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Agricultural Manure Management and Landfill Gas Capture and Destruction as Emissions Offsets under the Clean Development Mechanism, the Regional Greenhouse Gas Initiative, and U.S. Environmental Protection Agency's Climate Leaders Program

Prepared by the World Resources Institute for
the State of Washington Department of Ecology

August 2008

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Introduction

In effort to inform ongoing internal deliberations in the State of Washington, this paper evaluates the experience with two specific types of offsets: agricultural manure management and landfill gas capture and destruction. For each offset type, three existing offset programs are examined, including the international Clean Development Mechanism (CDM), the Northeast and Mid-Atlantic Regional Greenhouse Gas Initiative (RGGI), and the US Environmental Protection Agency's Climate Leaders program. The paper begins with an analysis of the generally accepted core offset project evaluation criteria—real, surplus/additional, verifiable, permanent and enforceable (RSVP & E). A brief discussion of the two project categories is provided before summarizing each program and explaining how they apply the core evaluation criteria to these project categories.

We note that the subject matter of this paper is one of inherent complexity. The paper seeks to provide a brief introduction and overview of the matters covered, with references to published papers or guidance documents that contain a more thorough treatment of the issues where appropriate. More thorough analysis of the offset types examined would require more time than the assignment anticipated.

General Offset Project Evaluation Criteria

In a cap-and-trade program, emissions offset credits are approved project-based reductions that occur at an emissions source or through an activity not covered by the emissions cap. By definition, offsets are in addition to the cap, and can be used (often to a limited extent) to satisfy compliance obligations under a cap-and-trade program. Expanding the cap in this manner can reduce the cost of an emissions trading program. However, such expansion can also reduce the environmental benefit of the program unless measures are taken to ensure that a reduction achieved through an offsets project is equivalent to a reduction at a capped source. This is accomplished by establishing procedures to ensure that a project-based reduction is real, surplus (i.e., additional), verifiable, permanent, and enforceable (RSVP&E). These terms are commonly understood as follows: [i]

> *Real.* An offset credit is real if it represents an actual net reduction or sequestration in emissions, and is not an artifact of incomplete or inaccurate emissions accounting, including leakage. Leakage is defined as an unintended increase in GHG emissions caused by a project. A frequently cited example of leakage is a forest sequestration project that simply shifts deforestation activities to other forest land, reducing or eliminating the net sequestration from the project.
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> *Additional.* The reduction or sequestration of emissions is additional if it would not have happened in the absence of the offset program. This counterfactual is fundamentally very difficult to prove, and thus different programs have dealt with this differently. Most programs include a screen for "regulatory additionality," which disqualifies those projects required by law, regulation, or judicial or administrative order. Some programs also include "financial additionality" screens that require a demonstration that a project is only viable because of the revenue generated through the receipt of offsets. Meanwhile other programs include performance thresholds and proxies meant to screen out those projects that would have occurred as a result of business-as-usual practices.
>
> *Verifiable.* An offset project is verifiable if it is possible to determine that the reduction or sequestration of emissions has actually occurred and was properly measured and counted.
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> *Permanent.* The reduction or sequestration of emissions is permanent if it cannot be reversed. Permanence is therefore only an issue for those offset types where the effects of a project can be

reversed, such as a forest fire reversing the sequestration of carbon in trees. Neither of the project types evaluated in this paper present any issues with respect to permanence.

Enforceable. An offset program is enforceable if it is backed by regulations and tracking systems that define the creation of offsets and provide for transparency.

While all of these terms are relatively straightforward in the abstract, actual implementation presents challenges. In general, existing programs have sought to balance certainty against administrative practicality.[1]

Landfill Methane Capture and Destruction: Brief Overview[ii]

Municipal waste deposited in landfills is anaerobically digested by bacteria, resulting in emissions to the atmosphere of methane, carbon dioxide, non-methane volatile organic compounds, nitrogen oxides, and carbon monoxide. As a result of these anaerobic processes, landfills account for the single largest source of anthropogenic methane emissions in the United States (25%). While emissions of methane are generally not directly regulated, significant methane emission reductions already occur via three federal regulations that restrict emissions of non-methane organic compounds at larger landfills:[2]

- The New Source Performance Standards (NSPS) for Municipal Solid Waste (40 CFR 60 subpart WWW), regulates landfills that commenced construction or made modifications after May 1991;
- Emission Guidelines (EG) for Municipal Solid Waste Landfills (40 CFR 60 Subpart Cc) – Regulates landfills that commenced construction before 5/30/1991, but accepted waste after 11/8/1987; and
- National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 63 subpart AAAA), regulates new and existing landfills.

Landfills are subject to these regulations if they have a design capacity of at least 2.5 million megagrams and 2.5 million cubic meters of municipal solid waste, and must install gas treatment systems if the calculated uncontrolled emissions exceed 50 megagrams per year. Control of these non-methane organic compounds typically also reduces emissions of methane. Therefore, the primary opportunities for offsets from this sector are from smaller and lower emitting landfills.

Agricultural Manure Management: Brief Overview[iii]

Manure management systems account for 7% of total anthropogenic methane emissions and 4.5% of N_2O emissions, which represent 8% and 5%, respectively, of total US anthropogenic greenhouse gas emissions in carbon dioxide equivalent emissions.[iv,v] Anaerobic digesters produce a more useful form of fertilizer by converting the organic nitrogen into a more bio-accessible form. The resulting product can be applied directly to land, or separated into solid and liquid states. Solid manure product can be used for garden supplements and bedding, while liquid manure product is often applied to agricultural land as fertilizer. Anaerobic digesters can reduce the environmental impact of high density animal feeding operations by reducing odors, water pollution, pathogen activity, and emissions of the greenhouse gases methane and

[1] It is worth noting here that offsets are not the only method available to reward climate beneficial project activities. For example, emissions allowances from under the cap, or auction revenue, can be awarded to projects that cannot meet the RSVP&E criteria.
[2] In addition, there may also be state and local regulations, though they generally follow federal regulations.

nitrous oxide (N_2O).[vi] These can be viewed as co-benefits of carbon offset projects, or as reasons to deploy these systems regardless of a greenhouse gas program.

The reduction in methane emissions by anaerobic digesters is somewhat counter-intuitive as it is anaerobic conditions that create the methane in the first place. However, anaerobic digesters can be equipped with a gas collection system and flare to destroy emissions of methane and other volatized organic compounds.

The best available science suggests that anaerobic digesters may reduce emissions of nitrous oxide. However, there remains a very high degree of uncertainty around estimates of N_2O emissions.[vii] Default emissions factors in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, which serve the basis for Clean Development Mechanism and US EPA Climate Leaders, have an uncertainty factor of two. This means that emissions can be underestimated by 50% or overestimated by 100%. Therefore, to avoid over rewarding offset projects, some programs (e.g., the California Climate Action Registry[viii]) do not reward offsets for estimated N_2O emission benefits. A full review of the nitrogen chemistry and its calculation issues is beyond the scope of this project, but appears to be worth further study.

At this time, anaerobic digesters are not widely deployed, accounting for only 0.07% of dairy manure systems and 0.02% of swine manure systems in 2006.[ix]

Landfill Gas Capture and Destruction and Agricultural Manure Management in the Clean Development Mechanism (CDM). [x,xi,xii,xiii,xiv,xv,xvi,xvii,xviii,xix,xx]

The Clean Development Mechanism: Brief Overview

The Clean Development Mechanism is an international offset program designed to help Annex I countries (i.e., developed countries) comply with their Kyoto emissions obligations by offsetting emissions in their countries with project-based emissions in developing countries. CDM Certified Emission Reductions—the name given to CDM offsets—also may be used by regulated entities under the European Union Emissions Trading Scheme (EU ETS) as a means of compliance. The intent of the CDM is not just to reduce the cost of compliance, but also to promote development in developing countries through technology and capital transfers.

The CDM employs a bottom-up, project-specific approach. That means project developers can at any time propose new methodologies for formal review. Methodology review and project approval requires: engagement of the host country via a local public process and formal national representatives called Designated National Authorities; an international public process; 3rd party verification by Designated Operational Entities; and review by the CDM Executive Board.[3] The CDM's bottom-up process leads to the development of methodologies that are highly tailored to specific projects, and thus not easily applied to a broad number of projects in a single category. As a result, the CDM has begun to develop consolidated methodologies. To date eleven such consolidations have been completed, including landfill gas capture and destruction and agricultural manure management. While these methodologies are consolidated, they are not standardized to the extent of the RGGI or EPA Climate Leaders methodologies. To some extent this may be attributed to the need to adapt to the very diverse circumstances in various developing countries.

[3] For a more detailed explanation of the CDM process see Chapter 2 of the Clean Development Mechanism: A User's Guide (http://www.undp.org/energy/docs/cdmchapter2.pdf), or *CDM in Charts Version 5.1* (http://www.iges.or.jp/en/cdm/pdf/charts.pdf).

RSVP&E. Projects must be verified and certified by Designated Operational Entities (DOEs). Verification is the process of reviewing data and calculations to ensure that reductions claimed actually occurred. By certifying these reductions, the DOE assumes liability for mistakes, misrepresentations, and fraud. For this reason DOEs are required to carry liability insurance to cover underperformance of projects. As DOEs must be accredited, gross negligence or fraud carries the possibility of losing accreditation. To prevent conflict of interest a single DOE cannot be involved in the pre-approval of project eligibility and methods as well as the ex post verification and certification of emissions reduction for the same project unless approved by executive board.[xxi]

The CDM has established a much more elaborate project-specific additionality test than RGGI and EPA's Climate Leaders. The *Tool for the demonstration and assessment of additionality* and the *Combined tool to identify the baseline scenario and demonstrate additionality* lay out multi-step evaluation processes for all project categories.

First applicants must identify alternatives to the offset project. Such alternatives should be consistent with current laws and regulations, but need not be if those laws and regulations are not systematically enforced and noncompliance is widespread. If there are no viable alternatives to the offset project, then it is not considered to be additional.

Second, applicants must perform either an investment analysis or barrier analysis. An investment analysis requires the applicant to demonstrate that the project is either less economically or financially attractive than one or more alternatives, or would not be economically or financially feasible without the revenue from the sale of offsets. A barrier analysis requires the applicant to demonstrate that the proposed project activity faces barriers preventing its implementation and that do not prevent the implementation of at least one of the alternatives.

As a credibility check to the above analyses, the applicant must evaluate the extent to which the proposed project type has already diffused in the relevant sector and region, unless it is a first of its kind.

Landfill Methane Capture and Destruction in the CDM

METHODOLOGY/REAL. Offsets are rewarded for the destruction of methane that would have occurred without the project. This translates into methane emissions captured and destroyed minus those emissions that would have destroyed in absence of the project. Captured emissions can be precisely quantified using continuous emissions monitors. Since emissions that would have been destroyed in absence of the project cannot be directly monitored, they are estimated through a landfill emissions model that incorporates waste-stream composition and annual waste deposition. Baseline calculations assume that landfills covered with soil, compost, or another oxidizing material will destroy 10% of potential methane emissions (i.e., oxidize CH_4 into CO_2 and H_2O).

Projects may also be eligible for offsets if they exceed control levels required by regulation or contract, so long as the quantity of reductions required are subtracted from the offset quantity. Projects may also be eligible for offsets even if methane emissions are already being partially reduced by some control technology before an offset project is installed (that of course increases the methane destruction rate). However, the reductions achieved by these previous activities must also be deducted from the offset quantity.

Physical leakage from the landfill gas capture devise is not directly calculated. If the landfill emission models are accurate, and projects are unlikely to increase the total methane generation capacity, then physical leakage should be captured through these calculations as this would be counted as gas emitted in

the baseline but not counted as gas destroyed by the project. However, it is beyond the scope of this report to evaluate these assumptions, or the landfill emissions model.

Applicants are required to estimate methane emissions from incomplete combustion at the flare using Annex 13, the *Methodological tool to determine project emissions from flaring gases containing methane*. According to this tool, since the efficiency of open flares cannot be measured reliably, projects with open flares must use default combustion efficiency values of 50% (i.e., applications must assume that only 50% of captured methane is actually destroyed in the flare). Enclosed flares should use a 90% default for combustion efficiency, unless the applicant can demonstrate a higher combustion efficiency through continuous monitoring of the flare.

Emissions associated with the generation of heat and electricity are deducted from calculations of emissions benefits. Meanwhile, projects may be eligible for offsets for those emissions avoided through the generation of electricity or supply of thermal energy. This issue is discussed in more detail on page 10 in *Issues Related to Electric Generation*.

This methodology fails to take into account carbon dioxide emissions generated from the oxidation of methane. This issue is discussed in greater detail in Appendix II.

Agricultural Manure Management in the CDM

METHODOLOGY/REAL. Offsets are rewarded for the destruction of methane that would have occurred without the project, and not total methane generated. This means that emissions benefits are calculated as the difference between baseline emissions minus project emissions and leakage. All of these variables are estimated using livestock characteristics. However, projects are required to continuously monitor methane capture by the digester via flow meters, and track ambient temperature. In the event that the measured amount of methane captured is smaller than the baseline estimated using manure management practices, then captured emissions must be used in place of the estimated baseline emissions (and estimates of capture and transport leakage, discussed below).

The CDM methodology takes a system-wide approach to emissions calculations, and requires applicants to account for emissions associated with the entire waste management system, and not just the digester. Applications must also account for all volatile organic solids (which are converted to methane in anaerobic conditions) discharged outside the project boundary (leakage). In accordance with IPCC guidelines, the methodology assumes that 15% of methane emissions will leak out of the gas capture system, and thus not be successfully flared. Applicants may use a lower value if they can demonstrate that it more accurately reflects on the ground conditions. In the event that the generated methane is transported offsite for use elsewhere, applicants must monitor the system for physical leakage of the methane.

As with the landfill gas capture and destruction offset projects, applicants are required to use Annex 13, the *Methodological tool to determine project emissions from flaring gases containing methane*. Thus, open flares must use default combustion efficiency values of 50%, and enclosed flares should use a 90% default for combustion efficiency, unless the applicant can demonstrate a higher combustion efficiency through continuous monitoring of the flare.

Emissions associated with the generation of heat and electricity are deducted from calculations of emissions benefits. Meanwhile, projects may be eligible for offsets for those emissions avoided through the generation of electricity or supply of thermal energy. This issue is discussed in more detail on page 10 in *Issues Related to Electric Generation*.

The CDM methodology includes equations to calculate the N_2O emissions benefits of a given project. As discussed previously, there may be significant uncertainty in these estimates.

The CDM fails to take into account carbon dioxide emissions generated from the oxidation of methane.

Landfill Gas Capture and Destruction and Agricultural Manure Management in the Regional Greenhouse Gas Initiative (RGGI)

The Regional Greenhouse Gas Initiative: Brief Overview[xxii]

The Regional Greenhouse Gas Initiative is a 10-state cap-and-trade program that will regulate emissions of carbon dioxide from large electric generators beginning on January 1, 2009. Participants include the following Northeast and Mid-Atlantic states: Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

RGGI allows regulated facilities to use offsets to cover 3.3 % of their compliance obligation, i.e., their covered CO_2 emissions. The intent for constraining the use of offsets was to encourage reductions by capped electric generators. Offset projects must be located in RGGI states and those US states or jurisdictions that have a Memorandum of Understanding (MOU) with the RGGI states.[xxiii] Cost containment concerns led to the adoption of price triggers that would increase the amount of offsets that can be used to 5% and 10%, and that would allow for the use of certain international allowances and offsets.

RGGI employs a "positive list" approach to offsets, meaning that the program establishes five eligible project categories as well as standards for their evaluation and approval. Those categories are: landfill methane capture and destruction, reduction in emissions of sulfur hexafluoride, sequestration of carbon due to afforestation, reduction or avoidance of CO_2 emissions from natural gas combustion due to end-use energy efficiency, and avoided methane emissions from agricultural manure management operations. This list is intended to be a starting point, and thus may be expanded over time. Future project evaluation standards would likely need to be adopted by regulation in each state.

The RGGI states have established a non-profit corporation, RGGI Inc., to provide technical advisory services to the RGGI states in the development and implementation of their program. However, project review and approval will be done by the RGGI states.

It is important to note that the RGGI offset program is not yet up and running. The Model Rule establishes guidelines for eligibility and accounting methodologies. However, there is only so much guidance that can be provided through regulatory language, and the RGGI states are developing application forms and guidance documents to fill in the gaps.

RSVP&E. RGGI requires that all offset projects be real, additional, verifiable, enforceable, and permanent. These terms are not defined, but are incorporated into project standards and evaluation protocols. Projects must be verified by accredited independent parties (i.e., 3rd party verifiers). Applications must be certified by the applicant and the independent verifiers. Furthermore, a centralized registry of projects will be maintained so that applicant activity can be monitored. Malfeasance can disqualify an applicant from submitting future applications.

RGGI requires projects to meet strict regulatory additionality criteria (i.e., projects cannot be required by federal, state, or local law, regulation, or administrative or judicial order). RGGI has sought to apply

specific performance thresholds and other proxies for additionality to screen out those projects that likely would have occurred anyway (i.e., in absence of the offset program). Furthermore, projects are not eligible for offsets if they receive funding or other incentives from any system benefit fund, or funds or other incentives provided through the consumer benefit or strategic energy purpose allocation required according to the RGGI MOU (25% of each states allowances). As a general matter, RGGI does not consider projects to be additional if they include an electric generation component, unless legal rights to all attribute credits (e.g., Renewable Energy Credits, or RECs) are transferred to the state or its agent. Interestingly, there agricultural manure management offset category includes limited exceptions to this requirement.

Landfill Methane Capture and Destruction in RGGI

ADDITIONALITY. Projects are only eligible for RGGI offsets if they occur at landfills that are not subject to the New Source Performance Standards (NSPS) for municipal solid waste landfills, 40 CFR Part 60, Subpart Cc and Subpart WWW. There is no indication that the omission of the National Emission Standards for Hazardous Air Pollutants (40 CFR 6 2 subpart AAAA) is intentional, and it is unclear whether projects subject to these regulations would meet the general additionality requirements (i.e., projects cannot be required by local, state, or federal law, regulation, or administrative or judicial order). This may be clarified in forthcoming guidance documents. It is currently unclear what means to be "subject to" these regulations, which simply govern emissions rates, and do not prescribe specific technologies. As such, these regulations could be interpreted to exclude those projects that have an emissions rate below that required by law even if they do not already flare, and could do so to obtain additional emissions benefits. Alternatively, this language could be interpreted more broadly understanding to include those projects. Guidance documents under development for the RGGI program will likely clarify this issue. It is worth noting that the more stringent interpretation of the existing RGGI language may be desirable under certain circumstances, for example if one wishes to employ a more stringent and administratively simpler additionality screen.

METHODOLOGY/REAL. Among eligible projects, offset allowances are awarded for 88% of methane emissions monitored (via continuous emissions monitors) and flared. This is because emissions benefits are deducted by 10% to account for those methane emissions that would have been naturally oxidized by the soil. The other two percent is deducted to account for methane that is sent to, but not destroyed by the flare (assumes the flare is 98% efficient).

RGGI s calculations do not account for methane emissions that escape from the cap or leaking valves or seals. While most of these emissions would have occurred in absence of the project, they would be oxidized 10% by the soil had a gas collection system not been installed. However, if these leaks are small, then this discrepancy would not be significant.

RGGI fails to deduct the carbon dioxide emissions generated by the combustion process from the offsets awarded. RGGI does not account for emissions associated with project construction or equipment related to project operation. Leakage is not discussed in the Model Rule.

Agricultural Manure Management in RGGI

ADDITIONALITY. In order to be eligible for offsets, digester input must be greater than 50% manure. Furthermore, the organic food waste input must be only that which would have otherwise been stored anaerobically. RGGI carved out an exception to its general additionality criteria for certain types of digester projects. Specifically, certain projects may receive funding or other incentives from a system benefit fund or through the consumer benefit or strategic energy purpose allocation required according to

the RGGI MOU, and may have an electric generation component without forfeiting other emissions attributes generated (e.g., RECs). To meet the exception, digesters must be located in a state that has a market penetration rate of 5% or less, or at farm with 4,000 or less head of dairy cows (or equivalent animal units), or must be a regional-type digester designed to accommodate 4,000 or less head of dairy cows (or equivalent animal units). While the RGGI Model Rule allows developers of these projects to receive both RECs and offsets, it is not clear that such double dipping would be allowed by the project developer under consumer protection laws (a more thorough discussion of this occurs on page 10 in *General Issues Related to Electricity Generation*).[xxiv]

METHODOLOGY/REAL. RGGI only awards offsets to eligible projects for methane emissions that were destroyed that would have been produced under uncontrolled anaerobic storage conditions and released directly to the atmosphere in the absence of the offset project. Baseline emissions are calculated based on measured manure input (kg/month), characteristics (i.e., total solids concentration and volatile solids concentration), and ambient temperature.

RGGI does not award offsets for reductions in emissions of nitrous oxide. There has been no publicly stated rationale for this. However, as stated previously, there is a high degree of uncertainty in nitrous oxide emission estimations, and for that reason some other programs do not reward projects for reductions in nitrous oxide emissions.[xxv]

While RGGI accounts for the combustion efficiency of landfill flares, it does not appear to account for the combustion efficiency of anaerobic digesters. RGGI also does not appear to account for the collection efficiency of anaerobic digesters. It is not clear whether these were deliberate decisions or methodological oversights, and it is not inconceivable that such calculations will be incorporated into the program after clarification in future guidance documents.

The program fails to account for the emissions of carbon dioxide caused by the combustion of methane. RGGI requires transport emissions to be accounted for in offset calculations for regional digesters only

Landfill Gas Capture and Destruction and Agricultural Manure Management in U.S. Environmental Protection Agency's Climate Leaders Program[xxvi]

U.S. EPA's Climate Leaders Program: Brief Overview[xxvii]

The Climate Leaders Program is a voluntary program run by the U.S. Environmental Protection Agency wherein partner companies commit to reducing greenhouse gas emissions and annually report their progress. This program only recently incorporated an offsets component, and published standards for the following six project categories: Reforestation/afforestation, commercial boiler efficiency improvements (space and hot water heating), industrial boiler efficiency improvements (industrial process applications), landfill methane collection and combustion, managing manure with biogas recovery systems (i.e., anaerobic digester), and transit bus efficiency improvements.

RSVP&E. EPA requires that all offset projects be real, additional, permanent, and verifiable, and embeds project-specific requirements into its methods. The Climate Leaders Program lacks 3rd party verification procedures, and historically EPA has not sought to verify reports via the Climate Leaders program. Therefore, while EPA requires that offset project performance be readily and accurately quantified, monitored, and verified, it is not clear that there is any process for them to actually ensure that is indeed the case. The voluntary EPA Climate Leaders program does not include "enforceable" among its offset project evaluation criteria.

METHODOLOGY (general). In a notable departure from the CDM & RGGI programs, EPA's Climate Leaders offset program requires project developers to assess emissions associated with project construction. Without any projects reported to date, it is premature to say just how significant an impact this will have on emissions calculations, however it seems as though construction emissions could represent a small fraction of total emissions for those project categories that are examined here. However, it is worth noting that this requirement does set a precedent that may prove quite significant in other, unexamined, project categories.

Landfill Methane Capture and Destruction in U.S. EPA's Climate Leaders Program[xxviii]

ADDITIONALITY. To be eligible for offsets, a project cannot be required by law. Projects are considered to be additional if landfill gas is not currently collected and combusted. Projects are also considered to be additional if only a minimal amount of landfill gas is currently collected and combusted, and a new system is added on to collect and destroy gas, so long as add-on system is separate from existing system, or monitored separately. Note that only those emissions destroyed by the new system are eligible for offsets.

METHODOLGY/REAL. Emissions benefits are calculated as captured and destroyed methane emissions minus 10% to account for those emissions that would have been naturally oxidized (and destroyed) by the soil in the absence of the project. A combustion efficiency of 98% is assumed. Landfill emissions can be monitored continuously or sampled monthly. Emissions associated with project construction and operation of collection and combustion equipment are also deducted from the emissions benefits (and thus offsets). EPA is still evaluating whether or not energy capture equipment should be eligible for offsets.

Project developers can use EPA's Landfill Gas Emissions Model, LandGEM, to estimate pre-project emissions and therefore quantify the potential financial benefit before deciding whether or not to invest in the activity.

As discussed in more detail in Appendix II, EPA's calculations fail to account for the carbon dioxide created by the oxidation (i.e., destruction) of methane. It is also worth noting that EPA's calculations do not account for methane emissions that escape from the cap or leaking valves or seals. EPA asserts that this is appropriate because these methane emissions would have occurred in absence of the project. However, this is not internally consistent with EPA's own methods, which deduct 10% from flared methane emissions to account for the methane that would have been naturally oxidized by the soil had a gas collection system not been installed. If these leaks are small, then this discrepancy would not be significant.

EPA asserts in its guidance documents that leakage is not expected to occur. However, if it is determined that leakage is likely, then leakage must be quantified and deducted from offset allowances.

Agricultural Manure Management in U.S. EPA's Climate Leaders Program[xxix]

ADDITIONALITY. To be eligible for offsets, a project cannot be required by law. Projects are considered to be additional if they did not previously collect and combust manure gas.

METHODOLOGY/REAL. EPA's guidelines define agricultural manure management projects more broadly than just the anaerobic digester. Instead, the project boundary includes all manure collection systems, storage and treatment areas, transportation, construction, and maintenance of the gas collection system.

Emission reductions are estimated using livestock characteristics, temperature, and gas collected. While direct continuous or monthly measurement of methane is preferred, modeling is acceptable. NO_x emissions are modeled. Offsets are based on emissions that would have occurred in the baseline scenario that were avoided. Therefore, applicants must quantify the methane and N_2O generated by the baseline manure management system, methane generated by project but not combusted, N_2O generated by each manure management system, and all emissions associated with fuel combustion at the manure management system. Projects must account for the digester's methane collection efficiency. According to EPA's guidance documents, capture efficiency is typically very high (i.e., greater than 95%). However, covered anaerobic lagoons with modular impermeable surfaces can have capture efficiencies as low as 50% depending on the fraction of lagoon surface area covered. Calculations assume a 98% combustion efficiency.

It is worth noting that EPA's AgSTAR FarmWare 3.0 can be used by project developers to help estimate methane production from digester, and therefore the potential financial benefits of a project before implementation.

As with the landfill gas capture and destruction methodology, Climate Leaders fails to account for the carbon dioxide generated from methane oxidation. EPA includes N_2O emissions benefits in the offset calculations, which some programs have avoided doing due to the scientific uncertainty associated with these estimates.

For this type of project, leakage is defined as increased emissions caused by the project, but not accounted for in the project boundary. EPA's methodology document asserts that these projects are not expected to result in leakage. However, if significant emissions are caused outside the project boundary by the project, they must be quantified and deducted from calculations of offset allowances. It is not clear how often such emissions would be calculated and reported as leakage without specific guidance requiring project developers to assess these emissions.

Issues Related to Electricity Generation

Both of the discussed project types are beneficial from a climate change perspective as they reduce emissions of methane to the atmosphere via combustion. These processes generate heat that can be used to produce useful steam or electricity. Whether or not the generation of useful steam or electricity should be credited depends on the nature of the program served by the offsets, and the broader regulatory framework.

For example, if electric sector is capped, then providing offsets for the generation of electricity would artificially inflate the cap, compromising the environmental integrity of the program. Under an economy-wide cap-and-trade program that covers all fossil fuel combustion, rewarding offsets for the production of useful steam would produce the same environmentally detrimental outcome.

It is also important to consider the interaction of an offsets program with Renewable Portfolio Standards (RPS). Implicit in some classes of Renewable Energy Credits (RECs) is that the electricity will come from a carbon-free, or greenhouse gas positive, source. Providing offsets for that process undoes those carbon benefits by allowing entities covered in a cap-and-trade program to emit more. Thus in a sense offsets turn "renewable" energy providers into carbon emitters. It is worth noting here that the National Association of Attorneys Generals have considered this matter and produced Environmental Marketing Guidelines for Electricity, which essentially conclude that project developers that obtain and use both RECs and offsets for the same activity may be violating consumer protection laws.[xxx]

In its general additionality requirements, RGGI explicitly excludes projects that include an electric generating component unless any and all attribute credits (e.g., RECs) are transferred to the RGGI states (where they would be held and not used or resold). As noted previously, a specific exception to this standard is provided to small agricultural manure management facilities located in states with low market penetration of anaerobic digesters.[xxxi] This was based on the recognition that digesters require significant economic stimulus to be viable. However, it is worth restating that it is not clear how this policy interacts with consumer protection laws. EPA's climate leaders program has not yet announced how it will treat useful steam and electric generation from these project categories. The CDM does allow projects to receive offsets for electric generation as there is currently no binding cap on carbon dioxide emissions in any developing country.

Conclusion

Each of the three programs reviewed has developed offset project evaluation criteria for both landfill methane capture and destruction and agricultural manure management after carefully weighing the needs of environmental integrity with perceived administrative feasibility and the role of the program (e.g., whether it is regulatory or voluntary, domestic, or international). Each program provides its own valuable lessons that can be applied to future domestic offset programs, and so future programs may wish to incorporate elements of each. As specific policies are evaluated it is important that regulators also consider how precisely an offset program will interact with the cap-and-trade program it serves, and whether or not it creates perverse disincentives for future regulation of sectors currently eligible for offset project categories.

Appendix I: Program Summary

	CDM	RGGI	Climate Leaders
Program Type	regulatory	regulatory	voluntary
Additionality Metrics	regulatory additionality, but applicant may consider to what extent actually enforced	regulatory additionality	regulatory additionality
	alternatives assessment followed by investment or barriers analysis, & then common practice analysis	only reward projects that exceed performance standards	projects must exceed business as usual activities
Involves Public Process	yes	no	no
Calculations: General			
Global Warming Potentials Employed (IPCC Assessment used)	2nd assessment	3rd assessment	2nd assessment
Account for CO2 emissions from Flares	no	no	no
Account for Construction Emissions	no	no	yes
Calculations: Landfill Methane Capture and Destruction			
Include Soil Oxidation (10%)	yes	yse	yes
Include Emissions Associated with Operation of Project-related Equipment	yes	no	yes
Account for Combustion Efficiency	yes, default 90% for closed flare, 50% for open flare, unless can demonstrate should be higher	yes, assume 98% combustion efficiency	yes, assume 98% combustion efficiency
Account for Physical Leakage from Capture System	indirectly due to modeling of baseline emissions	no	no
Primary Project Parameters Measured	continuous monitoring of captured gases, model baseline emissions	continuous monitoring of captured gases	continuous or monthly monitoring of captured gases
Calculations: Agricultural Manure Management			
Include Emissions Associated with Project Development and Operation	yes, heat and electricity use	manure transport for regional type digesters	manure transport, construction, electricity for blowers and heaters
Include N2O Emissions	yes	no	yes
Include AWMS beyond digester	yes	no	yes
Account for Combustion Efficiency	yes, default 90% for closed flare, 50% for open flare, unless can demonstrate should be higher	not in Model Rule	yes, assume 98% combustion efficiency
Account for Physical Leakage from Capture System	yes, assume 15%, unless demonstrate that lower	no	yes, applicant determines
Primary Project Parameters Measured	livestock characteristics, fraction of manure treated by each AWMS, ambient temperature	gas captured (monitored), measured manure input & characteristics, ambient temperature	livestock characteristics, gas captured (monitoring preferred, can be modeled), ambient temp

*AWMS = Agricultural Waste Management System

A note about Global Warming Potentials (GWP).[xxxii] RGGI and CDM selected Global Warming Potentials based on the most current science at the time the programs came into existence, and fixed those global warming potentials for the immediate future. RGGI will employ the Global Warming Potentials found in the 3rd assessment for the duration of the program, unless state regulations are amended. Meanwhile, the CDM will employ the GWPs found in the 2nd assessment through the end of the 1st commitment period of the Kyoto Protocol (2012), and may subsequently change them as scientifically justified.[xxxiii] EPA climate leaders uses GWPs from the Second Assessment Report to be consistent with current international agreements.[xxxiv] Locking in a single set of GWPs for a set period of time provides investment certainty to project developers. However, for programs that are long-term in nature it may be appropriate to retain the ability to update standards at some set time interval so that the program retains environmental integrity. Employment of different GWPs is not expected to present barriers to linkage so long as new programs are based on recent science, and existing programs do not use overly outdated science.

Appendix II: Estimating Emissions Benefits from Methane Destruction

Both landfill methane capture and combustion and agriculture manure methane management provide environmental benefit primarily through the conversion of methane to carbon dioxide. While both are greenhouse gases, this conversion is beneficial because the more potent greenhouse gas (methane) is converted into a less potent greenhouse gas (carbon dioxide). According to the most recent assessment by the Intergovernmental Panel on Climate Change, over a 100 year timeframe, methane will exert an effect 25 times more powerful than carbon dioxide.[xxxv] Thus if one were to capture one ton of methane and sequester it so that it could not be released into the atmosphere, it would have the equivalent benefit of preventing the release of 25 tons of carbon dioxide to the atmosphere. However, that is not what actually occurs. Instead, that ton of methane is converted into carbon dioxide, 2.8 tons of it to be precise. (This is because the lighter hydrogen molecules are replaced with heavier oxygen molecules as shown below.)

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Thus the actual atmospheric benefit of this process is 25 – 2.8, or 22.2 tons of carbon dioxide. However, none of the programs analyzed account for the actual chemical processes that occur. Instead, both programs have decided that the carbon dioxide emitted from this conversion process does not need to be subtracted out of emissions benefit calculations because it is "biogenic" in nature, and would have been emitted if the anaerobic conditions were never created. While the observation is correct, and may impact how one handles an emission inventory, it should not impact the calculation procedures for offsets. To be scientifically accurate, general calculation methodologies should be able to distinguish the hypothetical scenario of sequestering methane from the practice of turning that methane into carbon dioxide. Therefore, if one uses the most current global warming potentials, the actual benefit of converting a ton of methane into carbon dioxide is 25 – 2.8, or 22.2 tons of carbon dioxide equivalent emissions.

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