ANAEROBIC DIGESTION TECHNOLOGY:

HOW AGRICULTURAL PRODUCERS—AND THE ENVIRONMENT—MIGHT PROFIT FROM NUISIANCE LAWSUITS

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Abstract:

This article focuses on anaerobic digestion—a technology that converts biomass into methane that can be captured and used as biogas. The methane gas can also be converted into electricity through a generator. The biogas and electricity can be used at the facility where the biomass (such as livestock waste) is collected, or the electricity could be sold to the grid if net metering policies are available. There are also environment benefits from waste management, like methane destruction and prevention of nutrient run-off.

The typical on-farm anaerobic digestion unit costs approximately $1.2 million. Additional operating expenses (like digester repair and water costs) increase annual operating costs. As a result of the high up-front and operating costs, anaerobic digestion is not economically feasible in many areas of the nation, including the U.S. West, where energy prices are relatively low.

This article demonstrates that anaerobic digestion might be economically feasible when agricultural operations avoid the costs associated with a nuisance lawsuit. In fact, once the digester is actually installed and the costs of an imminent lawsuit are offset, the agricultural operation might financially profit from the technology. As a result of being forced to incur the up-front capital costs to mitigate a lawsuit, agricultural producers might be able to cover the operating costs of an anaerobic digester, and the project might serve to generate profit. The anaerobic digester can also improve environmental quality, as measured by a reduction in greenhouse gas (GHG) emissions and improved nutrient management practices. This article summarizes results based upon primary data collected from locations in the U.S. West, and a case study of Wyoming Premium Farms, a 20,000 swine operation in Wheatland, Wyoming.

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Catherine M.H. Keske[1]

I. Introduction

Nuisance lawsuits at the agricultural-residential fringe present significant risks to the economic viability of agricultural operations. Despite the prevalence of Right-to-Farm Laws in many states[2], agricultural producers report that the threat of a nuisance lawsuit frequently weighs heavily on their minds, even when the legal action has not been taken.[3] Research shows that nuisance lawsuits along the agricultural-residential fringe appear to be increasing in severity, as measured by damage awards and the impact on the community.[4]

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[2] Determinations of priority use, and case laws are often conflicted and paradoxical. See T.J. Centner, Agricultural nuisances: curbing the right-to-farm, Choices, 41-45. For a good summary of factors to consider for the mitigation of nuisance lawsuits, consult: Farm Protection from Nuisance Lawsuits. Penn State University. http://law.psu.edu/_file/aglaw/Farm_Protection_From_Nuisance_Lawsuits.pdf. Last accessed October 29, 2011.

[3] J. Lisansky, M.S. Andrews, R.A. Lopez, The Determinants of Right-To-Farm Conflicts 55 (2) Rural Sociology 246-255 (1988).

[4] Joshua M. Duke and Scott A. Malcom. Legal risk in Agriculture: Right-to-Farm Laws and Institutional Change 75 Agricultural Systems 295 (2003).

It is well established that the tort system is commonly used in environmental policy to drive costs to the point where a party is forced to forego—or adopt—practices desired by the opposing party. This is frequently chastised by economists as an inefficient approach to environmental policy, and detrimental to technological innovation.[5] However, lawsuits can also improve the efficient allocation of environmental goods. For example, in the absence of lawsuits, right-to-farm laws might result in commodity over-production, at the expense of environmental degradation such as nutrient run-off from animal waste.[6] Specifically, in the case of densely populated animal operations, if not for concern over a possible nuisance lawsuit, agricultural producer might increase the size of the operation environmental goods without regard for unpleasant odor or nutrient run-off. Other environmental costs which escape nuisance lawsuits at this time (like greenhouse gas emissions) might also be incurred. In fact, societal costs of agriculture that are not directly borne by the producer present a classic illustration of an environmental externality. Thus, threat of a nuisance lawsuit is one means for providing incentive for agricultural producers to reduce negative environmental and societal impact.

This article demonstrates that in some cases when a nuisance lawsuit involving an agricultural operation is imminent, the agricultural producer might be able to install technology that could result in profits for their operation. Specifically, anaerobic digestion technology becomes economically feasible when agricultural producers are in a position to mitigate lawsuits that might otherwise result from odor and waste management. In other words, a nuisance lawsuit

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[5] See in general, W. Kip Viscusi, The Social Costs of Punitive Damages against Corporations in Environmental and Safety Torts 87 Geo. L.J. 285 (1998-1999).

[6] See in general, John C. Bergstrom and T.J. Centner, Agricultural Nuisances and Right-to-Farm Laws: Implications of Changing Liability Rules 19(1) Review of Regional Studies 23-30.

can serve as the mechanism that makes a technology economically feasible, while reducing environmental impact.

This article focuses on anaerobic digestion—a technology that converts biomass into methane that can be captured and used as biogas, or that can be converted into electricity through a generator. The biogas and electricity can be used at the facility where the biomass is collected, or the electricity could be sold to the grid if net metering policies are available.[7] In addition to energy generation and greenhouse gas reduction, anaerobic digestion also reduces odor—an important consideration for agricultural operations, including swine and dairy facilities. Odor is also a key factor in several nuisance lawsuits.

This article presents the author's original research illustrating that mitigating imminent nuisance lawsuits can potentially can make anaerobic digestion technology economically feasible in the U.S. West.[8] The data presented in this project were collected in a case study of Wyoming Premium Farms in Wheatland, Wyoming[9]. An enterprise budget is presented to illustrate the potential on-farm profitability of an anaerobic digester that has been built to mitigate a nuisance lawsuit. Results show that lawsuit mitigation can offset most of the up-front capital costs. Once the digester is installed, so long as producers are able to offset operating costs, the anaerobic digester can add profitability to the operation. In addition, the anaerobic digester provides

[7] Some utilities have "net metering" policies, where small energy generators (like those with an anaerobic digester), can offset their energy consumption by producing their own electricity. The value of the energy offset varies by utility.

[8] Much of the original research in this article is based upon findings presented in a report to the Colorado Governor's Energy Office. See Catherine M. Keske, Economic Feasibility Study of Colorado Anaerobic Digestion Projects (2009), available at: http://soilcrop.colostate.edu/keske/index.html.

[9] Photographs of the Wheatland, Wyoming anaerobic digester are available in Appendix B.

environmental benefits from reducing nutrient loading from animal waste. Overall methane and CO_2 emissions are also reduced. In other words, in the case of anaerobic digestion, both producers and the environment might be able to profit from a nuisance lawsuit.

II. <u>Anaerobic Digestion Energy Technology</u>[10]

Anaerobic digestion is a biological process by which microorganisms convert organic material into biogas, containing methane and carbon dioxide. Biogas produced by this process can be utilized to generate electricity or can be cleaned up and supplied to natural gas lines. A presentation of this bio-chemical process is shown in Figure 1.0. This figure illustrates that in the digester, organics are removed as they are converted to methane while nutrients (nitrogen and phosphorus) are conserved. The end product is a low odor, high nutrient, stabilized waste suitable for land application as fertilizer. The results of the bio-chemical process also provide positive environmental benefits. The GHGs are not released from the animal waste into the atmosphere, and the non-point source nutrients are not available as run-off.

[10] Technical material presented in Section II was first published by Catherine Keske and Sybil Sharvelle, In: Technical and Economic Feasibility of Anaerobic Digestion: (Sybil Sharvelle and Catherine Keske, Eds.), Montana State University Extension (2011) URL: E3Ainfo.com . Final website address is still pending.

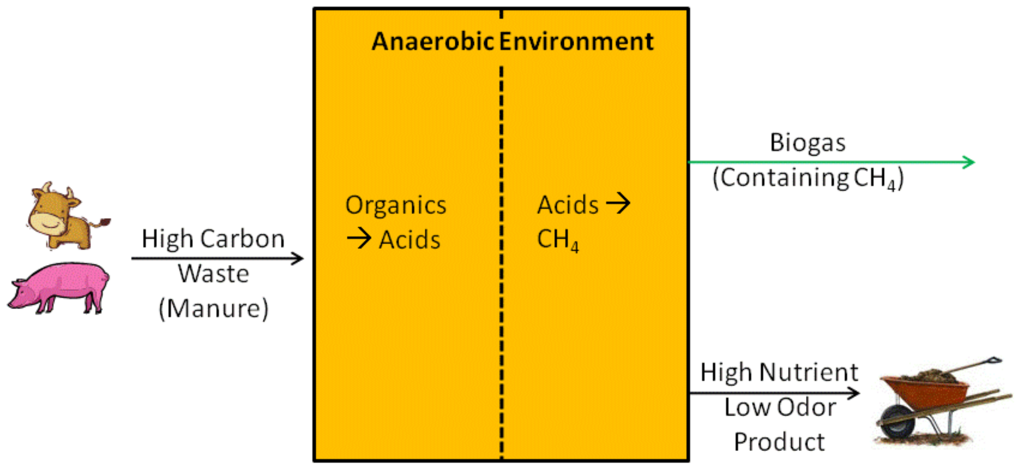

Figure 1.0 Depiction of Anaerobic Digestion Process

Anaerobic digesters are typically large reactors constructed of either concrete or steel. The volume of the reactor depends on the volume of wastes to be processed in the system. With most conventional digesters, a holding time of 20 - 30 days is required to convert manure solids into methane. Methane gas can be utilized onsite, serve as fuel for an electricity generator, or be purified and supplied to natural gas lines (Figure 2.0). Recently, there is a growing interest in purification of biogas for resupply to natural gas lines due to high maintenance requirements for electricity generators. This requires that all gas components aside from methane are removed.

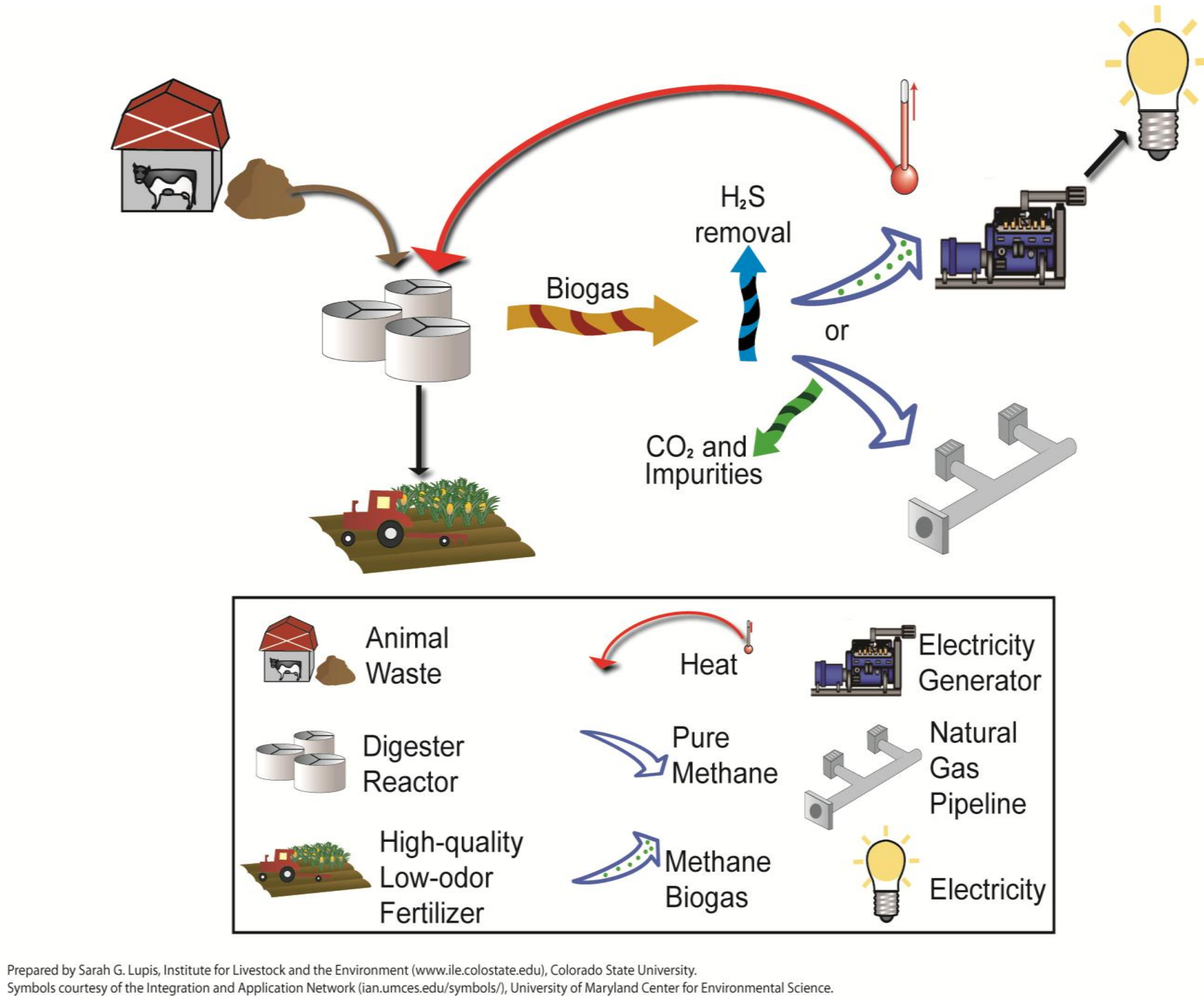

Figure 2.0 Anaerobic Digestion System Configuration

Dilution of waste with water is most practical when there is an available source of wastewater; therefore, it is not uncommon for anaerobic digestion technology to be implemented at waste water treatment plants.[11] The improvements to air (including odor reduction) have led

[11] U.S. Department of Energy, Federal Energy Management Program, Biomass and Alternative Methane Fuels (BAMF) Super ESPC Program, ORNL 2004-02594/abh (July 2004), Available at: http://www1.eere.energy.gov/femp/pdfs/bamf_wastewater.pdf

several agricultural operations to implement anaerobic digestion in different areas of the country, but with mixed success. As reported by U.S. EPA AgStar, 18% of the anaerobic digestion units built for agricultural farms have been shut down for technical and economic reasons.[12] This high shut-down rate is particularly dramatic when considering that the median start-up cost for an AD unit is $1.2 million.[13] The majority of the anaerobic digesters still in operation are in the eastern U.S., where water is more abundant. In arid climates animal wastes, as collected, can have very high solids content because waste management methods applied at dairies located in the arid west differ from other parts of the United States. For example, water is not usually utilized to flush dairy barns in Colorado as is done in areas where water is plentiful. Instead, manure is often scraped from concrete floors or dry lots. While dairy waste has a solids content of 10-14% as excreted, solids content has been measured as high as 90% on dry lots in Colorado. For wastes containing more than 20% solids, substantial quantities of water may be required for anaerobic digestion. This can add to the cost of operating the digester. In addition, when clean groundwater is added to an anaerobic digester, it will adsorb nutrients and pathogens which may then create more Removal of rocks, soil, and sand typically involves addition of water to the waste and subsequent settling of the particles, thus adding complexity, capital cost, and additional maintenance for an anaerobic digester system in the western U.S.

[12] U.S. Environmental Protection Agency AgStar Program, Project Report (July 2011), available at: http://www.epa.gov/agstar/projects/index.html. Last Accessed October 29, 2011. Statistics do not include those reported under construction.

[13] *Supra* 12.

III. Estimated Costs of Nuisance Lawsuits: A Summary of Verdicts

Both technology providers and agricultural operators affirm that anaerobic digestion units effectively reduce agricultural odors that often prompt nuisance lawsuits.[14] Anaerobic digestion units can provide a measurable reduction in odor, in addition to playing a role in the management air emissions, water quality, and waste management.[15] Proper management of all of these environmental quality aspects can help to improve neighbor relations and mitigate nuisance lawsuits on agricultural operations. However, when faced with high anaerobic digestion capital investment costs, it can be difficult to determine whether the large investment justifies potential future legal expenses.

While legal costs are frequently calculated in the cost of doing business, the risk associated with an odor-related nuisance lawsuit can be difficult to estimate. The majority of cases are settled outside of court and insurance companies typically subsidize the settlements. Furthermore, when nuisance verdicts are handed down by courts, documentation of the damage

[14] Keske *supra* note 13.

[15] John H. Martin, *An Assessment of the Performance of the Colorado Pork, LLC. Anaerobic Digestion and Biogas Utilization System.* Report submitted to Kurt Roos, U.S. Environmental Protection Agency AgSTAR Program. EPA Contract #68-W7-0068 March 18, 2003. Dr. Martin's technical report also included an economic analysis, which noted an *annual loss* in farm income at $931/year or $0.19 per unit of sow capacity per year. The rate of return with internal financing, which was the method of financing the CP system, was slightly less than seven percent. The start-up project capital expenses were heavily subsidized by federal funding.

awards (which include punitive damages) can be challenging to find. Not all verdicts and settlements are reported. Also, opinions from appellate judges don't routinely mention awards.

A summary of recent nuisance lawsuit awards and settlements can be found in Figure 3.0. The cases are ordered by year. Also listed are the states where the lawsuit was filed, case or plaintiff as available, and type of operation. The settlement and damage values (which include punitive damages) have not been corrected for inflation. The type of agricultural operation is listed on the right hand column.

Figure 3.0 Summary of Financial Awards from Agricultural Nuisance Suits Involving Odor

Claims Awarded in Nuisance Suits				
Year	**State**	**Award**	**Plaintiff/Case**	**Operation**
1991	NE	$375,600	Kopecky v. National Farms, Inc.	Swine
1996	KS	$12,100	Settlement—plaintiff/respondent both undisclosed in news article.	Swine
1998	KS	> $15,000	Twietmeyer v. Blocker	Beef feedlot
1999	MO	$5,200,000	Vernon Hanes et al. v. Continental Grain Company	Swine
2001	OH	$19,182,483	Seelke et al. v. Buckeye Egg Farm, LLC and Pohlman	Egg/Poultry
2002	IA	$33,065,000	Blass, McKnight, Henrickson, and Langbein v. Iowa Select Farms	Swine
2004	OH	$50,000,000	Bear et al. v. Buckeye Egg Farm, Anton Pohlman and Croton Farms, LLC	Egg/Poultry
2006	AL	$100,000	Sierra Club, Jones, and Ivey v. Whitaker and Sons LLC	Swine
2006	MO	$4,500,000	Turner v. Premium Standard Farms Inc.; Contigroup Co., Inc.	Swine
2007	IL	$27,000	State of Illinois (Plaintiff). Respondent undisclosed.	Swine

The awards listed in Figure 3.0 ranged from $12,100-$50,000,000. Seven of the ten reported cases involved swine operations. Two cases involving large awards were against the same owner of two Ohio egg production facilities. There was one example of a settlement to a Kansas cattle feedlot. Six of the documented cases occurred west of the Mississippi.

Blass et al. v. Iowa Select Farms presents the most unusual case, because a high punitive damage award ($32,065,000) was distributed to only four neighboring farm couples. Most large awards of that magnitude involve class action lawsuits. In this case, couples reported having been subject to noxious gases, offensive odors and excessive amounts of flies. The couples sued Iowa Select Farms complaining that improperly-disposed-of swine carcasses and unsanitary conditions created health risks. The couples also alleged that Iowa Select willfully and recklessly located the 30,000-hog facility on the 640-acre farm without regard to its impact on neighbors. An expert at trial testified that the farm produced as much excrement as 90,000 to 150,000 people.[16]

In addition to information gathered from legal databases, personal interviews with western agricultural producers yielded similar results. Mr. Doug Derouchey of Wyoming Premium Farms in Wheatland, Wyoming reported that his operation spent approximately $200,000 in legal fees fighting two lawsuits, in which plaintiffs were seeking approximately $2,000,000 in punitive damages. [17]

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[16] Jean Hays, *Jury Punishes Feedlot Owner for Making Neighbors' Lives Miserable.* The Wichita Eagle. May 27, 1998. See also Mark Harrison, *Hog Farmers Settle Lawsuit.* The Fort Payne, Alabama Times-Journal. June 23, 2006.

[17] In personal communication with Mr. Doug Derouchey, he reports that the farm's single most important consideration for purchasing an AD unit mitigation of nuisance lawsuits. He estimates that earlier this decade, Wyoming Premium Farms paid roughly $200,000 in legal costs to fight two nuisance lawsuits, where the plaintiffs were seeking a total of approximately $2 million in punitive damages. The digesters were built as part of this negotiated settlement agreement. Personal interview and site visit July 22, 2009.

Evidence of large legal awards provides context for the enterprise budget shown in Figure 3.0. An imminent lawsuit that could result in more than $5.9 million in damages (including punitive damages) or fines in one year would overcome a 20% decrease in revenues and an increase in costs, from the expected conditions presented in the enterprise budget. In other words, preventing legal conflict can justify the net losses from an AD project.

IV. Installation of an Anaerobic Digester to Mitigate a Nuisance Lawsuit: A Case Study of Wyoming Premium Farms, LLC[18]

As noted in Section III., many of the nuisance claims on record involve swine operations. Cases with high punitive damage awards also involve swine operations. Not all of the nuisance suits have occurred in regions with high population pressures, including the Wyoming Premium Farms operation in Wheatland Wyoming. The Wyoming Premium Farms case illustrates two interesting rural western issues. One is that agricultural operations are susceptible to legal action, even in areas that are not experiencing rapid population growth, like Wheatland, Wyoming. Second, the topography of high elevation land results in cross-winds, and odor problems may be more difficult to predict than the mere presence of a "downwind" housing development. Therefore, trend of nuisance suits could persuade livestock operations to consider

[18] Addition contact information: Wyoming Premium Farms: 912 North Wheatland Highway Wheatland, Wyoming

Main contact: Mr. Doug Derouchey, Operations Manager and Minority Owner

Phone: 307-322-2266

http://www.wpfllc.com/

adoption of AD units as a management practice, even when the operation is not located in an urban-rural interface. The Wyoming Premium Farms case study serves as an illustration of how AD technology might be economically feasible if the installation arises as a result of lawsuit mitigation.

Wyoming Premium Farms is a 6,000 acre swine operation located in Wheatland, Wyoming. The operation is primarily owned by Japanese investors. Mr. Doug Derouchey, the operations manager, is the minority business owner. There are approximately 5,000 sows and 18,000 other swine in various stages of development, ranging from nursery to finishing. The operation owns two complete mix AD units that service four separately located barns. Approximately 20,000 gallons of waste are generated from the four collective barns each day. The AD units run 24 hours per day, seven days per week. AD #1, installed in 2003 at the sow barn for $1 million, presents 80kW capacity. AD#2, with 160kW capacity, was installed in 2004 to accommodate the other swine. The operation has a methane gas line tap, but the infrastructure is not feasible to support a gas line. Unused gas is flared.

In contrast to most projects, the Wyoming Premium Farms digesters were purchased in cash and received no government financial support. This is an important principle for Mr. Derouchey, who suggested the installation of the digesters to the majority owners. Mr. Derouchey believes that, "These are probably the only two digesters in the nation that were built with not one government dollar." Derouchey is forthright that the main purpose for the installation of the AD units was to mitigate costs stemming from nuisance lawsuits, and that the projects would otherwise not be economically viable. There are times when the digester does not return economic profit, including periods of long shut down, high maintenance costs due to the corrosiveness of the biogas, and low supply prices for selling electricity to the grid.

Mr. Derouchey was interviewed during two telephone calls and a July 22, 2009 site visit. He is accustomed to providing tours to visitors who have an interest in learning more about the digesters. Mr. Derouchey allowed photos to be taken of one of the digester units and he was willing to share some financial information, which has been integrated into the enterprise budget and sensitivity analysis in Section V. Photographs of the operation are presented in Appendix B.

1) Cost Information for Wyoming Premium Farms:

As follows is a summary of cost information from Wyoming Premium Farms. This data is integrated into the enterprise budget and sensitivity analysis in Sections V and VI.

A. *Peak demand charges*: Mr. Derouchey reports that at least one time/month, the generator is forced to shut down during peak demand. Even when it is down for as short as 15 minutes during peak demand, Derouchey estimates that the operation is forced to pay $1,500-$3,000 in monthly charges to Wheatland Rural Electric.

B. *Annual maintenance costs:* Mr. Derouchey estimates that he pays approximately $20,000 per year for maintenance. Included in these estimates are:

   - Replacement generator parts from RCM International.
   - Routine oil maintenance (which takes places approximately once every 10 days).
   - Engine maintenance and repair specialists (e.g. $60/hr. for a specialized engine operator trained in tractor maintenance and repair from Caterpillar). At one time,

Wyoming Premium Farms needed to contract with AD repair specialists from Missouri for digester maintenance and repair, but this need has been reduced since local labor have accumulated more experience in this specialized work.

C. *Major engine repairs:* In addition to annual maintenance fees, Derouchey states that he has "overhauled" and conducted major repairs to both engines on two separate occasions during the past five years. This involved replacement of valves, pistons, etc. Direct costs were estimated at approximately $20,000 (approximately $5,000 per incident, with two incidents observed for each digester). In addition to this expense, the operation was forced to purchase electricity during the times of generator shut down.

D. *On-farm labor for routine maintenance:* Mr. Derouchey currently employs the equivalency of one full-time laborer to maintain the AD units. Although AD review is required seven days per week, the estimated time of dedicated labor necessary to run the digesters is approximately 40 hours a week. The farm pays workers $8.76/hr. as part of a government sponsored agricultural work program. Housing, included in the worker's compensation, is not calculated in this expense. Thus, costs for routine labor are $350 each week and $18,221 every year.

2) Revenue and Cost Offsets for Wyoming Premium Farms:

As follows is a summary of revenue and cost offset information from Wyoming Premium Farms. Cost offsets can be treated as revenues. This data is integrated into the analysis in Sections V and VI.

A. Lawsuit mitigation: $2,000,000 punitive damages (2003 dollars) and $200,000/year in legal fees.

B. Cost offset of irrigation system: The company is able to offset electricity and water costs by using electricity and effluent water to power a 125 horse power motor irrigation system. The irrigation system pumps 200/gallons per minute of effluent water onto irrigated silage corn (used to feed the swine and beef cattle). Additional irrigation water is also used and pumped at a rate of 600 gallons from a well. Based upon operational costs from four irrigation units, Derouchey estimates that he saves roughly $4,500/month for the 4 months of irrigation season ($18,000 annually). The other four irrigators are not located close enough to the generator infrastructure to utilize the energy.

C. Cost offset for lighting/fans: Mr. Derouchey reports saving approximately $2,000-$3000 each year from using on-farm electricity for lighting and fans.

D. Net Metered Electricity: Mr. Derouchey supplies excess electricity to Tri-State at a rate of $0.02/kWh. He is unsure of the average volume that he sells to Tri-State each month.

E. *Fertilizer:* The solids separators enable Mr. Derouchey to uses the remaining solids as fertilizer for silage corn, which is used to offset feeding costs for the 900 head cow-calf operation. Corn is also occasionally fed to the swine during the finishing process. Derouchey estimates that the operation produces 750 acres of corn each year and that he saves $150/acre in fertilizer costs for an annual savings of $112,500.

F. Carbon credits: Mr. Derouchey reports that he sold carbon credits through 2007, although has not reported the volume sold or the revenues collected. He believes that the operation was able to sell the credits at a price of roughly $5/tonne, close to the market peak of $7/tonne. At publication, the Chicago Climate Exchange (CCX) closed its trading operation, and now serves as a registry. When it closed in 2010, CO_2 was trading on the CCX at $0.10 metric tonne.[19]

V. **Economic Analysis of an Anaerobic Digester Unit in the U.S. West**

Section V. presents an enterprise budget of the costs and revenues from installing and operating a large anaerobic digester in Colorado or Wyoming.[20] This section also describes how agricultural producers can reduce their operating costs to make the AD unit profitable. Using data from the Wyoming Premium Farms example, the budget illustrates that AD technology can offset costs incurred by a nuisance lawsuit with $2,000,000 in punitive damages and $200,000 in legal fees. Once an AD unit is installed, the agricultural operation can actually turn a profit so long as operational costs can be controlled. It is the lawsuit that provides the cost justification for installing the unit.

[19] For emissions trading registry information, see the Colorado Climate Exchange Website: https://www.theice.com/ccx.jhtml. Last accessed October 29, 2011.

[20] This model applies to Colorado and Wyoming electricity infrastructure and prices. Keske, supra 8 at 44-48.

To illustrate this, three economic conditions have been created and are presented in Figure 4.0. These conditions describe the costs and revenues associated with an AD unit, and do not reflect the farm operating budget, as a whole. That is, total costs and revenues must also be added to the farm operating ledger to show how the entire farm would lose or profit from the three economic conditions.

The first condition, “Lawsuit”, reflects Mr. Deyrouchy’s reported anticipated punitive damages and legal expenses. This dollar value is consistent with the Figure 3.0 summary of agricultural nuisance lawsuit verdicts. There are not revenues associated with the AD unit, because it is not installed. There is a loss of $2,200,000, which must be subtracted from the agricultural operation’s profits. In many cases, a loss this great might close the agricultural operation.[21]

The second “Expected” condition illustrates the financial revenues and cost mitigation from AD installation. While the producer incurs costs, the AD unit also mitigates the lawsuit damages. Hence the anticipated legal and accounting costs are considerably lower, although the costs of on-going legal and accounting costs have been portrayed as rather high, to provide a conservative cost estimate. Once installed, the AD unit in this scenario serves as a co-digester with a relatively large waste stream.

[21] John P. Hewlett and Dana Hoag, Chapter 16 In Applied Risk Management in Agriculture, Dana Hoag, Ed., (2009), 353-354.

Figure 4.0 Three Budgetary Conditions for an Anaerobic Digester

			Economic and Production Conditions		
	Unit	Amount	Lawsuit	Expected	Good
Revenue					
Sale of electrical power					
Energy and VOM Payment	kVA	68,657,404		$4,394,074	$6,327,466
Capacity Payment	kW	94,069		$893,656	$1,286,864
Sale or use of Carbon Credits	CO_2	22197		$2,563,754	$7,831,102
Total				$7,851,483	$15,445,432
Production Costs					
Utilities				$78,971	$63,177
Feedstock Procurement				$1,039,030	$831,224
Bio-mass waste licensing fee				$150,000	$120,000
Waste Disposition Operating Cost				$122,000	$97,600
Water utilization				$461,727	$369,381
Compensation & Benefits				$342,000	$273,600
Feedstock Mangement				$165,000	$132,000
Operational Mgmt & Suprv.				$250,000	$200,000
Maintenance and Upgrades				$400,000	$320,000
General and Administrative					
Lease Agreement for Land				$100,000	$100,000
Insurance (General Liability)				$50,000	$50,000
Legal and Accounting			$2,200,000	$20,000	$20,000
Total			$2,200,000	$3,178,728	$2,576,982
Earnings Before Interest Taxes & Amortization			**$2,200,000**	**$4,672,755**	**$12,868,450**
Interest				$1,037,350	$1,037,350
Amortization				$263,368	$263,368
Depreciation				$2,671,832	$2,671,832
Taxable Income				$700,205	$8,895,899
Income Tax (40%)				-$280,082	-$3,558,360
Producers Tax Credit ($0.019/kWH)				$280,082	$3,558,360
Net Income			**$2,200,000**	**$700,205**	**$8,895,899**

The "Expected" condition shows potential for a positive rate of return on co-digestion project, which will generate an annual return equal to $700,205. However, the return would typically not be high enough to install used in the enterprise budget reflect only a 3.66% annual return on investment, which is a rather low of a return given the high amount of risk that the operator must incur in capital costs[22]. Furthermore, in order to achieve a positive return on investment, several key assumptions must be met, including carbon credits being sold at $5.50/tonne, with reasonable control of production costs.[23] It is also assumed that revenues could be generated from selling electricity to the grid for a price of $0.07 per kWh.[24] At present, economic conditions required for a positive AD project return make the project somewhat risky,[25] and agricultural producers could just as easily sustain a loss as they would a profit. However, the installation of the AD unit clearly offsets legal expenditures, and losses sustained from the installation of an AD unit would not be as great as a punitive judgment. Other verdicts presented

[22] Duane Griffith, Chapter 5 In Applied Risk Management in Agriculture, Dana Hoag, Ed., (2009).

[23] The Chicago Climate Exchange traded carbon dioxide between $0.10-$0.25 per metric tonne, for two years, before it closed at the end of 2010. See Matthew DeBord. The Fall and Rise of the Carbon Coalition, July 27, 2011 at http://www.huffingtonpost.com/matthew-debord/the-fall-and-rise-of-the-carbon-coalition_b_910442.html These prices are far lower than the price required for revenues from carbon markets, which are necessary for this budget. However, it can be argued that the social cost of carbon should be much higher and that $5.50 per metric tonne is the low point when all social costs are calculated. See Catherine M.H. Keske, Terry Iverson, Sam Evans, and Gregory Graff, Designing a Technology-Neutral, Benefit-Pricing Policy for the Colorado Electricity Sector, (December 2010). Available at: http://soilcrop.colostate.edu/keske/index.html. See also Catherine M.H. Keske, Costs of Environmental and Performance Attributes of the Colorado Electricity Sector, *The Electricity Journal* 24(9), (2011), DOI: 10.1016/j/tej/2011.09.020.

[24] Price per kWh in Colorado for energy buy-back is approximately $0.02. Keske *supra* 8 at 43.

[25] In Keske, supra 8 at 26-48, interviews with agricultural producers and technology providers implied downward variability in production revenues (e.g. tipping fees, energy production, energy prices per kWh) and costs (e.g. maintenance fees, unexpected downtime) could vary as much as 20% in total.

in Table 3.0, such as the 2006 Turner v. Premium Standard Farms Inc.; Contigroup Co., Inc. (which is also a swine operation) would result in much greater losses, if an AD unit is not installed.

In absence of a nuisance lawsuit, low electricity buy-back prices such as typical net metering prices at $0.02/kWh, make it more difficult to justify a digester investment.[26] Return on investment takes longer when electricity costs are low and the value of selling excess electricity produced or offsetting consumption is also lower. In the Intermountain West, electricity costs are generally lower than the eastern United States. This is primarily due to relatively inexpensive coal and hydroelectric resources that are available for electricity generation. While the environmental damages resulting from burning coal could be factored into future energy policy, the current price per KWh of electricity is low compared to other regions of the country.[27] Appendix A further elaborates on the revenue assumptions built into the enterprise budget model.[28]

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[26] Keske *supra* note 8 at 46-50. Also see Eliabeth R. Leuer, Jeffrey Hyde, and Tom L. Richard, *Investing in Methane Digesters on Pennsylvania Dairy Farms: Implications of Scale Economies and Environmental Programs.* Agricultural and Resource Economics Review 37(2): 188-203 (2008).

[27] Keske *supra* 8.

[28] Revenues and costs are summarized in Keske *supra* note 8 at 44-50.

As summarized in the interview with Mr. Deyrouchy Section IV., controlling AD operational costs is critical to profitability. Cost control is also important to increasing profitability for an agricultural production, in general.[29] The sensitivity analysis measures the responsiveness of income to a 1% change (essentially in either the positive or negative direction) in operational variables. In other words, the sensitivity analysis effectively accounts for price volatility and models how these price changes affect the viability of a project.[30] This analysis compares the variables that contribute to profitability in order to determine how to best control costs or generate revenues, and where to expend managerial effort. In other words, a sensitivity analysis can provide producers a "road map" to improving profitability with an AD unit.

A sensitivity analysis is conducted with 20% changes of all variables in the "Expected" condition in Figure 4.0. This reflects three budgetary conditions:

- A baseline of "Expected" economic conditions, showing a positive annual return on investment. This is illustrated in the middle column of Figure 4.0.
- A budget modeling a 20% increase in each of the variables (with minor modifications) and a return of $8,895,899, or a 46.45% return on investment. This reflects the "Good" economic condition in Figure 4.0, and the "Good" economic condition in Figure 5.0
- A budget modeling an approximate 20% reduction in each of the variables (unless otherwise specified) and a negative annual return on investment of -30.78%. This "Poor" economic

[29] Catherine M. Keske, Using Horsepower to Cut Costs, Ag Women and Risk newsletter, Issue 2 (Spring 2009) http://www.ext.colostate.edu/pubs/ag_natr/0903_women-ag.pdf

[30] Operational variables selected for the sensitivity analysis were identified through interviews with technology providers, agricultural operations managers, and academic and trade publications. Keske, *supra* 8 at 26-36.

condition is not illustrated in the Figure 4.0 budget, but it is represented in the Figure 5.0 sensitivity analysis.

In summary and as shown in Figure 5.0, operational income is most sensitive to changes in production costs. A 1% change in production costs resulted in a 14.54% change in income. Examples of production costs might include unplanned AD maintenance and increases in labor. Operational income is also sensitive to energy production. A 1% change in energy production capacity (which is a function of engine efficiency and energy prices) yields an 11.14% change in operational income. The results of the sensitivity analysis are consistent with qualitative data gathered from interviews with agricultural producers, who report that changes in costs and energy production have a significant impact on project returns.[31]

While the enterprise budget estimates that an AD project in the state of Colorado can be profitable, changes in only a few key variables can affect project profitability significantly. Net income is highly sensitive to changes in electricity pricing for net metering. Other variables included in the sensitivity analysis, along with their respective changes on net income are: capacity payment (1.25%), water—measured in cost per acre-foot (1.21%), energy purchase payment from net metering (6.15%), and carbon credits per tonne (4.0%).

[31] It is important to note that the enterprise budget and sensitivity analysis specifically address economic feasibility of AD in the western U.S. Although data are available from other projects across the country, the decision was made to use regional-specific data in order to account for Intermountain West policies and practices. For example, published reports reflecting electricity use charges ranging from $0.08-$.12/kWh in New York or Pennsylvania yield a different budget compared to the typical $0.03-$0.07kWh prices seen in the Intermountain West. *Supra* note 25.

Figure 5.0 Results of Sensitivity Analysis

	% Change in Income for 1% Change in Variable	Economic and Production Conditions		
		Poor	**Expected**	**Favorable**
Capacity Payment Rate	1.25%	$7.60	$9.50	$11.40
Energy/VOM Payment Rate	6.15%	$0.02	$0.06	$0.08
CO_2 cost/tonne[32]	4%	$0.5	$5.50	$14
Water Cost[33]	1.21%	$600.00	$600.00	$25
Energy Production	11.14%	54,925,923	68,657,404	82,388,885
(billing capacity)	NA	75255	94069	112883
(methane produced)	NA	17758	22197	26636
Production Costs	14.54%	$3,780,473	$3,178,727	$2,576,982
Net Income	**NA**	**-$5,896,108**	**$700,205**	**$8,895,899**
Annual Return on Investment	NA	-30.78%	3.66%	46.45%

[32] Richard Tol, The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties, Energy Policy 33 (2004), 2064-2074. Carbon dioxide emission prices in metric tonne reflect the prices that a producer might be able to obtain, rather than the marginal damage from the carbon dioxide emissions. Tol concluded that the true environmental benefits of a tonne carbon likely were substantially lower than $50/tonne. Median CO_2 prices were imputed in the “Good” economic condition.

[33] Based upon price per acre foot of water leasing in Colorado. Water Strategist Database (2009), Claremont, CA. The cost per acre price of water provided in the “expected” condition ($600) appeared high by agricultural water standards ($25 to lease agricultural water), validated by Dr. Christopher Goemens, Colorado State University water economist. However, parameters associated with the water price (municipal prices) were not available, and the price was not adjusted. Instead, the same price was applied to the “poor” economic scenario, and the typical agricultural per acre-foot water cost (25) was applied to the “good” condition. However, net income was not as sensitive to water costs or capacity payment, as other variables.

An interesting result is the effect of price changes per metric tonne of carbon credits on net income (4.0%). Anecdotal advice and published academic studies[34] suggest that positive net income of an AD project often hinges on carbon credits. However, this sensitivity analysis does not show this to be the case. If net income were to show high sensitivity to carbon credit price changes, producers may show rapid reductions in profit, considering the rapid change in carbon credit prices from over $7/tonne in May 2008 to below $0.1/tonne in December 2010. However, the sensitivity analysis shows that there is a more substantial reduction in net income with an increase in costs or reduction in generator energy production. Therefore, an operation should focus its efforts on cost reduction and ensuring efficient operation of the AD unit, and less on the price of carbon. Likewise, AD is more economically feasible in states with higher electricity costs to offset.

Several policy implications can be drawn from the sensitivity analysis. First, given the volatility around certain variables, it can be concluded that a regional digester project in the Intermountain West is a risky venture. In order to increase the likelihood of success in co-digestion projects (which have the potential to yield environmental benefits), the state may wish to subsidize the difference between "typical" prices and a more extreme, unfavorable prices. Second, the producers may be able to facilitate discussions with energy companies to negotiate a more favorable rate for net metering, or reduction of energy costs for alternative energy projects. Third, should the environmental, or "social costs" of carbon offset prices reflect the "true" environmental costs of methane or CO_2, then there might be more financial incentives for producers who emit these GHGs to implement AD technology. However, present evidence illustrates that reducing operational costs and lawsuit mitigation hold the keys to economic profitability.

[34] *Supra* 25

V. How Agricultural Producers—And the Environment—Might Profit from Nuisance Lawsuits

While it is has established that anaerobic digestion has the potential to generate natural gas and electricity, at this writing the technology does not typically to pay for itself in the western United States unless there is a nuisance lawsuit. However, the use of anaerobic digestion technology at these few sites, including Wyoming Premium Farms, has led to innovative technological research that might reduce AD operating costs.[35] Reduced operating costs in a few parameters, such as water costs or repair costs, could be enough make anaerobic digestion economically feasible, which would open the door to a market.

For example, high solids content waste is a major barrier that has been identified as unique to the arid western United States. Technology providers have consistently noted that research dollars spent to study methods for overcoming high solids content waste may provide considerable payback for future implementation of AD technology in these arid regions of the country.[36] At the moment, private funding for high solids content research may not yield economic returns for industry, but research conducted at sites that have already implemented anaerobic digestion to prevent lawsuits appear to be sparking engineering innovations that could reduce costs.

Until improvements in engineering design lead to a more stable and predictable AD market, it appears as though nuisance lawsuits are the primary way that an AD system can be financially justified in the western U.S. Interviews with technology providers and agricultural

[35] Catherine M.H. Keske, How Lawsuits Could Ignite an Energy Market: The Case of Anaerobic Digestion, *Environmental Law Reporter* (December 2011).

[36] Keske *supra* note 8.

operation managers[37] also validate that AD systems for a Colorado or Wyoming single farm project are not economically viable at this time, unless there is a key cost savings from lawsuit mitigation.[38]

However, it is worth noting that many of the environmental benefits provided by AD units are not factored into the financial benefits of an AD unit. For example, emerging research is showing that the environmental benefits provided by carbon credits considerably exceed the market value. In this example, Tol (2004) summarized the environmental literature for the non-market and environmental values from CO_2 reduction. Of the 28 studies he reviewed, the *median* value (50th percentile) of estimated environmental benefits reflected a $14/tonne price. The mode (most common), mean, and 95th percentile values were $2/tonne, $93/tonne, and $350/tonne, respectively.

On a similar note, methane is estimated to have 21 times the atmospheric warming potential compared to CO_2, and livestock waste is a large contributor of methane emissions.[39] Preliminary work estimates mean marginal social damage costs at $205/metric tonne of methane, though methane regulation and trading markets are more inchoate at this time as compared to CO_2 markets.[40] Nitrogen oxide emissions ("NO_x) also have been linked to agricultural practices, among other sources. Volatilization of Nitrogen from manure management and other urban pollutants cause complex

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37 Sybil Sharvelle, *Final Report on Results from Waste Characterization and Biochemical Methane Potential Tests Conducted on Wastes from Aurora Organic Dairy, P*resented to ActNeutral, Inc. October 2008.

38 Keske *supra* note 4 at 9-36.

39 United States Environmental Protection Agency Climate Change Home Page. http://www.epa.gov/outreach/scientific.html. Last accessed October 30, 2011.

40 Stephanie Waldhoff, David Anthoff, Steven Rose, and Richard S.J. Tol. The Marginal Damage Costs of Different Greenhouse Gases: An Application of Fund. The Economic and Social Research Institute. Working Paper 380. March 2011. http://www.esri.ie/UserFiles/publications/WP380/WP380.pdf. Last Accessed October 30, 2011.

chemical reactions that lead to health and environmental impacts across time and geographical space. NO_x has also been linked with poor visibility and long term O_3 concentration in national parks such as Rocky Mountain and Mesa Verde, as well as wilderness and natural areas.[41] Marginal damage estimates from NOx in the Intermountain West is approximately $381/ton.[42] These marginal damage estimates are only based upon health impacts, and would presumably be much higher when damages to recreation opportunity and natural areas are included in marginal damage estimates.

Non-point source pollution from agricultural production also poses considerable water quality concerns.[43] The bio-chemical processing of the animal waste allows for the effluent product to retain high nutrient content, and is suitable for field application. As with the case of Wyoming Premium Farms, the effluent can be applied to field corn, in lieu of fertilizer. This reduces fertilizer costs for the agricultural producer. The effluent can also be applied in a manner where the nutrients are less likely to volatilize and cause less net environmental impact.

Clearly, there are environmental benefits to be gained from installing an anaerobic digestion unit. The implementation of these units by agricultural producers is a matter of cost. The cost offset of nuisance lawsuits makes AD an economically viable the western U.S., and producers might even profit from these systems so long as they are able to offset their operating

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[41] *Supra* 8 at 26.

[42] *Supra* 23.

[43] Marc Ribaudo, J. Delgado, LeRoy. Hansen, Mark Livingston, R. Moshiem, and J. Williamson. "Nitrogen in Agricultural Systems: Implications for Conservation Policy." Economic Research Report No. 127, USDA/Economic Research Service, Washington, DC, September 2011.

expenses. When externalities caused by environmental impacts are quantified, installation of an AD system is even more justified because environmental damage costs are also offset. It so appears, at least with this particular market that the agricultural producer and the environment might benefit from a nuisance lawsuit.

Appendix A

Gross Revenue. Gross revenue can be further explained as follows:

Gross Revenue = Energy and VOM Payment + Capacity Repayment + Carbon Credit

(1) Energy +VOM Payment = Energy Produced *.064 (expected price per kWh)

(2) Capacity Repayment = Capacity Rate (assumed at 9.55) * Billing Capacity

Billing Capacity=Energy Produced/Hours of operation per month (average of 744)

(3) Carbon Credit=Methane produced*5.5 (carbon price per ton)*21 (gas conversion rate)

Methane produced=

[Energy produced per month/ Sum of energy produced] *

[Annual methane produced in metric tonnes]

Feedstock conversion to energy. Feedstock is converted to "energy produced". This is determined as follows:

(1) Volume of slurry (lbs./day) converts to lbs of solids: % solids in feedstock=8%.

(2) Conversion to methane produced: 5.6 $ft.^3$/lbs. of solids.

This is the estimated conversion rate of feedstock from lbs. of solids to gas

(3) Biogas produced=methane produced/molecular ratio (.7) of methane to biogas

(4) Energy produced in BTUs =biogas produced*Heat content (65) BTU/$ft.^3$

Models are based upon technical assumptions for co-digestion, as a consistent level of diverse feedstock is required to ensure engine efficiency.

Appendix B

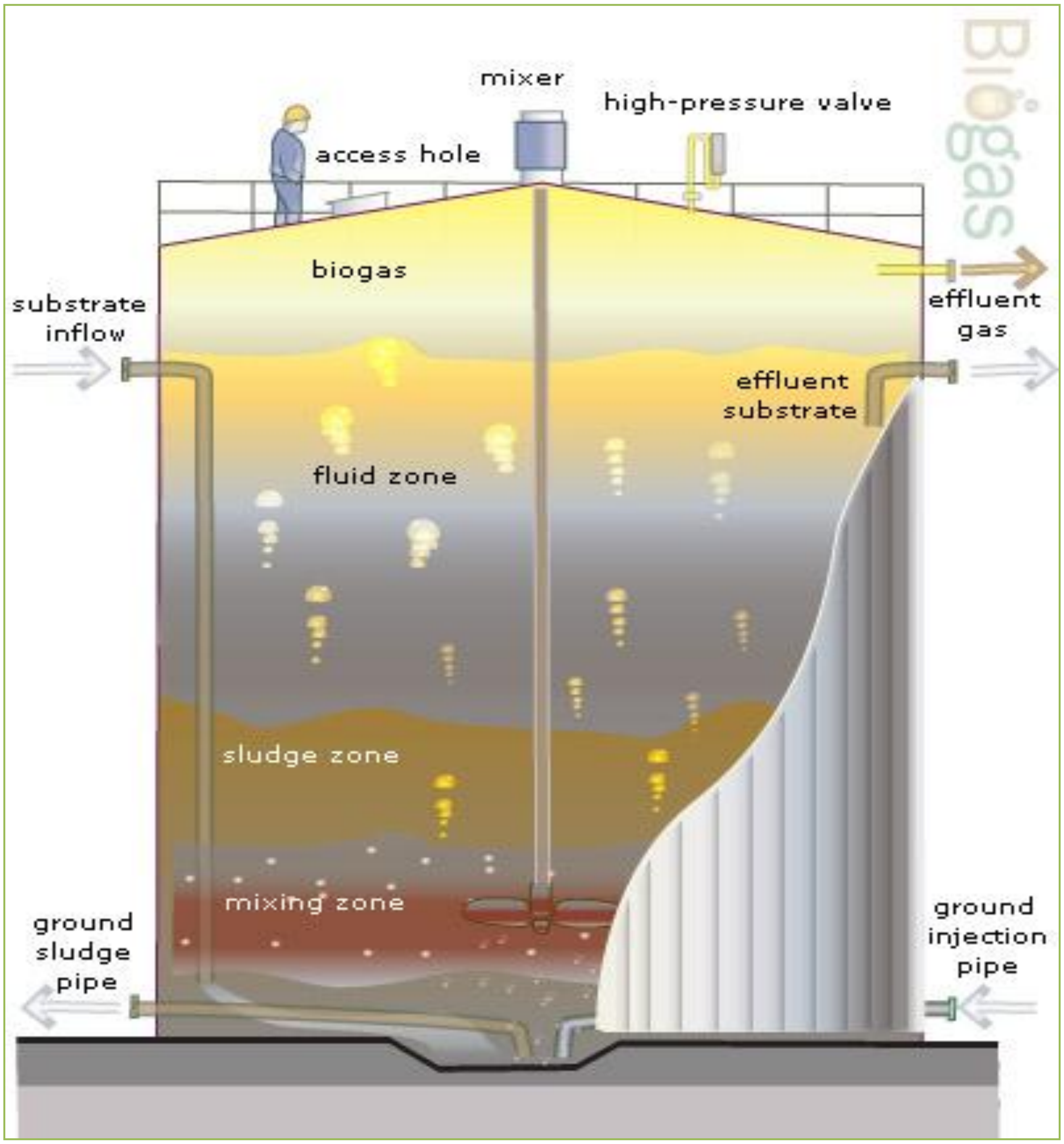

Illustration of a complete mix digester. Illustration courtesy of Renewable Energy Association and Dr. Sybil Sharvelle[44]

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[44] Renewable Energy Association Website and Contact information: http://www.r-e-a.net/biofuels/biogas/anaerobic-digestion. Dr. Sybil Sharvelle's Contact information: http://www.engr.colostate.edu/faculty-staff/profiles.php?id=134

Photo 1.0 Wyoming Premium Farms AD Unit #2, view from the south, looking north. The blue tower is an inactive holding tank. (at right)

Photo 2.0 Wyoming Premium Farms AD Unit #2, view from the east, facing west. (below)

Photo courtesy of Catherine Keske