

- ### Agenda
- Brief Overview of AB 32
  - Landfill Methane Primer
  - Sources and Emissions
  - Draft Regulatory Concepts
  - Enforcement and Implementation
  - Next Steps
  - Discussion

- ### California Global Warming Solutions Act of 2006 (AB 32)
- On June 21, 2007, the Board approved the first two components of the Landfill Methane Capture Strategy as a discrete early action measure.
    - Require the installation of gas collection and control systems (GCCS) at smaller landfills that are not currently required to install controls
    - Increase landfill methane capture efficiencies
    - Increase energy recovery from landfill methane
  - ARB is collaborating with CIWMB on the development of the control measure

**California Global Warming Solutions Act of 2006 (AB 32)**  
 Requirements for Discrete Early Action Measures

- Adopted and made enforceable before January 1, 2010
- Achieve the maximum technologically feasible and cost-effective reductions in greenhouse gases (GHG) from pertinent sources to achieve 2020 GHG emission limit levels
- No relaxation in conventional air pollutant controls

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**Landfill Methane Primer**

- Landfill gas results from the natural decomposition of organic waste in landfills
- Landfill gas composition:
  - ~ 45 – 50% methane
  - ~ 40 – 60% carbon dioxide
  - < 1% trace gases

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**Landfill Methane Primer**

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**Landfill Methane Primer**

- Methane generation rate depends on waste type, age, moisture, temperature, pH, alkalinity and nutrients
- Methane is released to the atmosphere if not captured and controlled

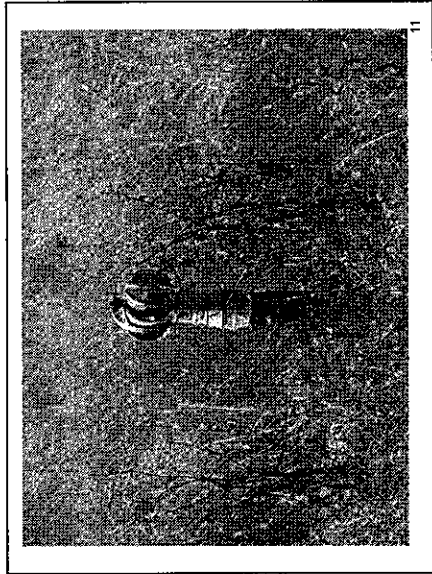
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### Landfill Methane Primer

#### Significance of Landfill Gas

- Methane is a potent GHG gas, 21 times the GWP of carbon dioxide
- Health hazards associated with trace gases
- Explosive danger (5% - 15%)
- Odor nuisance
- Potential energy recovery of methane

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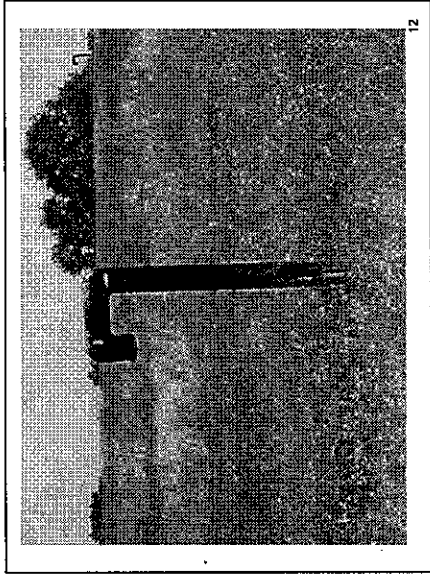
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### Landfill Methane Primer

#### Collection and Control Systems

- Active Collection Systems
  - Methane extraction wells and/or horizontal trenches
  - Methane moving equipment (e.g., piping and blowers)
  - Methane combustion, energy recovery, treatment, or conversion equipment
- Passive Collection Systems
  - Cutoff trenches or vents
  - Allow methane to flow into the atmosphere

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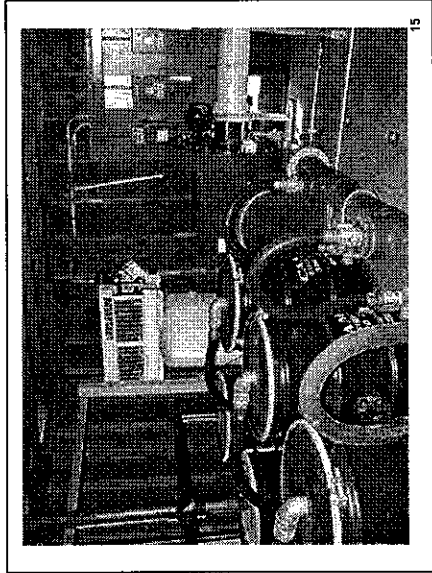


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## Landfill Methane Primer Collection and Control Systems

- Control Devices
  - Flares (open and enclosed)
  - Reciprocating engines
  - Turbines
  - Microturbines
  - Boilers

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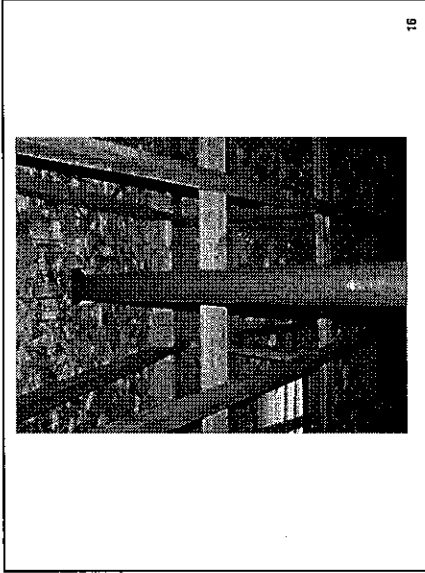


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## Landfill Methane Primer Collection and Control Systems

- Other Technologies
  - LFG to CNG
  - LFG to pipeline quality natural gas
  - Fuel cell
  - Carbon adsorption

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**Sources and Emissions**

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**Sources and Emissions**

- Passive venting – 24
  - 1990: 0.16 MMTCO2E
  - 2005: 0.16 MMTCO2E
- Carbon adsorption – 2
  - 1990: 0.01 MMTCO2E
  - 2005: 0.01 MMTCO2E

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**Sources and Emissions**

- Total landfill emissions inventory – 372
  - 1990: 6.58 MMTCO2E
  - 2005: 5.83 MMTCO2E
- >500,000 tons WIP w/o controls – 26
  - 1990: 0.23 MMTCO2E
  - 2005: 0.56 MMTCO2E

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**Draft Regulatory Concepts**

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### Draft Regulatory Concepts

#### Applicability

- All new and existing MSW landfills >500,000 tons of degradable WIP
- MSW landfill ARB staff is examining the feasibility of a threshold <500,000 tons of WIP.
- Alternatively, base applicability on surface emissions rather than size.

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### Draft Regulatory Concepts

#### Methane Collection and Control Requirements

- Statewide surface emission standards to maximize collection efficiencies
- 50 ppm integrated surface sampling
- 500 ppm (or lower) instantaneous sampling

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### Draft Regulatory Concepts

#### Methane Collection and Control Requirements

- Active gas collection and control system (GCCS) and submit design plan
- Flexibility for other emissions control methods based on site-specific conditions
- Some existing passive and carbon adsorption systems may no longer be allowed to openly vent methane
- Some exemptions may apply

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### Draft Regulatory Concepts

#### Methane Collection and Control Requirements

- Collection of gases from uncontrolled areas of the landfill where waste has been placed for 2 years or more, or at final grade

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### Draft Regulatory Concepts

#### Methane Collection and Control Requirements

- At closed landfills, require GCCS to remain in operation for a longer period of time
- Landfill methane gas combusted with or without energy recovery, or routed to a conversion system

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### Draft Regulatory Concepts

#### Monitoring, Recordkeeping, and Reporting Requirements

- Quarterly (or more frequent monitoring) to ensure proper operation of GCCS
- Submit subsurface perimeter monitoring results (if available)
- Spacing requirement of 25 feet between walking grid pattern for surface monitoring
- Maintain records of monitoring results and report exceedances of operating parameters

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### Draft Regulatory Concepts

#### Methane Collection and Control Requirements

- If flare is used as control device, it must be enclosed ground type
- Control device designed and operated to reduce methane by a specified destruction efficiency (to be determined)

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### Draft Regulatory Concepts

#### Compliance Schedule

- Accelerated installation of GCCS (compared to federal requirements)
- Schedule would consider time for design, permitting, and installation of GCCS
- More time provided for landfill owners electing to recover the landfill methane gas for energy utilization

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### Draft Regulatory Concepts

#### Potential Exemptions

- Landfills must meet all the following:
  1. Demonstrate a low potential for generating gas;
  2. Meet surface emission standards; and
  3. Not pose a threat to human health or the environment.
- Landfills which contain only non-decomposable, inert solid waste, or hazardous waste would also be exempt

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### Draft Regulatory Concepts

#### Potential Issues

- Some landfill owners may not have the necessary funds to install GCCS earlier than what would have been required under the federal requirements
- Smaller and older landfills (closed >30 years) may not generate enough methane to support some types of control devices, such as a flare

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### Draft Regulatory Concepts

#### Potential Issues

- Reporting requirements
- Some existing passive and carbon adsorption systems may no longer be allowed to openly vent methane

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### Implementation and Enforcement

- Airborne Toxic Control Measure not appropriate
- MOU or Interagency Agreement with local air districts, California Integrated Waste Management Board, other agencies

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### Next Steps

- ARB is seeking comments and will continue to work with stakeholders
- Landfill Technical Review Workgroup meetings
- February 2008 – Second public workshop to discuss the draft regulatory language (tentative)

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### Next Steps

- Late Sept. 2008 – Staff report (Initial Statement of Reasons), will be available for a 45 day formal public review and comment
- November 2008 – Board hearing to officially adopt the landfill methane control measure
- Fall 2009 – Anticipated effective date of the control measure

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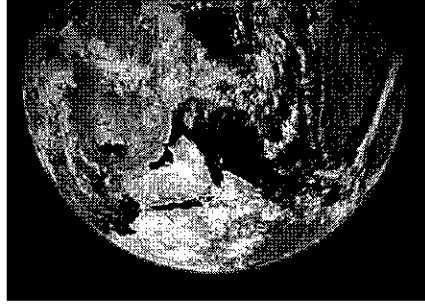
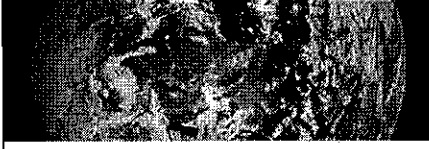
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Landfill Methane Control Measure  
 Website:  
<http://www.arb.ca.gov/cc/ccea/landfills/landfills.htm>



Thank you.

# Questions about Draft Regulatory Concepts?



# **Solid Waste Industry for Climate Solutions**

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September 5, 2007

Doug Thompson  
California Air Resources Board  
1001 I Street, P.O. Box 2815  
Sacramento, CA 95812-2815

**Subject: *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions***

Dear Mr. Thompson:

SWICS members appreciate the opportunity to provide comments on the Preliminary Draft (Draft), "*Regulation for the Mandatory Reporting of Greenhouse Gas Emissions.*" The letterhead organizations and undersigned parties to this letter are part of an informal coalition of solid waste industry stakeholders known as "Solid Waste Industry for Climate Solutions" (SWICS). We have organized ourselves in this fashion to better represent the interests of the solid waste industry in discussions regarding climate change issues.

The landfill industry understands the importance of both developing credible and defensible inventories, and accurately reporting greenhouse gas (GHG) emissions. This is a key reason why the members of the SWICS group have joined the California Climate Actions Registry (CCAR). In addition to ensuring inventories and reports meet rigorous standards, one of the key goals of the CCAR is developing consistency with other inventory and reporting programs around the country and internationally; also an important goal of SWICS members. In fact, this is also a requirement of AB 32, Section 38530 (b)(3) & (c)(2), which calls for consistency with the CCAR, and "*existing and proposed international, federal, and state greenhouse gas emission reporting programs and make reasonable efforts to promote consistency among the programs established*

*pursuant to this part and other programs, and to streamline reporting requirements on greenhouse gas emission sources.”*

In Section 95100, *Purpose*, of the Draft, it is stated that this Article is designed to meet the requirements of AB 32. Although staff has verbally relayed the intent to work with the CCAR, we have yet to see evidence of this in writing. In fact, we find the Draft to be counter to the language in AB 32, which directs CARB to *streamline reporting requirements on greenhouse emission sources*. Establishing a program to use CCAR reporting tools, protocols and all inventories is an important step to achieving a *streamlined* program. Also, in the spirit of achieving *streamlining*, we believe the current version of the Draft is complex, confusing and overly burdensome to implement, and therefore, should be simplified. As a starting point, we believe that either in the Staff Report, or as a preamble to the Draft, staff should fully outline how the proposed language fulfills each of the requirements contained in Section 38530 of AB 32. In many cases, we fail to understand this link. The details of our concerns are presented below.

### **Ranking of Sources by Contribution**

AB 32 has at its core the requirement to adopt regulations to report and verify statewide GHG emissions. As outlined in Section 38530 (b)(1), these requirements must begin with the “*sources or categories of sources that contribute the most to statewide emissions*.” This requirement focuses CARB’s valuable resources to the most important sources of GHG emissions first, an important means of *streamlining* the program. The sources of GHG covered in the proposed regulations were characterized by staff in the August 15, 2007 Workshop, as representing 94% of point source CO<sub>2</sub> emissions. However, AB 32 requires that the reporting sources be characterized according to contribution to *statewide emissions*, not just point sources; staff does not comply with this requirement. Referring to the Final CAT report, the top sector contributing to GHG emissions is the Transportation sector, representing 41.2% of statewide emissions. In fact, also referring to this report, Fossil Fuel Combustion contributes 81% of the total GHG emissions, in CO<sub>2</sub> equivalents.

In the latest draft inventory released by CARB, landfills contribute approximately 1% of the GHG emissions. If carbon sequestration is accounted for, landfills are at worst carbon neutral, yet the reporting of this sector is grouped in with all other point source sectors, without the most important sectors (transportation and fossil fuel combustion) being addressed first. This approach is counter to the direction established in AB 32 to focus on the most important sources first.

SWICS recommends that CARB establish full Mandatory Reporting requirements for the highest emitting sources of GHG emissions first, based on statewide totals for all emissions, in accordance with the requirement of AB 32. For sectors, such as the biomass/gas sector, which are small contributors to statewide GHG emissions, as a starting point, only GHG emissions from electrical generating equipment should be required, since this is a specific requirement in AB 32. However, recognizing the number

of sources that are members of the CCAR, CARB should begin a program to develop the technical tools to extract the needed inventory data from the CCAR inventories. This will *streamline* CARB and industry efforts while promoting *consistency* in mandatory reporting programs.

### **Streamlining Mandatory Reporting Requirements**

As suggested above, CARB can focus its resources by developing full Mandatory Reporting for the highest emitting sources of GHG emissions first. Reviewing the Draft, SWICS finds the language to be confusing and difficult to administer. Landfills, for instance, can be a mix of sources, including electrical generating equipment, general combustion equipment (flares) and fugitive emissions of methane. In addition, landfill gas is often supplemented with natural gas or propane for start-up of equipment, or just to supplement lower BTU landfill gas to enable the use of electrical generating equipment that have specific BTU requirements, or for flame stabilization. However, in all cases, landfill gas is the primary fuel. Adding to the complexity of many landfill operations, are often both complex owner/operator relationships and electrical generating contracts. Many of these complex characteristics also exist with waste-to-energy facilities.

The proposed requirements of the Draft, perhaps in an attempt to be very generic, are very confusing when dealing with complex facilities, such as landfills. Part of the confusion, as described above, is trying to understand why certain information is needed. For example, it is clear that AB 32 requires an accounting of GHG emissions from electricity consumed in the state, but why is CARB requiring the generators of greater than 1 MW to supply this information? The retailer sellers, as specified in AB 32, should be responsible for this. Also, general combustion equipment producing greater than 25,000 metric tonnes of CO<sub>2</sub>, must report GHG emissions. However, at landfills for instance, flares are a source of biogenic CO<sub>2</sub> with de minimis levels of uncombusted methane. It is not clear why CARB is using valuable resources to produce a program to account for biogenic CO<sub>2</sub> emissions, especially since most of this information is available from local districts or CCAR inventories. The focus should be on the anthropogenic CO<sub>2</sub> emissions from fossil fuel combustion that comprise the bulk of the GHG emissions in the state.

SWICS recommends that CARB separate out de minimis sources of GHG emissions, such biomass/gas facilities, and have a simplified list of requirements established in conjunction with the CCAR. In this way, CARB can focus the more stringent Mandatory Reporting requirements on the real sources of anthropogenic CO<sub>2</sub> emissions.

Finally, landfills, or any source category, should be allowed to submit an inventory for all sources at a facility in one inventory rather than piecemeal reporting under multiple sectors such as power production or stationary combustion. This will ensure emissions are attributed to the proper source category and will ensure that double-counting does not occur. In addition, landfills would then be able to submit one single inventory and one

point in time whenever the landfill source category becomes subject to the Mandatory Reporting requirement.

### Definitions

*Renewable Energy* – CARB provides examples of *renewable energy* that omit, but should include biogas, biomass and municipal solid waste. Many official sources have defined these terms; two examples can be found at:

- California’s Public Resources Code; Sections 25740 – 25751  
(<http://www.leginfo.ca.gov/cgi-bin/waisgate?WAISdocID=00886713869+0+0+0&WAIAction=retrieve>)
- Federal Energy Policy Act of 2005, Sections 203 and 205

SWICS request that definition be revised to include these terms.

### Detailed Comments

1. *Section 95103* – In several instances, reference is made to requirements that pertain to “*biomass-derived fuels*.” Perhaps this should be handled in a separate definition, but it should be clear that reference to *biomass-derived fuels* should not mean “*only*” a *biomass-derived fuel*. So for instance, if a landfill gas-fired turbine or engine has a permit that allows 25% of the heat input to come from natural gas, that gas mixture should still be considered a *biomass-derived fuel*. The natural gas in this case could be used for startup, or in cases where flame stabilization is needed. Likewise, a waste-to-energy facility fueled by municipal solid waste, should also be considered a *biomass-derived fuel* despite the fact that some portions of MSW are fossil fuel derived, and natural gas may be used for start-up and flame stabilization. MSW should be considered a renewable energy, in its entirety.

One instance where the distinction is important is in Section 95103 (c)(3) which allows triennial verification for facilities combusting only *biomass-derived fuels*. Facilities meeting any of the criteria specified above should be allowed to verify their reporting triennially.

2. *Section 95103 (b)* – The Draft outlines the reporting schedule for existing facilities. As discussed above, the language is confusing, especially for more complex sources such as landfills. In the spirit of *consistency* and *streamlining*, the reporting and verification schedules should coincide with the CCAR schedules, especially in those cases where CARB would be extracting its reports from the CCAR reports.
3. *Section 95104 (a)* – In this section, the data report is to include *emissions occurring during routine maintenance, start-ups, shutdowns, upsets and*

*downtime*. This requirement is excessively burdensome to facilities, especially the operators of complex facilities such as landfills. The level of records that would be needed to comply with this section will be substantial. CARB needs to substantiate why this information is needed. It is likely that emissions during these events, on an annual basis, will be de minimis. This is especially true for sectors, such as biogas, that are an insignificant portion of the statewide inventory of GHG emissions. In addition, already in place are local air district requirements, administered through permits and regulations that would limit emissions during these events ensuring the emission are de minimis. SWICS recommends that this section be removed.

4. *Section 95104 (b)* – This section contains a requirement to *maintain an effective greenhouse gas estimation program*. The reporting required in AB 32 also requires third party verification. It is this verification that will determine if the estimation programs are effective. In light of this, the requirement to maintain an *effective* program is unnecessary, and should be considered an excessive administrative requirement. Furthermore, it is a vague requirement that is unenforceable and not within the spirit of *streamlining*.
5. *Section 95107 Enforcement* – This section contains stringent enforcement requirements for instances of non-compliance. Given the extent and ramification of enforcement actions specified here, there should be allowed a transition period of at least one reporting year, where more benign “notice-to-comply” type tickets would be issued.

### **Closing**

The solid waste industry is prepared to comply with its obligations under a Mandatory Reporting program in the state; however, SWICS requests that such a program be fair and balanced and consistent with AB 32. Most importantly, we strongly request that CARB streamline the Mandatory Reporting wherever possible, including use of the existing CCAR inventory system to the greatest degree feasible.

Thank you for your consideration of the above issues. If you require any further information or have any questions, please contact any one of the undersigned individuals.

Sincerely,

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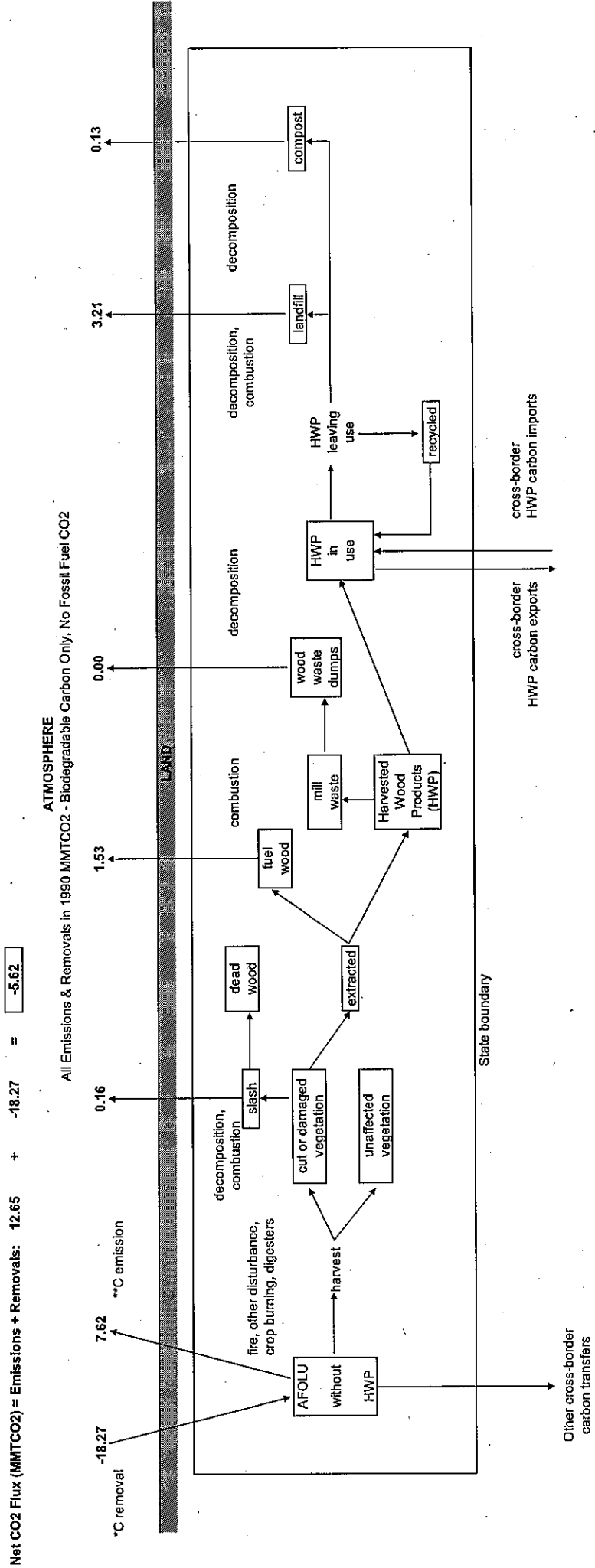
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Adapted from:  
 1. Figure 12.A.2. System boundary of the Atmospheric Flow Approach.  
 In: Chapter 12, Harvested Wood Products, Volume 4, Agriculture, Forestry, and Other Land Use (AFOLU), 2006 IPCC Guidelines for National Greenhouse Gas Inventories.  
 IPCC National Greenhouse Gas Inventories Programme.

2. Figure 1-6. Flow diagram illustrating the various destinations of pre-harvest carbon after commercial harvest.  
 In: Baseline Greenhouse Gas Emissions for Forest, Range, and Agricultural Lands in California. (2004) California Energy Commission PIER final report 500-04-069F.



\*AFOLU carbon removal from the atmosphere includes vegetation growth in Forests and Range land, and growth of woody and non-woody crops.  
 \*\*AFOLU carbon emissions to the atmosphere includes emissions from: Forest and Range land use change (development) and other unspecified disturbance, decomposition/combustion of slash from tree harvest, fuel wood combustion, decomposition of wood mill waste and Harvested Wood Products in landfills and composting facilities, agricultural burning of field crops, orchard and vineyard prunings, and digester gas combustion.

The Atmospheric Flow Approach estimates fluxes of carbon to and from the atmosphere for the forest and wood products pools within the state boundary, and reports where and when emissions to the atmosphere and removals from the atmosphere occur. The state includes in its estimate of emissions/removals the removals of carbon from the atmosphere due to vegetation biomass growth, and the carbon release to the atmosphere from the oxidation of harvested wood products that are consumed in the state. (Adapted from: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry, and Other Land Use.)

**Draft: Land Use, Land Use Change & Forestry (LULUCF) Biodegradable Carbon Emissions & Removals August 7, 2007**  
(MMT CO<sub>2</sub>)

Category	Data Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<b>Removals</b>																
Forest Growth	Winrock	-18,270	-17,672	-16,959	-19,310	-18,449	-18,479	-19,037	-19,102	-17,258	-19,699	-19,492	-16,925	-20,201	-18,898	-18,433
Rangeland Growth	Winrock	-13,141	-13,118	-13,096	-13,074	-13,052	-13,052	-13,052	-13,052	-13,052	-13,052	-13,052	-13,042	-13,032	-13,022	-13,012
Ag Growth (Woody)	Winrock	-1,104	-1,102	-1,100	-1,099	-1,097	-1,097	-1,097	-1,097	-1,097	-1,097	-1,097	-1,096	-1,086	-1,084	-1,083
Ag Growth (Non-Woody)	Winrock	-0,526	-0,503	0,371	-1,739	-0,948	-0,956	-0,977	-0,977	-2,260	-2,273	-1,718	-0,734	-0,895	-0,706	-0,701
<b>Removals</b>	Winrock	-3,499	-2,948	-3,133	-3,400	-3,353	-3,375	-3,912	-3,782	-3,850	-3,278	-3,626	-2,654	-5,179	-4,076	-3,627
<b>Removals</b>		-18,270	-17,672	-16,959	-19,310	-18,449	-18,479	-19,037	-19,102	-17,258	-19,699	-19,492	-16,925	-20,201	-18,898	-18,433
<b>Emissions</b>																
Forest/Rangeland Fires (Combustion & Decomposition)	Winrock	7,618	7,050	7,561	7,599	7,963	8,001	8,595	8,777	8,810	8,292	8,452	8,154	8,457	8,912	8,605
Ag Burning of Field Crops (Combustion)	NASS	2,032	2,028	2,025	2,022	2,018	2,018	2,018	2,018	2,018	2,018	2,018	2,017	2,015	2,014	2,012
Ag Burning of Orchard & Vineyard Prunings (Combustion)	NASS	3,639	2,968	3,493	3,500	3,763	3,765	4,322	4,452	4,370	3,808	3,936	3,674	3,939	4,286	3,957
Development of Forest/Rangelands (Land Use Change)	Winrock	0,796	0,773	0,779	0,808	0,906	0,916	0,937	0,942	1,050	1,073	1,098	1,094	1,106	1,116	1,141
Forest/Rangeland Other Emissions (Unspecified)	Winrock	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021	0,021
Digester Gas Used for Electricity Generation (Combustion)	EIA	1,208	1,206	1,204	1,202	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,199	1,199	1,197	1,196
Slash Left Behind from Harvests (Decomposition)	Winrock	0,022	0,034	0,039	0,047	0,054	0,062	0,068	0,145	0,151	0,173	0,180	0,150	0,178	0,279	0,268
Fuel Wood from Harvests (Combustion)	Winrock	0,156	0,156	0,156	0,156	0,155	0,155	0,155	0,155	0,155	0,155	0,155	0,155	0,155	0,155	0,155
Compositing of Harvested Materials (Decomposition)	Winrock	1,532	1,529	1,526	1,524	1,521	1,521	1,521	1,521	1,521	1,521	1,521	1,520	1,519	1,518	1,517
Wood Waste Dumps	USEPA Data	0,134	0,162	0,191	0,222	0,256	0,288	0,321	0,357	0,394	0,433	0,470	0,472	0,475	0,499	0,510
Landfilled Waste Not Including Yard Waste (Emissions)	CIWMB	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Landfill Gas Emissions Not from Electricity Generation (Combustion & Fugitive)	ARB	3,210	3,346	3,557	3,816	4,042	4,350	4,503	4,530	4,749	4,745	4,931	5,248	5,430	5,426	5,510
Landfill Gas Used for Electricity Generation (Combustion)	ARB	2,469	2,600	2,806	3,061	3,282	3,564	3,732	3,754	3,969	3,960	4,141	4,200	4,523	4,558	4,565
<b>Emissions</b>	EIA	0,741	0,746	0,751	0,756	0,761	0,766	0,771	0,775	0,780	0,785	0,790	0,795	0,800	0,805	0,810
<b>Emissions</b>		12,651	12,243	12,992	13,318	13,938	14,296	15,096	15,341	15,629	15,148	15,530	15,550	16,037	16,509	16,296
<b>Net LULUCF CO<sub>2</sub> Flux</b>		-5,619	-5,428	-3,966	-5,992	-4,510	-4,182	-3,940	-3,761	-1,628	-4,551	-3,962	-1,375	-4,165	-2,388	-2,137

Description

The net CO<sub>2</sub> flux resulting from Land Use, Land Use Change and Forestry (LULUCF) in the sector Agriculture, Forestry, and Other Land Use (AFOLU) is estimated from summing CO<sub>2</sub> removals from the atmosphere and CO<sub>2</sub> emissions to the atmosphere on managed lands. Removals of CO<sub>2</sub> from the atmosphere occur as a result of vegetation growth. Emissions of CO<sub>2</sub> to the atmosphere occur as a result of a variety of land use activities. These include emissions resulting from oxidation of timber harvest slash, fuel wood, landfilled or composted wood products consumed in the state, biomass consumed in wildland fires, crop residue burning, digesters, and emissions from other disturbances (land use change or unspecified). CO<sub>2</sub> emissions from Wood Waste Dumps, and CO<sub>2</sub> removals and emissions (yard waste) from urban forests and landscapes will be included pending further data.

Data Sources

Winrock: CEC (2004). Baseline Greenhouse Gas Emissions for Forest, Range, and Agricultural Lands in California. PIER Final Project Report CEC-500-04-069F. Per-year forest and rangeland emission and removal rates for period 1994 - 2000 in Table 1-21, scaled to state-wide. CEC (2006) Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004. Publication CEC-600-2006-013-SF. Emissions and removals are back-cast to 1990 from 1994 using -0.1707% per year forest land area decline trend from 1953 to 1994, from p. 14 in Shih (CDF, 1998): The Land Base of California's Forests. Emissions and removals forecasted from 2000 using 4% forest land decline predicted for 1997 to 2050 in the Pacific Coast Region, from p. 53 in: Area Changes for Forest Cover Types in the United States, 1952 to 1997, with projections to 2050. (2004) USDA Forest Service, Pacific Northwest Research Station publication PNW-GTR-613. CO<sub>2</sub> emissions and removals for Woody and Non-woody crops are estimated from Winrock-reported crop net CO<sub>2</sub> flux (Table 2-7, interpolated for intervening years, extrapolated after 1997) and crop burning CO<sub>2</sub> emissions estimated by ARB.

NASS: Crop acreage data from USDA National Agricultural Statistics Service. Crop burning CO<sub>2</sub> emissions estimated by ARB using USEPA publication AP-42 crop fuel loading and ARB crop emission factors.

EIA: Energy Information Administration, U.S. Dept. of Energy

USEPA Data: Harvested Wood Products use data provided by Kenneth Skog (Forest Products Laboratory, USDA Forest Service, Madison, WI), scaled to state based on population.

CIWMB: California Integrated Waste Management Board.

ARB: From IPCC Mathematically Exact First-Order Decay Model, with CIWMB SWIS Waste-in-Place data and Landfill Survey Data.