

## DRAFT Development of Potential Offsets Related to Anaerobic Digesters

(Version 09/15/08)

### Introduction

This paper presents a draft assessment of the potential for meaningful carbon offsets from anaerobic digestion (AD) of dairy manure and co-digestion of dairy manure with other organic materials such as organic fraction municipal solid waste (OFMSW). AD is a biological process in which organic carbon materials are broken-down by bacteria into a biogas consisting of methane, carbon dioxide (CO<sub>2</sub>) and other trace gases. This carbon conversion has been shown at the commercial-scale to lead to numerous advantages including odor, pathogen and GHG emission reductions. AD facilities are bio-refineries, producing multiple products from multiple inputs through synergistic co-processing. As bio-refineries, AD operations present controlled, contained environments that support accurate measurement of inputs and outputs related to carbon emission offsets.

The US Environmental Protection Agency (EPA) estimates that approximately 3.5% of all US anthropogenic methane emissions results from dairy manure management. Methane emissions from dairy manure have risen by approximately 50% between the years 1990 and 2005 primarily because of industry shifts towards more concentrated animal feeding operations that utilize manure handling systems. These systems are more susceptible to anaerobic conditions and methane release.<sup>1</sup> Numerous national and international studies of current AD technologies have documented reductions in methane over conventional nutrient handling practices. In addition to methane reductions related to manure management, AD provides opportunities to:

- Entrap methane related to co-digestion of OFMSW.
- Displace CO<sub>2</sub> emissions through use of AD co-products, including generated electricity, pipeline-quality natural gas, transportation and boiler fuels, and conversion to other chemical forms (e.g., ammonia, methanol).

The Agricultural Sector Carbon Market Workgroup (ASCMW) believes there is significant potential to develop real, additional, and verifiable greenhouse gas (GHG) emission reductions as a result of AD methane capture and co-products.

### Basis for Selection

Because AD projects are bio-refineries with the potential to produce a wide variety of co-products, this section does not provide an exhaustive list of potential AD carbon offsets. Instead, it examines those offsets for which protocols exist and/or data is readily available. Since the following GHG reductions are beyond what would have happened in the absence of AD projects and are not required by regulation, the ASCMW believes they are additional and creditable.

Washington State has approximately 450 dairies consisting of 230,000 milking/dry cows, 74,000 heifers and 42,000 calves.<sup>2</sup> According to United States Environmental Protection Agency (EPA), current AD technology is most effectively applied on dairies of 500 cows or more.<sup>3</sup> In Washington, 135 dairy facilities, comprising 166,757 cows and 50,088 heifers, have sufficient herd size to warrant immediate consideration.<sup>4</sup> Using the Intergovernmental Panel on Climate Change (IPCC) Tier 2 methodology for estimating methane emissions from liquid/slurry manure storage facilities and a methane conversion

factor of 39 percent for cool climates, it is estimated that AD would reduce emissions by 2.75 Metric Tons (MT) CO<sub>2</sub>e/cow/year.<sup>5,6</sup> This translates into a total avoided emissions of approximately 0.5 MMT CO<sub>2</sub>e/year from Washington's 135 largest dairies.

A recent study at Washington State University (WSU) indicates that, compared to a manure-only AD baseline, co-digestion of OFMSW at an 18% volumetric flow rate increased biogas yield by 63%.<sup>7</sup> Additional research data indicate that this figure may be conservative since potential biogas production from co-digestion can be much higher depending upon the type and volume ratio of OFMSW used as substrate. Since OFMSW digestion may result in a diversion of OFMSW from landfills, a corresponding baseline landfill avoided emission can be ascertained, equal to approximately 5.68 MT CO<sub>2</sub>e/dry MT OFMSW digested.<sup>8</sup> This number, expanded for the 135 largest Washington dairies, yields an additional methane capture of 1.88 MMT CO<sub>2</sub>e/year.<sup>9</sup> In addition to methane capture, the process would remove approximately 0.33 MMT (dry) of OFMSW waste from the landfills every year.

***[NOTE FOR WORK GROUP DISCUSSION: Landfill avoidance rate used above does not coordinate with the WARM model used by CAT and the BWG.]***

In Washington State, the primary end-use of AD-captured methane is electricity production for the grid. When AD projects produce electricity, they displace CO<sub>2</sub> emissions associated with the fossil fuel based electricity resources they displace. The Northwest Combine Heat and Power Application Center's most conservative estimate for AD power production is 2 KWh/cow/day, yielding an energy production potential of 383,602 KWh/day or 140,099 MWh/year from Washington's 135 largest dairies. Using the 2007 Climate Action Team (CAT) marginal emission rate of 0.5 MT CO<sub>2</sub>e/MWh electricity generated, AD on Washington dairies would provide a carbon offset from electricity displacement of 0.07 MMT CO<sub>2</sub>e/year.<sup>10</sup> If a 63% increase in biogas production resulting from co-digestion with OFMSW is assumed, the carbon offset from electricity displacement would increase to approximately 0.1 MMT CO<sub>2</sub>e/year.

Recovered nitrogen (N) and phosphorous (P) fertilizers are expected to be a primary co-product of AD projects. It is reasonable to assume that AD projects will extract approximately 75% of the total phosphorus from AD effluent.<sup>11</sup> At this recovery rate, Washington's 135 largest dairies would be capable of recovering 4,128 MT P/year.<sup>12</sup> AD-recovered phosphorus is expected to be substantially equivalent to triple superphosphate (TSP) and serve as a direct replacement in the marketplace. Since Washington farms applied 15,556 MT P fertilizer inputs in 2001, AD-recovered nutrients would satisfy approximately 27% of on-farm market demand for non-manure P fertilizer.<sup>13</sup> TSP fertilizer production emits 1.1 MT CO<sub>2</sub>e/MT P<sub>2</sub>O<sub>5</sub>. As a direct replacement for TSP, AD-recovered P on Washington dairies would offset an additional 4,541 MT CO<sub>2</sub>e/year.<sup>14</sup> At the expected recovery rate of 75%, Washington's 135 largest dairies may be capable of recovering 33,425 MT N/year.<sup>15,16</sup> AD-recovered ammonium sulfate is expected to serve as a direct replacement for granular N fertilizers in the marketplace. Since Washington farms applied 176,000 MT of synthetic N fertilizer inputs in 2001, AD-recovered N from the largest 135 dairies represents approximately 20% of on-farm market demand.<sup>17</sup> The most common form of dry N fertilizer is urea, the production of which emits approximately 4.0 MT CO<sub>2</sub>e/MT N. As a direct replacement for urea, AD-recovered N on Washington dairies would offset more than 0.1 MMT CO<sub>2</sub>e/year.<sup>18</sup>

In addition to methane capture, electricity production offsets, and nutrient recovery, AD projects may realize embedded GHG reductions from:

- Combined heat and power energy applications.
- Fiber co-products that offset GHG emissions from peat-mining/soil amendment production.
- Methane used as transportation and boiler fuels that offset fossil fuel-based CO<sub>2</sub> emissions.

While not quantified here, it is expected that GHG reductions related to the wide variety of bio-refinery co-products may accrue to the AD project according to the offset protocols applied.

### Summary of Selected AD Offsets

AD Activity	Offset Basis	Offset Potential
Manure Digestion	Captured Methane	0.5 MMT CO <sub>2</sub> e/year
OFMSW Do-digestion	Captured Methane	1.9 MMT CO <sub>2</sub> e/year
Electrical Generation	Displaced fossil fuel-based CO <sub>2</sub> emissions	0.1 MMT CO <sub>2</sub> e/year
Nutrient Recovery	Displaced fossil fuel-based CO <sub>2</sub> emissions	0.1 MMT CO <sub>2</sub> e/year
<b>TOTAL</b>		<b>2.6 MMT CO<sub>2</sub>e/year</b>

### Additionality

The principle of “additionality” attempts to preserve the integrity of the GHG emissions cap by excluding projects that would be expected to occur in “Business As Usual” (BAU) scenario. Tests for the additionality of any particular project range from broad eligibility rules and standardized performance measures to specific, project-based determinations.<sup>19</sup> Regional Greenhouse Gas Initiative (RGGI), for example, includes broad eligibility rules: AD projects located in states with an AD market penetration rate of greater than 5% are declared to be “business as usual” and, therefore, non-additional.<sup>20</sup> In contrast, project-based mechanisms may recognize that BAU scenarios differ from region to region due to localized economic, technological and regulatory barriers to development. Acknowledging the importance of project-specific considerations, the ASCMW believes broad eligibility rules may artificially constrain AD project development and project-specific approaches should be used. The ASCMW is not advocating a novel approach to additionality. Rather, it supports use of existing, project-based mechanisms. The Clean Development Mechanism (CDM), created by the Kyoto Protocol, provides one example of project-based approaches to additionality.<sup>21</sup> CDM acknowledges that BAU characterization may vary dramatically by location or sector. The CDM mechanism applies two initial tests:

1. *Investment Test*: Is the project economically feasible in the absence of offset credit revenue?
2. *Barrier Test*: Are any significant barriers to implementation (e.g., local resistance to new technologies, local obstacles to feedstock procurement) overcome by offset revenue.

If the project passes either initial test, CDM applies a “common practice” (or BAU) test as an ultimate credibility check. Typical BAU approaches that compare the emissions performance of the project to that associated with BAU technologies or activities. If the project does not achieve greater emission reductions than other technologies/activities, it is not considered to be additional. CDM application of this test differs somewhat. It identifies other technologies/activities operating in the region that are similar to the new project’s activity, and considers whether those activities faced barriers or enjoyed benefits that were not applicable to the new project in order to make an additionality determination. In this way, the CDM provides multiple, project-based avenues to additionality. The tool also ensures

credible assessment while recognizing that simplified BAU tests may artificially exclude projects from offset development.

## Baseline Establishment

The issues of additionality and baseline establishment are closely related. A project “baseline” consists of GHG emissions that would be expected to occur in the BAU scenario in the absence of project activity. Therefore, if baseline emissions are determined to be lower than the actual level of BAU emissions, some of the offsets issued for the project will be “non-additional.” The ASCMW believes that the most credible baseline estimates will come from methodologies that include project-specific considerations. Baseline proposals in this section can be divided into two groups:

1. Manure Management and OFMSW Co-digestion baselines: Directly avoided emissions through methane capture.
2. End-use Baselines: Emissions avoided through various end-uses of previously captured methane and/or AD bio-refinery co-products. Offsets related to these end uses are not redundant, but result from carbon-beneficial use of captured methane and AD co-products.

### Manure Management Baseline

It is generally acknowledged that standardized manure management emissions estimates that ignore site-specific factors introduce large uncertainties into a baseline estimate. In an effort to establish credible baselines for methane emissions from conventional manure handling practices, EPA developed a methodology that improves upon standardized estimates by considering site-specific conditions, including (1) volatile solids (VS) available in the manure, (2) ambient lagoon temperature on microbial conversion kinetics, (3) management and design factors such as course solids removal, and (4) VS carry over during long-term storage.<sup>22</sup> In addition, the EPA methodology quantifies broader project emissions, such as

- Methane (CH<sub>4</sub>) and Nitrous Oxide (N<sub>2</sub>O) generated by the baseline manure management system;
- CH<sub>4</sub> that is generated by the project but not combusted by the project;
- N<sub>2</sub>O generated by the project manure management system; and
- CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emitted during any manure management system electricity generation and fuel combustion (including transportation in the baseline systems and the project).

While the protocol can be improved through greater attention to site-specific conditions and/or further study of manure management emissions, it is sufficiently project-based to yield a very credible baseline emission estimate.

### OFMSW Co-digestion Baseline

Although the California Climate Action Registry (CCAR) is expected to publish guidance on baseline development in early 2009, no detailed protocol exists for development of offsets related to co-digestion of OFMSW.<sup>23</sup> In the absence of useful methodologies, two typical approaches to emissions avoidance in OFMSW co-digestion are used:

1. Assume that OFMSW has no CO<sub>2</sub> emissions impact and provide no carbon offset credit.<sup>24</sup>
2. Assume that all OFMSW is destined for uncontrolled anaerobic storage (i.e., landfill) and provide an offset accordingly.<sup>25</sup>

Each approach, by itself, is inadequate to determine a meaningful offset baseline related to co-digestion of OFMSW. The first fails to credit well-documented environmental gains from diverting OFMSW from

landfills or other methane emitting end uses.<sup>26</sup> The second incorrectly assumes that all OFMSW is destined for landfill and, therefore, all methane capture from co-digestion is additional. The ASCMW believes that carbon offsets from methane capture related to OFMSW co-digestion are real, additional, verifiable and creditable emissions reductions. In the absence of rigorous protocols, the ASCMW supports development of a mechanism that includes project-specific assessment of:

1. The initial use from which the OFMSW was diverted (e.g., landfill).
2. The characteristics, including methane generation potential, of the co-digested OFMSW.

Where scientific literature fails to accurately reflect actual emissions profiles of various wastes and/or their uses, primary data collection should be accomplished to ensure credible baseline development. Such a protocol will use reliable emissions data for the wide range of wastes and uses in order to establish project-specific baselines for OFMSW co-digestions offsets.

#### End-use Baseline

In addition to the baseline considerations already mentioned, potential GHG offsets exist from end use of AD-captured methane and the wide variety of AD co-products.

EPA recently established a protocol that addresses offset development from four distinct end uses of AD-captured methane:

1. Generation of hot water or steam from boilers (onsite and offsite).
2. Generation of electricity (displacing onsite fossil fuel use).
3. Delivery of captured methane into a pipeline system or simple conversion to Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG).
4. Other direct uses—retrofits only (e.g., furnaces, kilns, engines, space heaters)—for various commercial and industrial uses, greenhouses, onsite leachate evaporation systems, and cooling.

The EPA protocol is thorough in its emissions quantification for these offset opportunities and should be used for offset development. However, the protocol fails to address offsets related to fossil fuel-derived fertilizer and grid electricity displacements.<sup>27</sup>

Grid electricity production by any AD project is metered and, therefore, directly measurable, but numerous approaches exist for determining the emissions offset that for electricity production. Chicago Climate Exchange (CCX), for example, calculates energy offsets at a rate of 0.4 MT CO<sub>2</sub>e/MWh electricity generated based on a default offset rate of a typical gas combined cycle power plant.<sup>28</sup> In contrast to the CCX approach, CDM provides mechanisms to determine project-based, region-specific offset rates.<sup>29</sup> The Climate Action Team (CAT) offset rate of 0.5 MT CO<sub>2</sub>e/MWh takes regional grid resources into consideration.<sup>30</sup> However, according to the Northwest Power and Conservation Council, higher CO<sub>2</sub> emission costs will result in coal-fired resources being the marginal resource more hours of the year which would yield a higher offset rate for marginal renewable resources in the Northwest.<sup>31</sup> In addition, certain biomass energy sources, such as AD, are not intermittent resources and may be appropriately classed as base load rather than marginal. As base load power, AD projects would likely displace standalone coal-based power at a rate of approximately 1 MT CO<sub>2</sub>e /MWh.<sup>32</sup> The ASCMW believes that use of standardized offset rates without attention to actual, project-specific power resource displacement puts the Northwest region at a disadvantage in the Western Climate Initiative context. The offset rate developed by CAT should be reviewed in light of:

1. Recent studies/data, to include consideration of the increasing presence of coal-fired resources in the marginal power mix.

2. Designation of non-intermittent renewable power, such as AD, as base load power.

No protocols exist for developing carbon offsets related to the wide variety of AD co-products, including recovered nitrogen and phosphorus fertilizers that displace fossil fuel-based products, fiber products that displace peat-mining emissions, and methane transportation fuel that displaces petroleum fuels. Like grid electricity metering, many AD co-products are easily quantifiable because of the closed, controlled-conditions of AD facilities. Moreover, the carbon benefit from various co-product end uses is expected to be real and verifiable in the AD bio-refinery environment. Because of the real, additional and verifiable carbon reductions available from these co-products, protocols should be developed and/or expanded to address to include the climate benefit from these important opportunities.

### **Regulatory Uncertainty Related to AD and AD Co-digestion**

Regulatory uncertainty creates barriers to project development and investment. Currently, the implementation of Federal and State air quality, water quality, and solid waste regulations to AD lacks clarity. Depending on their application to livestock facilities, EPA air quality regulations may support or hinder AD development. Washington State agencies have overlapping and potentially conflicting responsibilities and regulations related to AD. And local health jurisdictions may apply state solid waste regulations dramatically different from county to county. Agencies are working together, beginning to describe regulatory approaches to AD and AD co-digestion of OFMSW. However, if Washington State is to realize offset opportunities related to AD in the near term, regulators and policy makers at all levels will have to provide regulatory clarity and consistency.

### **Recommendations**

***[NOTE FOR WORK GROUP DISCUSSION: Does the group prefer a few broad recommendations with details in the text or many recommendations touching on the issues above. The following recommendations represent the latter approach.]***

#### General

- AD-1** Regulatory programs related to AD carbon offset development should revise protocols whenever scientific advancements demonstrate that existing protocols are inadequate to establish AD baselines reliably.
- AD-2** Carbon offsets from methane capture related to manure and/or OFMSW should be creditable because they are real, additional and verifiable emissions reductions.
- AD-3** Carbon offsets from AD co-products, including recovered nutrients, transportation fuels, and soil amendments should be creditable to AD projects because they are real, additional emissions reductions that are highly verifiable in the context of AD bio-refineries.

#### Baselines

- AD-4 Baselines for offset projects related to manure management AD should be developed using EPA “Climate Leaders Greenhouse Gas Inventory Protocol Offset Project Methodology for Project Type: Management Manure with Biogas Recovery Systems.”**
- AD-5 Baselines for offset projects related to AD co-digestion of OFMSW should include:**
- 1) Project-specific determinations of the initial use from which OFMSW was diverted in order to determine OFMSW offsets reasonably.**
  - 2) The characterization of OFMSW materials and their expected methane production.**
- AD-6 Baselines for offset projects related to AD-captured methane end use (other than grid electricity displacement) should be developed using EPA “Climate Leaders Greenhouse Gas Inventory Protocol Offset Project Methodology for Project Type: Captured Methane End Use.”**
- AD-7 CAT Technical Coordination Team should review offset rates related to AD grid electricity displacement including assessments of:**
- 1) Increasing presence of coal-fired resources in marginal power mix.**
  - 2) Designation of non-intermittent renewable power, such as AD, as base load power.**
- AD-8 Protocol development should consider the full range of real, additional and verifiable carbon offsets available through AD application, including co-products such as recovered nutrients, transportation fuels and soil amendments.**

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