project GHG emission reductions must be “additional” to what would have otherwise occurred.

It must be demonstrated that the existing disposal practice of the excess biomass waste residues at the beginning date of the project is through either:

- Open burning in the vicinity of the production site.

- Decay and decomposition in the vicinity of the production site, with no commercial value derived from the end-product.

The project developer must demonstrate there are no alternative uses for the biomass waste. It must not be currently economical within the local market to sell biomass waste as a product or process feedstock. This requires providing documentation of previous historical disposal practices, current disposal practices (in the absence of the proposed project), and future planned/anticipated disposal practices.

3.3. **Energy Recovery**
The biomass must be used in an energy recovery facility. The energy recovery facility must:

- Meet all Federal, State, and local environmental regulations, including (but not limited to) air quality, water discharge, and solid waste.

- Produce energy (e.g. electricity, heat, fuel) that is under direct control of, the project developer or under the direct control of an entity that has a contractual agreement with the project developer (or an affiliate of the project developer) to produce energy.

- Produce energy that is valuable and utilized, and would not have otherwise been generated.

3.4. **Location**

This protocol is applicable to biomass recovery project operations that are located in California.

3.5. **Project Start Date**

Projects are eligible which begin after the date of approval of the protocol, and after the necessary project initiation forms have been completed and approved.
4. **GHG Assessment Boundary**

The biomass for energy project boundary is defined to include all GHG emissions from operations that are the result of the biomass for energy project. The physical boundary of the biomass for energy project is shown in Figure 1. GHG emissions must be accounted for operations, as detailed in Table 1, including:

**Baseline, Business as Usual**

- Open biomass burning. Includes quantification of CO₂, CH₄, and N₂O.
- Decay and decomposition of biomass disposal in field. Includes quantification of CH₄ and N₂O.

**Biomass for Energy Project**

- Fossil fuel fired engines, at the site where the biomass is generated, that would not have been used had the biomass been disposed of through open burning or left to decay. This includes engines that power biomass processing equipment used at the site of waste generation – including chippers, grinders, shredders, loaders, excavators, conveyors, etc. Includes quantification of CO₂.
- Fossil fuel fired engines used to facilitate transport of excess biomass from the site of generation to the energy recovery facility. Includes quantification of CO₂.
- Biomass usage at the energy recovery facility. For biomass combustion boilers, quantification of CO₂ is required. The quantification of CH₄ and N₂O is not required as it is considered negligible for a combustor that meets state and local air quality regulations. Other types of energy recovery units may require quantification of CH₄ and N₂O.
- Fossil fuel fired engines, at the energy recovery site, that are associated with the biomass usage that would not have been used otherwise used in the absence of the project. Includes quantification of CO₂ emissions.
- Fossil fuel fired engines used for transportation of equipment and personal to the excess biomass processing site. Includes quantification of CO₂ emissions.
- Fossil fuel fired engines used at biomass for energy facility for operation of auxiliary equipment, such as conveyors and loaders. Includes quantification of CO₂ emissions.
5. **GHG Reduction Calculation Methods**

5.1. **Biomass for Energy Project**

5.1.1. **Biomass Processing Rate**

Determine the quantity of biomass (total wet weight), BM\(_{W}\), meeting the above eligibility criteria, which is delivered to the energy recovery facility:

\[ \text{BM}_{T, W} \]

Quantity of wet (green) biomass utilized at energy recovery facility (wet tons). Determined from the summation of direct weight measurement of every separate biomass delivery received at the energy recovery facility.

Determine the quantity of biomass (total bone dry weight), BM\(_{T, D}\), as:

\[ \text{BM}_{T, D} = \text{BM}_{T, W} \times (1 - M) \]  

(Eq. 1)

where:

\[ M \]

Moisture content of biomass (%). Determined through sampling and analysis of the biomass delivered to the energy recovery facility. (Sampling and measurement will be based on ASTM E870-82, ASTM D 3173, or equivalent. Sampling will occur at biomass energy recovery facility.)

5.1.2. **Energy Produced from Biomass**

Determine the energy content of biomass delivered to the biomass energy recovery facility, Q\(_{BM}\), (MMBtu) as:

\[ Q_{BM} = \text{BM}_{T, D} \times \text{HHV}_{BM} \]  

(Eq. 2)

where:

\[ \text{HHV}_{BM} \]

Higher Heating Value of biomass waste (MMBtu/dry ton). Determined by periodic or most current sampling and analysis of biomass. (Measurement of HHV will be based on ASTM E870-82, ASTM D 5865, or equivalent.)

Next, determine the energy produced from the biomass at the energy recovery facility, E\(_{BM}\), as:

\[ E_{BM} = Q_{BM} \times f \]  

(Eq. 3)

---

1 HHV is utilized within this protocol instead of LHV because it is more prominently used in the biomass energy recovery industry. If LHV is utilized, appropriate conversion factors must be used to calculate an equivalent HHV.
where:

\[ f \]  
Energy production generation efficiency. Determined as the ratio of net useful energy produced by the facility (gross energy produced minus parasitic plant energy requirements) to the total fuel heat input rate. This parameter must be determined on a basis of HHV.

For the production of electricity, this is referred to as the facility heat rate (determined as the kWh\(_e\) new electricity / MMBtu fuel input).

The efficiency will be based on measurements of facility operations using the biomass waste based on an annual facility average efficiency.

5.1.3. **GHG Displaced by Energy Produced from Biomass**

Determine the GHG emissions from fossil fuel combustion that are displaced by the energy produced from the biomass, GHG\(_E\), as:

\[
GHG_E = E_{BM} \times E_{FE} \tag{Eq. 4}
\]

where:

\[ E_{FE} \]  
Emission factor for CO\(_{2e}\) from energy generation that is displaced by the biomass for energy project (tons CO\(_{2e}\) / unit of energy supplied by the excess biomass for energy facility).

It is recommended that for displaced electricity, the use of a factor of 800 lb CO\(_{2e}\) / MW – based on marginal electricity generation supplied by a combined cycle natural gas turbine plant.

5.1.4. **GHG Emissions from Ancillary Biomass Handling, Processing, and Transportation Operations**

Determine the amount of GHG resulting from ancillary biomass handling, processing, and transport operations, GHG\(_{AUX}\), as:

\[
GHG_{AUX} = GHG_{TRANS} + GHG_{PROC} \tag{Eq. 5}
\]

where:

\[ GHG_{TRANS} = VM \times MPG \times EF_{FF} \tag{Eq. 6} \]
GHG \textsubscript{TRANS} \quad \text{CO}_2 \text{e} \text{ emissions from vehicles used to transport biomass to the energy recovery facility; and vehicles used to transport workers to the biomass processing site.}

VM \quad \text{Vehicle miles driven for biomass transport (round trip); and miles driven to transport workers to the biomass processing site. In reporting period.}

MPG \quad \text{Vehicle mileage achieved by transport vehicles (miles/gallon).}

EF\textsubscript{FF} \quad \text{Emission factor for CO}_2 \text{ for fossil fuel combustion (lb CO}_2 \text{ / gal fuel)} \quad \text{for diesel, 22.23 lb CO}_2\text{/gallon; for gasoline, 19.37 lb CO}_2\text{/gal.}

\begin{align*}
\text{GHG}_{\text{PROC}} &= (T\text{\textsubscript{FF}} \times R\text{\textsubscript{FF}}) \times \text{EF}\text{\textsubscript{FF} (Eq. 7)}
\end{align*}

where:

\begin{align*}
T\text{\textsubscript{FF}} \quad \text{Time equipment used to operate biomass processing equipment, including grinders, chippers, shredders, conveyors, and loaders, bulldozers, and excavators. (Reported in hours).}

R\text{\textsubscript{FF}} \quad \text{Average volumetric fuel use rate (gallons per hour) for equipment used to operate biomass processing equipment, including grinders, chippers, shredders, conveyors, and loaders, bulldozers, and excavators. (Reported in hours).}

5.1.4 \textit{GHG Emissions From Biomass Combustion}

Determine \text{CO}_2 \text{ from biomass combustion, as:}

\begin{align*}
\text{GHG}_{\text{BCOM}} &= \text{BM}_{\text{T, D}} \times \text{EF}_{\text{CO}_2 \text{ BM}}
\end{align*}

where:

\begin{align*}
\text{EF}_{\text{CO}_2 \text{ BM}} \quad \text{Emission factor for CO}_2 \text{ from biomass combustion, recommended as 1.8 tons CO}_2 \text{ / ton dry biomass.}

5.1.5. \textit{GHG Emissions From Biomass for Energy Project}

Determine the biomass for energy project GHG emissions, \text{GHG}_{\text{PROJ}}, as:

\begin{align*}
\text{GHG}_{\text{PROJ}} &= \text{GHG}_{\text{AUX}} - \text{GHG}_{\text{E}} + \text{GHG}_{\text{BCOM} (Eq. 8)}
\end{align*}
5.2. Baseline

5.2.1. Baseline Biomass Disposal Practice

Determine the quantity (dry tons) of biomass that would have been uncontrolled open burned, BM\textsubscript{OB, D}, and the quantity of biomass that would have been left to decay in the field, BM\textsubscript{DD, D}, as

\[ BM_{OB, D} = BM_{T, D} \times X_{OB} \]  \hspace{1cm} (Eq. 9)
\[ BM_{DD, D} = BM_{T, D} \times X_{DD} \]  \hspace{1cm} (Eq. 10)

where:

- \( X_{OB} \): Fraction (dry weight %) of biomass that would have been uncontrolled open burned. Based on historical, current, and future projected practices.
- \( X_{DD} \): Fraction (dry weight %) of biomass that would have been left to decay in the field. Based on historical, current, and future projected practices.

5.2.2. GHG Emissions from Baseline Disposal

Determine GHG emissions that would have resulted from the baseline disposal practices, GHG\textsubscript{BASE}, as the sum of emissions from uncontrolled open burning, GHG\textsubscript{OB}, and field decay and decomposition, GHG\textsubscript{DD}, as:

\[ GHG_{BASE} = GHG_{OB} + GHG_{DD} \]  \hspace{1cm} (Eq. 11)

where:

- \( GHG_{BASE} \): Total baseline greenhouse gas emissions, as CO\textsubscript{2} equivalent (tons CO\textsubscript{2}e)
- \( GHG_{OB} \): Greenhouse gas emissions from uncontrolled open burning, as CO\textsubscript{2} equivalent (tons CO\textsubscript{2}e)
- \( GHG_{DD} \): Greenhouse gas emissions from field decay and decomposition, as CO\textsubscript{2} equivalent (tons CO\textsubscript{2}e)

and,

\[ GHG_{OB} = (EF_{OB, CO2} \times BM_{OB, D} \times BF) + (EF_{OB, CH4} \times BM_{OB, D} \times BF \times 21) + (EF_{OB, N2O} \times BM_{OB, D} \times 310) \]  \hspace{1cm} (Eq. 12)
GHG_{DD} = EF_{DD, CH4} * BM_{DD} * 21 + EF_{DD, N2O} * BM_{DD} * 310 \quad \text{(Eq. 13)}

where:

EF_{OB} \quad \text{Emission factor for CO2, CH4 and N2O from uncontrolled open pile burning of biomass. Recommend the use of:}

- CO2 : 1.8 tons CO2 / ton dry biomass
- CH4 : 0.004 ton CH4 / ton dry biomass
- N2O : 0.00015 ton N2O / tons dry biomass

BF \quad \text{Biomass burn out efficiency of the open pile burn. Recommend the use of 95%}.

EF_{DD} \quad \text{Emission factor for CH4 and N2O from in-field decay and decomposition of biomass. Recommend the use of 0.05 ton CH4 / ton dry biomass. Recommend the use of 0 tons N2O / ton dry biomass.}

5.3. **Net GHG Project Reduction**

Determine GHG reductions from biomass waste to energy recovery project, GHG_{NET}, as:

\[ GHG_{NET} = GHG_{BASE} - GHG_{PROJ} \quad \text{(Eq. 14)} \]
6. **Monitoring**

Project data monitoring requirements are shown Form B.
7. **Reporting and Recordkeeping**

7.1. **Project Commencement**

Form A must be completed, submitted, and approved prior to project commencement, as discussed in Section 2 and 3.

7.2. **Recordkeeping**

Form B can be used to collect, maintain, and document the required information. Information is to be kept for a period of 10 years after it is generated, or 7 years after the last verification.

7.3. **Reporting**

Form C can be used to report on project emission reductions. Reporting must be made on a monthly basis.

Project developers must report GHG emission reductions on an annual (12-month) basis.
8. **Glossary of Terms**

**Additionality**: Biomass residue management practices that are above and beyond business as usual operation, exceed the baseline characterization, and are not mandated by regulation.

**Biogenic CO$_2$ Emissions**: CO$_2$ emissions resulting from the combustion and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, and are not part of the baseline or project emissions characterization/calculation.

**Biomass energy recovery operator**: Entity that owns and/or operates a facility that processes and utilizes biomass waste as a feedstock to generate useful energy (electricity).

**Biomass generator**: Landowner or independent contractor that conducts operations that result in the generation of biomass residuals.

**Biomass residue**: Non-fossilized and biodegradable organic material originating from plant material, which due to economic considerations are disposed of through open burning or deposited at the site of generation and left to decay and decompose or are transported to a landfill.

**Carbon dioxide (CO$_2$)**: The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.

**CO$_2$ equivalent (CO$_{2e}$)**: The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.

**Emission Factor (EF)**: A value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. short tons of methane emitted per dry ton of biomass combusted).

**Existing biomass for energy project**: A project that generates biomass material that meets all qualification requirements of this protocol that diverts less than 100% of biomass waste material generated to a biomass energy recovery facility.

**Flaring**: Use of a combustion device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.

**Fossil fuel**: A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.

**Greenhouse gas (GHG)**: Includes carbon dioxide (CO$_2$), methane (CH$_4$), nitrous oxide (N$_2$O), sulfur hexafluoride (SF$_6$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs).
Global Warming Potential (GWP): The ratio of radiative forcing (degree to warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO2.

kWh: Kilowatt-hour of electricity.

Methane (CH\textsubscript{4}): A GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.

MMBtu: Million British thermal units.

MWh\textsubscript{e}: Megawatt-hour of electricity.

Nitrous oxide (N\textsubscript{2}O): A GHG with a GWP of 310, consisting of two nitrogen atoms and a single oxygen atom.

Open Burning: The intentional combustion of biomass material without processing or energy recovery operations.

Project Developer(s): An entity (or multiple entities) that undertakes a project activity, as defined in the Biomass for Energy Protocol. Project developers include, but are not limited to biomass waste generators, biomass waste energy recovery operators, and/or third party aggregators.

Syngas: Synthetic gas produced through industrial processing of biomass material into gaseous (i.e. methane) or further refined into liquid fuels (biofuels).

Third Party Aggregator: An entity that facilitates the project as is not the landowner, biomass waste generator, or biomass waste energy recovery operator for the purpose of generating GHG emission offset credits.
9. **References**


Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report, Changes in Atmospheric Constituents and in Radiative Forcing, Chapter 2, pp. 211-216, 2007.


10.  **Emission Factors**
Methane Emission Factors for Open Burning of Biomass

<table>
<thead>
<tr>
<th>Reference</th>
<th>CH4 as reported by author</th>
<th>CH4 lb/dry ton fuel consumed</th>
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<tbody>
<tr>
<td>Broadcast Logging Slash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardwood (fire)</td>
<td>6.1 g/kg fuel consumed</td>
<td>12.2</td>
</tr>
<tr>
<td>Conifer short needle (fire)</td>
<td>5.6 g/kg fuel consumed</td>
<td>11.2</td>
</tr>
<tr>
<td>Conifer long needle (fire)</td>
<td>5.7 g/kg fuel consumed</td>
<td>11.4</td>
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<td>Logging slash debris dozer piled conifer (fire)</td>
<td>1.8 g/kg fuel consumed</td>
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<tr>
<td>Broadcast Burned Slash</td>
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<tr>
<td>Douglas fir</td>
<td>11.0 lb/ton fuel consumed</td>
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<tr>
<td>Ponderosa pine</td>
<td>8.2 lb/ton fuel consumed</td>
<td>8.2</td>
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<tr>
<td>Mixed conifer</td>
<td>12.8 lb/ton fuel consumed</td>
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<tr>
<td>Pile and Burn Slash</td>
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<td>Tractor piled</td>
<td>11.4 lb/ton fuel consumed</td>
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<tr>
<td>Crane piled</td>
<td>21.7 lb/ton fuel consumed</td>
<td>21.7</td>
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<tr>
<td>U.S. EPA, Compilation of Air Pollutant Emission Factors, AP-42, Section 2.5, Open Burning, October 1992, Table 2.5-5. (Based on G. Yamate et al., 1975; L. Fritschen, et al., 1970; and D. Sandberg et al., 1975).</td>
<td></td>
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<tr>
<td>Unspecified</td>
<td>5.7 lb/ton material burned</td>
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<td>Hemlock, Douglas fir, cedar</td>
<td>1.2 lb/ton material burned</td>
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<tr>
<td>Ponderosa pine</td>
<td>3.3 lb/ton material burned</td>
<td>6.6</td>
</tr>
<tr>
<td>90% combustion efficiency</td>
<td>3.8 g/kg fuel consumed</td>
<td>7.6</td>
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<tr>
<td>B. Jenkins, et al., Atmospheric Pollutant Emission Factors from Open Burning of Agricultural</td>
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<tr>
<th>Description</th>
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</tr>
<tr>
<td>Almond pruning pile burn</td>
<td>1.2</td>
</tr>
<tr>
<td>Douglas fire pile burn</td>
<td>1.9</td>
</tr>
<tr>
<td>Walnut pruning pile burn</td>
<td>2.0</td>
</tr>
</tbody>
</table>


Literature search on biomass open burning

1 - 20 g/kg dry fuel 10.0
Nitrous Oxide Emission Factors for Open Burning of Biomass


0.00015 ton / ton dry
Methane Emission Factors for Decay and Decomposition of Biomass


Assumes 9% carbon in biomass is converted to carbon in methane. Biomass has a molecular formula of C_{6}H_{10}O_{6}.  

0.05 ton / ton dry
Nitrous Oxide Emission Factors for Decay and Decomposition of Biomass

Engineering judgment. At temperatures of in-field decay and decomposition, \( \text{N}_2\text{O} \) is expected to be negligible. Nitrogen in fuel will go to \( \text{NH}_3 \).

0 ton /ton dry
11. **Attachments**

**Table 1. Biomass for Energy Project -- Source Categories, GHG Sources, and GHG Emissions**

<table>
<thead>
<tr>
<th>Source</th>
<th>Associated GHGs</th>
<th>Included in GHG assessment boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Uncontrolled Pile Burning</td>
<td>CO₂</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Included</td>
</tr>
<tr>
<td>In-field Decay and Decomposition</td>
<td>CO₂</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Included</td>
</tr>
<tr>
<td>Biomass for Energy Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation -- engine combustion of fossil fuels</td>
<td>CO₂</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Not included; negligible</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Not included; negligible</td>
</tr>
<tr>
<td>Processing and Handling at Generation Site - engine combustion of fossil fuels</td>
<td>CO₂</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Not included; negligible</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Not included; negligible</td>
</tr>
<tr>
<td>Energy Recovery Facility</td>
<td>CH₄</td>
<td>Not included for combustors; may need to be included for other energy processing types</td>
</tr>
<tr>
<td></td>
<td>CO₂</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Not included; negligible</td>
</tr>
<tr>
<td>Processing and Handling at Energy Recovery Facility – engine combustion of fossil fuels</td>
<td>CO₂</td>
<td>Included</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>Not included; negligible</td>
</tr>
<tr>
<td></td>
<td>N₂O</td>
<td>Not included; negligible</td>
</tr>
<tr>
<td>GHGs from conventional energy production displaced by energy from biomass waste</td>
<td>Dependent on conventional energy source</td>
<td>Included</td>
</tr>
</tbody>
</table>
Figure 1. System Boundary Definition

Figure 2. Example Calculation, Reporting and Monitoring forms submittal
**Form A. Project Definition**

<table>
<thead>
<tr>
<th>Date:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Title:</td>
<td></td>
</tr>
<tr>
<td>Project Developer:</td>
<td></td>
</tr>
<tr>
<td>Project Address:</td>
<td></td>
</tr>
<tr>
<td>Permitting Status:</td>
<td></td>
</tr>
</tbody>
</table>

### Biomass Generation & Disposal Information

<table>
<thead>
<tr>
<th>Composition of Biomass (including moisture content)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Historic, Current, and Anticipated Disposal Practice</td>
<td></td>
</tr>
<tr>
<td>Biomass Generation Rate (green tons/day)</td>
<td></td>
</tr>
<tr>
<td>Cost of Biomass Processing and Transport ($/green ton)</td>
<td></td>
</tr>
</tbody>
</table>

### Biomass Energy Recovery Information

<table>
<thead>
<tr>
<th>Type of Energy Produced</th>
<th>Electricity</th>
<th>Heat</th>
<th>Fuels</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name &amp; Location of Energy Recovery Facility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation Rate of Recovered Energy (MMBtu/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Users/Purchasers of Recovered Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Form B. Monitoring and Recordkeeping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Data Unit</th>
<th>How Measured</th>
<th>Measurement Frequency</th>
<th>Reported Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM&lt;sub&gt;T, W&lt;/sub&gt;</td>
<td>Biomass delivered to energy recovery facility</td>
<td>wet tons / delivery</td>
<td>Transport vehicle weight scale</td>
<td>Every separate delivered load</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Moisture content of biomass</td>
<td>moisture, wt. %</td>
<td>Sampling and analysis of biomass wastes</td>
<td>Every separate delivered load</td>
<td></td>
</tr>
<tr>
<td>HHV&lt;sub&gt;BM&lt;/sub&gt;</td>
<td>Higher heating value of biomass waste</td>
<td>Btu/lb, dry</td>
<td>Sampling and analysis of biomass wastes</td>
<td>Periodic – at least once per month</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>Energy production efficiency of energy recovery facility</td>
<td>net useful energy / biomass heat input</td>
<td>Measurement of boiler output and waste fuel input. Alternatively, based on manufacturer design specifications</td>
<td>Start of program; and updated as needed</td>
<td></td>
</tr>
<tr>
<td>VM</td>
<td>Vehicle miles traveled for biomass transport</td>
<td>miles</td>
<td>Vehicle odometer</td>
<td>Periodically (at least weekly)</td>
<td></td>
</tr>
<tr>
<td>MPG</td>
<td>Transport vehicle gas mileage</td>
<td>miles / gallon</td>
<td>Measurement of vehicle miles traveled and gas usage</td>
<td>Start of program, and updated as needed</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Data Unit</td>
<td>How Measured</td>
<td>Measurement Frequency</td>
<td>Reported Measurement</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>$V_{FF}$</td>
<td>Volume of fossil fuels used to power biomass processing equipment, e.g., shredders, chipper, grinders, conveyors, loaders, excavators, bulldozers</td>
<td>gallons</td>
<td>Measurement of diesel fuel usage and/or equipment operating hours</td>
<td>Periodically (at least weekly)</td>
<td></td>
</tr>
<tr>
<td>$X_{OB}$</td>
<td>Fraction of biomass that would have been open burned</td>
<td>%, wet biomass</td>
<td>Determined based on current economics and operating practices</td>
<td>Start of program, and updated as needed</td>
<td></td>
</tr>
<tr>
<td>$X_{DD}$</td>
<td>Fraction of biomass that would have been left in field to decay and decompose</td>
<td>%, wet biomass waste</td>
<td>Determined based on current economics and operating practices</td>
<td>Start of program, and updated as needed</td>
<td></td>
</tr>
</tbody>
</table>
### Form C. Reporting

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Data Unit</th>
<th>Reported Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM&lt;sub&gt;DD, D&lt;/sub&gt;</td>
<td>Biomass left in field to decay</td>
<td>bone dry tons</td>
<td></td>
</tr>
<tr>
<td>BM&lt;sub&gt;OB, D&lt;/sub&gt;</td>
<td>Biomass open burned</td>
<td>bone dry tons</td>
<td></td>
</tr>
<tr>
<td>BM&lt;sub&gt;T, D&lt;/sub&gt;</td>
<td>Biomass delivered to energy recovery facility, adjusted for moisture</td>
<td>bone dry tons / delivery</td>
<td></td>
</tr>
<tr>
<td>BM&lt;sub&gt;T, W&lt;/sub&gt;</td>
<td>Biomass delivered to energy recovery facility</td>
<td>wet tons / delivery</td>
<td></td>
</tr>
<tr>
<td>E&lt;sub&gt;BM&lt;/sub&gt;</td>
<td>Energy produced from energy recovery facility</td>
<td>kWh</td>
<td></td>
</tr>
<tr>
<td>EF&lt;sub&gt;DD, CH4&lt;/sub&gt;</td>
<td>Emission factor for in-field decay and decomposition</td>
<td>tons CH&lt;sub&gt;4&lt;/sub&gt;/ton dry biomass</td>
<td></td>
</tr>
<tr>
<td>EF&lt;sub&gt;DD, N2O&lt;/sub&gt;</td>
<td>Emission factor for nitrous oxide from in-field decay and decomposition</td>
<td>tons N&lt;sub&gt;2&lt;/sub&gt;O/ton dry biomass</td>
<td></td>
</tr>
<tr>
<td>EF&lt;sub&gt;E&lt;/sub&gt;</td>
<td>Emission factor for CO&lt;sub&gt;2&lt;/sub&gt;e for existing electricity generation</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e/unit energy</td>
<td></td>
</tr>
<tr>
<td>EF&lt;sub&gt;FF&lt;/sub&gt;</td>
<td>Emission factor for fossil fuel combustion</td>
<td>lb CO&lt;sub&gt;2&lt;/sub&gt;/gallon fuel</td>
<td></td>
</tr>
<tr>
<td>EF&lt;sub&gt;OB, CH4&lt;/sub&gt;</td>
<td>Emission factor for methane from open pile burning</td>
<td>tons CH&lt;sub&gt;4&lt;/sub&gt;/ton dry biomass</td>
<td></td>
</tr>
<tr>
<td>EF&lt;sub&gt;OB, N2O&lt;/sub&gt;</td>
<td>Emission factor for nitrous oxide from open pile burning</td>
<td>tons N&lt;sub&gt;2&lt;/sub&gt;O/ton dry biomass</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>Energy production efficiency of energy recovery facility</td>
<td>net useful energy / biomass waste heat input</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Data Unit</td>
<td>Reported Value</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td>GHG&lt;sub&gt;AUX&lt;/sub&gt;</td>
<td>GHG resulting from ancillary biomass handling, processing, and transport</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;BASE&lt;/sub&gt;</td>
<td>GHG resulting from baseline disposal practices</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>GHG resulting from decay and decomposition</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;E&lt;/sub&gt;</td>
<td>GHG displaced from energy production from biomass</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;NET&lt;/sub&gt;</td>
<td>Net GHG reductions from</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;OB&lt;/sub&gt;</td>
<td>GHG resulting from open burning activities</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;PROC&lt;/sub&gt;</td>
<td>GHG resulting from ancillary biomass handling and processing</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;PROJ&lt;/sub&gt;</td>
<td>GHG resulting from the biomass waste to energy project</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>GHG&lt;sub&gt;TRANS&lt;/sub&gt;</td>
<td>GHG resulting from transport operations</td>
<td>tons CO&lt;sub&gt;2&lt;/sub&gt;e</td>
<td></td>
</tr>
<tr>
<td>HHV&lt;sub&gt;BM&lt;/sub&gt;</td>
<td>Higher heating value of biomass</td>
<td>Btu/lb, dry</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Moisture content of biomass</td>
<td>moisture, wt. %</td>
<td></td>
</tr>
<tr>
<td>MPG</td>
<td>Transport vehicle gas mileage</td>
<td>miles / gallon</td>
<td></td>
</tr>
<tr>
<td>Q&lt;sub&gt;BM&lt;/sub&gt;</td>
<td>Heat content per delivery of biomass at facility</td>
<td>MMBtu</td>
<td></td>
</tr>
<tr>
<td>R&lt;sub&gt;FF&lt;/sub&gt;</td>
<td>Average volumetric fuel use rate for processing equipment</td>
<td>gallons/hour</td>
<td></td>
</tr>
<tr>
<td>T&lt;sub&gt;FF&lt;/sub&gt;</td>
<td>Time equipment used for processing operations</td>
<td>hours</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
<td>Data Unit</td>
<td>Reported Value</td>
</tr>
<tr>
<td>-----------</td>
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<tr>
<td>$X_{DD}$</td>
<td>Fraction of biomass that would have been left in field to decay and decompose</td>
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<td>%, wet biomass</td>
<td></td>
</tr>
</tbody>
</table>