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CATHERINE M.H. KESKE\*

# Anaerobic Digestion Technology: How Agricultural Producers and the Environment Might Profit from Nuisance Lawsuits

## ABSTRACT

*Anaerobic digestion technology converts biomass into biogas, which may be purified into methane. Agricultural producers use a generator to convert the methane biogas into electricity, which they can later use, or sell in its purified form. Anaerobic digesters improve environmental quality, as measured by a reduction in greenhouse gas emissions and improved nutrient management practices. This article demonstrates that anaerobic digestion technology is an economically feasible way to avoid the costs associated with a nuisance lawsuit. In fact, an agricultural operation that installs a digester to mitigate the costs of an imminent lawsuit could financially profit from the technology. Agricultural producers generate profit when an anaerobic digester produces enough energy to outweigh its operating costs. However, anaerobic digestion technology is not yet a cost-effective alternative to doing nothing, at least for agricultural producers not threatened by a nuisance lawsuit in the western United States. This article summarizes results based upon primary data collected from agricultural operations in the western United States and a case study of Wyoming Premium Farms, a 20,000 swine operation in Wheatland, Wyoming.*

## I. INTRODUCTION

A typical on-farm anaerobic digestion (AD) unit costs approximately \$1.2 million.<sup>1</sup> Additional operating expenses (like digester repair and water costs) increase annual operating costs.<sup>2</sup> As a result of the high

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1. Catherine M.H. Keske, *E<sup>3</sup>A: Anaerobic Digesters Applications for the Farm or Ranch, Determine*, MONT. STATE UNIV. EXTENSION (June 29, 2012) <http://www.e3a4u.info/Fact%20Sheets/Digester/Digester-step3.pdf>.

2. *Id.* at 1; see also CATHERINE M.H. KESKE, ECONOMIC FEASIBILITY STUDY OF COLORADO ANAEROBIC DIGESTION PROJECTS (2009), available at [http://soilcrop.colostate.edu/keske/pdf/GEO\\_8-28-09\\_AD\\_Economic\\_Feasibility\\_by\\_Keske.pdf](http://soilcrop.colostate.edu/keske/pdf/GEO_8-28-09_AD_Economic_Feasibility_by_Keske.pdf).

up-front and operating costs, AD is not economically feasible in many areas of the nation, including the western United States, where energy prices are relatively low.<sup>3</sup>

Nuisance lawsuits, however, present significant risks to the economic viability of agricultural operations. Despite the prevalence of right-to-farm laws in many states,<sup>4</sup> agricultural producers report that the threat of a nuisance lawsuit frequently weighs heavily on their minds, even when legal action has not been taken.<sup>5</sup> 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.<sup>6</sup>

The tort system is an established tool to implement environmental policy.<sup>7</sup> It is commonly used to drive costs so that a party is forced to forego—or adopt—practices desired by the opposing party. This use of civil tort actions is frequently chastised by economists as an inefficient approach to environmental policy and as detrimental to technological innovation.<sup>8</sup>

Nuisance lawsuits can, however, maintain the efficient allocation of environmental goods.<sup>9</sup> For example, in the absence of lawsuits, right-to-farm laws might result in commodity overproduction at the expense of environmental degradation, such as nutrient runoff from animal waste.<sup>10</sup> Specifically, in the case of densely populated animal operations, if not for concern over a possible nuisance lawsuit, an agricultural producer might increase the size of the operation without regard for unpleasant odor or nutrient runoff. Other environmental costs which escape nuisance lawsuits at this time (like greenhouse gas emissions)

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3. Keske, *supra* note 1; *Total Cost Electricity Pricing: A Market Solution for Increasingly*; see also C.M.H. Keske, et al., *Rigorous Environmental Standards*, 25 *THE ELEC. J.* 7 (2012).

4. Determinations of priority use and case laws are often conflicted and paradoxical. See Terence J. Centner, *Curbing the Right-to-Farm*, 15 *CHOICES: THE MAG. OF FOOD, FARM & RES. ISSUES*, 41 (2000). For a good summary of factors to consider for the mitigation of nuisance lawsuits, consult PENN STATE DIXON AGRIC. LAW RES. & REF. CNT., *Farm Protection from Nuisance Lawsuits*, PENN STATE DIXON LAW CENTER, [http://law.psu.edu/\\_file/aglaw/Farm\\_Protection\\_From\\_Nuisance\\_Lawsuits.pdf](http://law.psu.edu/_file/aglaw/Farm_Protection_From_Nuisance_Lawsuits.pdf).

5. Judith Lisansky et al., *The Determinants of Right-To-Farm Conflicts*, 55 *RURAL SOCIOLOGY* 246 (1988).

6. Joshua M. Duke & Scott A. Malcolm, *Legal risk in Agriculture: Right-to-Farm Laws and Institutional Change*, 75 *AGRIC. SYS.* 295 (2003).

7. See generally Richard B. Stewart, *Pyramids of Sacrifice? Problems of Federalism in Mandating State Implementation of National Environmental Policy*, 86 *YALE L.J.* 1196 (1977).

8. See generally W. Kip Viscusi, *The Social Costs of Punitive Damages Against Corporations in Environmental and Safety Torts* 87 *GEO. L.J.* 285 (1998).

9. Duke & Malcolm, *supra* note 6.

10. See generally John C. Bergstrom & Terence J. Centner, *Agricultural Nuisances and Right-to-Farm Laws: Implications of Changing Liability Rules*, 19 *REV. OF REG'L STUD.* 23 (1989).

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, the threat of a nuisance lawsuit provides an incentive for agricultural producers to reduce the negative environmental and societal impacts of their operations.

This article argues that AD 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 can serve as the mechanism that makes a technology economically feasible, while reducing environmental impact. This article also presents results of a case study that suggest lawsuit mitigation can offset most of up-front capital costs. Once an AD unit is installed, it can add profitability to the operation if producers are able to offset operating costs.

An AD unit provides environmental benefits by reducing nutrient loading, the amount of nutrients entering an ecosystem during a period of time (most notably a water way), from animal waste.<sup>11</sup> Overall methane and CO<sub>2</sub> emissions are reduced while energy is generated and odors are reduced.<sup>12</sup> Odor is an important consideration for agricultural operations, including swine and dairy facilities, to avoid nuisance lawsuits.<sup>13</sup>

Part II and III of this Article present the author's original research illustrating that mitigating imminent nuisance lawsuits can potentially make AD technology economically feasible in the western United States.<sup>14</sup> Part IV presents data from a case study of Wyoming Premium Farms in Wheatland, Wyoming. Part V presents an enterprise budget to illustrate the potential on-farm profitability of an AD unit that has been built to mitigate a nuisance lawsuit. Part VI of this article suggests that both producers and the environment might be able to profit from a nuisance lawsuit.

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11. See generally J.B. Holm-Nielsen et al., *The Future of Anaerobic Digestion and Biogas Utilization*, 100 *BIORESOURCE TECH.* 5478 (2009).

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

13. J. Ronald Miner, *Nuisance concerns and odor control*, 80 *J. OF DAIRY SCI.* 2667, 2671 (1997).

14. Much of the original research in this article is based upon findings presented in a report to the Colorado Governor's Energy Office. See KESKE, *supra* note 2.

## II. ANAEROBIC DIGESTION ENERGY TECHNOLOGY<sup>15</sup>

Anaerobic digestion is a biological process by which microorganisms convert organic material into biogas, containing methane and carbon dioxide.<sup>16</sup> Biogas produced by this process can be utilized to generate electricity or can be cleaned up and supplied to natural gas lines.<sup>17</sup> The digester removes organics as it converts them to methane, while conserving nutrients (nitrogen and phosphorus). The end product is a low odor, high nutrient, stabilized waste suitable for land application as fertilizer. The results of this biochemical process provide positive environmental benefits. The greenhouse gases are not released from the animal waste into the atmosphere, and the nonpoint source nutrients are not available as runoff.

Anaerobic digesters are typically large reactors constructed of either concrete or steel. The volume of the reactor depends on the volume of waste the system must process. 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.<sup>18</sup> Recently, there is a growing interest in purification of biogas for resupply to natural gas lines due to high maintenance requirements for electricity generators.<sup>19</sup> This requires removal of all gas components aside from methane.

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15. Technical material presented in Part II was first published by Catherine Keske and Sybil Sharvelle in *TECH. AND ECON. FEASIBILITY OF ANAEROBIC DIGESTION* (2011), available at <http://www.e3a4u.info/content.cfm?page=anaerobic%20Digesters>.

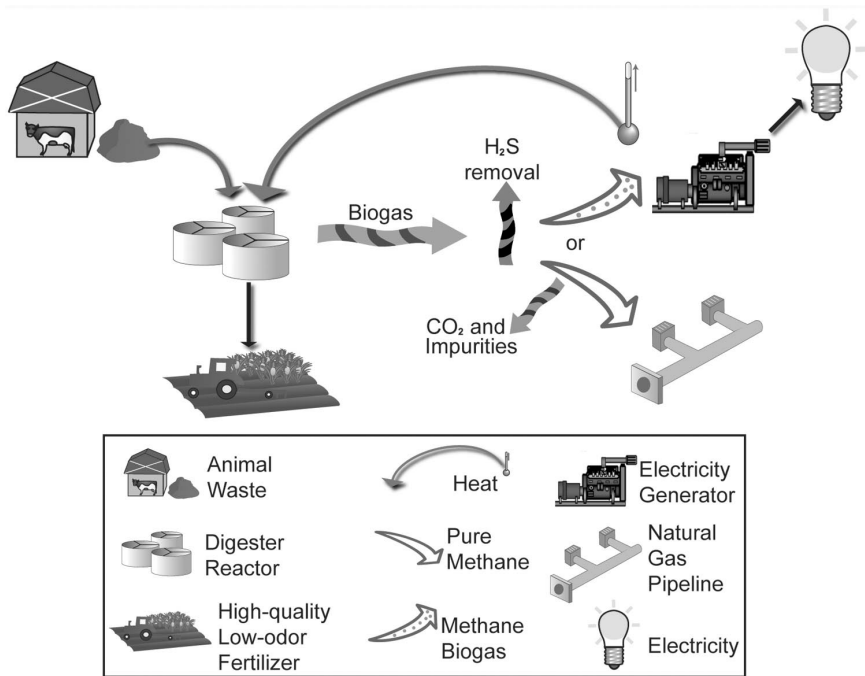
16. David P. Chynoweth et al., *Renewable Methane from Anaerobic Digestion of Biomass*, 22 *RENEWABLE ENERGY* 1 (2001).

17. Walid El-Khattam & Magdy M.A. Salama, *Distributed Generation Technologies, Definitions and Benefits*, 71 *ELEC. POWER SYS. RES.* 119 (2004).

18. See Figure 1.

19. *ANAEROBIC DIGESTION AT COLORADO CATTLE OPERATIONS*, <http://www.engr.colostate.edu/~jlabadie/Decision%20Tree/intro.cfm> (last visited Aug. 4, 2012).

FIGURE 1: Anaerobic Digestion System Configuration<sup>20</sup>



Prepared by Sarah G. Lupis, Institute for Livestock and the Environment ([www.ile.colostate.edu](http://www.ile.colostate.edu)), Colorado State University. Symbols courtesy of the Integration and Application Network ([ian.umces.edu/symbols/](http://ian.umces.edu/symbols/)), University of Maryland Center for Environmental Science.

Dilution of waste with water is most practical when there is an available source of wastewater; therefore, it is not uncommon to implement AD technology at waste water treatment plants.<sup>21</sup> The improvements to air (including odor reduction) have led several agricultural operations to implement AD in different areas of the country, but with mixed success. As reported by the U.S. Environmental Protection Agency AgStar Program, 18 percent of the AD units built for agricultural farms have been shut down for technical and economic reasons.<sup>22</sup> This high shutdown rate is particularly dramatic when considering that the median start-up cost for an AD unit is \$1.2 million.<sup>23</sup> The majority of the

20. Permission to use granted by author.

21. U.S. DEP'T OF ENERGY, FED. ENERGY MGMT. PROG., Biomass and Alternative Methane Fuels (BAMF) SUPER ESFC PROGRAM FACT SHEET (2004), available at [http://www1.eere.energy.gov/femp/pdfs/bamf\\_wastewater.pdf](http://www1.eere.energy.gov/femp/pdfs/bamf_wastewater.pdf).

22. U.S. ENV'T'L PROT. AGENCY, AGSTAR PROGRAM: PROJECT REPORT (2011), available at <http://www.epa.gov/agstar/projects/index.html> (statistics do not include those reported under construction).

23. KESKE, *supra* note 1.

AD units still in operation are in the eastern United States, where water is more abundant. In arid climates, animal wastes 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 percent as excreted, solids content has been measured as high as 90 percent on dry lots in Colorado. For wastes containing more than 20 percent solids, substantial quantities of water may be required for AD. This can add to the cost of operating the digester. In addition, when clean groundwater is added to an AD unit, it adsorbs nutrients and pathogens as well as rocks, soil, and sand. Removal of these solids typically requires addition of water to the waste and subsequent settling of the particles, thus adding complexity, capital cost, and additional maintenance for an AD system in the western United States.

### III. ESTIMATED COSTS OF NUISANCE LAWSUITS: A SUMMARY OF VERDICTS

Both technology providers and agricultural operators affirm that AD units effectively reduce agricultural odors that often prompt nuisance lawsuits.<sup>24</sup> In addition to effectively reducing agricultural odors, AD units play a role in the management of air emissions, water quality, and waste management.<sup>25</sup> Proper management of all of these environmental quality aspects can improve neighbor relations and mitigate nuisance lawsuits on agricultural operations. However, when faced with high AD 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.<sup>26</sup> Further-

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24. Keske, *supra* note 2.

25. JOHN H. MARTIN, JR., AN ASSESSMENT OF THE PERFORMANCE OF THE COLORADO PORK, LLC. ANAEROBIC DIGESTION AND BIOGAS UTILIZATION SYSTEM (2003) (Report submitted to Kurt Roos, U.S. Environmental Protection Agency AgSTAR Program). 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.

26. Greg Andrews, *Nuisance Law, Land Use Control, and Environmental Law Impacts on Pork Producers: A Legal Perspective*, in INDUSTRIALIZED ANIMAL AGRICULTURE, ENVIRONMENTAL QUALITY, AND STRATEGIES FOR COLLABORATIVE PROBLEM SOLVING AND CONFLICT RESOLUTION;

more, when courts hand down nuisance verdicts, documentation of the damage awards (which include punitive damages) can be challenging to find, as not all verdicts and settlements are reported. To further complicate matters, opinions from appellate judges do not routinely mention awards.

Figure 2 presents a summary of recent nuisance lawsuit awards and settlements. 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 2: Summary of Financial Awards from Agricultural Nuisance Suits Involving Odor**

Damage Claims Awarded in Nuisance Suits				
Year	State	Damages Awarded	Case	Operation
1991	NE	\$375,600	Kopecky v. National Farms, Inc. 510 N.W.2d 41 (Neb. 1994)	Swine
1998	KS	\$65,000	Twietmeyer v. Blocker	Beef feedlot
1999	MO	\$5,200,000	Vernon Hanes v. Cont'l Grain Co. 58 S.W.3d 1 (Mo. Ct. App. 2001)	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	Egg/Poultry
2006	AL	\$100,000	Sierra Club, Jones, and Ivey v. Whitaker & 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	Swine
2010	MO	\$11,000,000	Undisclosed Plaintiffs v. Premium Standard Farms Inc.; Contigroup Co., Inc.	Swine

The awards listed in Figure 2 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

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PROCEEDINGS OF A REGIONAL WORKSHOP 49 (William Park ed., 1997), available at <http://srdc.msstate.edu/publications/archive/208.pdf> (sponsored by the Southern Regional Information Exchange Group 10 Southern Rural Development Center Farm Foundation).



cattle feedlot. Six of the documented cases occurred west of the Mississippi.

Out of all the cases listed in Figure 2, *Blass, et al. v. Iowa Select Farms*<sup>27</sup> is the most unusual because the court distributed a high punitive damages award (\$32,065,000.00) to only four neighboring farm couples.<sup>28</sup> As shown in this example, most awards of that magnitude involve class action lawsuits. However, in *Blass, et al. v. Iowa Select Farms*, specific couples reported having been subject to noxious gases, offensive odors, and excessive amounts of flies.<sup>29</sup> The couples sued Iowa Select Farms complaining that improperly disposed of swine carcasses and unsanitary conditions created health risks.<sup>30</sup> 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.<sup>31</sup> An expert at trial testified that the farm produced as much excrement as 90,000 to 150,000 people.<sup>32</sup>

Swine producers in western states also demonstrate that they are susceptible to nuisance lawsuits as a result of odor. In addition to information gathered from legal databases, personal interviews with western agricultural producers yielded similar results. For example, 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.<sup>33</sup>

The case of Wyoming Premium Farms provides the context for the enterprise budget shown in Figure 4, which illustrates three budgetary

27. *Blass, et al. v. Iowa Select Farms, Inc., et.al.* Sac County No. LACV018147 (Oct. 9, 2002). Although the awards were reduced after the jury verdict, this remains a stark example of the amount juries are willing to grant.

28. *Iowa Select Farms Loses Lawsuit Plans Appeal*, HIGH PLAINS MIDWEST AGRI. J (Oct. 18, 2002) <http://www.hpj.com/archives/2002/IowaSelectFarmsloseslawsuit.CFM>; Joe Vansickle, *Nuisance Lawsuits On the Rise*, NAT'L HOG FARMER (Mar. 15, 2003), [http://nationalhogfarmer.com/mag/farming\\_nuisance\\_lawsuits\\_rise](http://nationalhogfarmer.com/mag/farming_nuisance_lawsuits_rise).

29. *Id.*

30. *Id.*

31. *Id.*

32. 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*. TIMES-JOURNAL, (Fort Payne, Ala.), June 23, 2006.

33. See KESKE, *supra* note 2. Interview with Mr. Doug Derouchey (July 22, 2009). 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.

conditions for an anaerobic digester. For example, an imminent lawsuit that could result in more than \$5.9 million in damages, including punitive damages or fines, in one year. This could justify (and essentially offset) the capital costs incurred for installing an AD system. In other words, preventing legal conflict justifies 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<sup>34</sup>

As noted in Part III, many nuisance claims involve swine operations; many with high punitive damage awards. Many nuisance suits occur in regions with high human populations. However, nuisance suits can occur even where people and swine are not in close proximity to each other. An example of a nuisance suit in a region with low population pressure is the Wyoming Premium Farms operation in Wheatland, Wyoming.

The Wyoming Premium Farms case illustrates two interesting rural, western issues. First, 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 crosswinds, and odor problems may be more difficult to predict than the mere presence of a “downwind” housing development. Therefore, the trend of nuisance suits could persuade livestock operations to consider 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 also illustrates how AD technology might be economically feasible if installation occurs as a result of lawsuit mitigation.

Wyoming Premium Farms is a 6,000-acre swine operation located in Wheatland, Wyoming. Japanese investors are the primary owners of the operation.<sup>35</sup> Mr. Doug Derouche, 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. The four collective barns generate approximately 20,000 gallons of waste each day.<sup>36</sup> The AD units run 24 hours per

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34. Additional contact information: Wyoming Premium Farms: 912 North Wheatland Highway Wheatland, Wyoming. Main contact: Mr. Doug Derouche, Operations Manager and Minority Owner. Phone: 307-322-2266. Website: <http://www.wpflc.com/>

35. See KESKE, *supra* note 2.

36. See U.S. ENV'T'L PROT. AGENCY, *supra* note 22.

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. Unused gas is flared.

In contrast to most projects, the Wyoming Premium Farms purchased the digesters with 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 his two digesters “are probably the only two digesters in the nation that were built with not one government dollar.”<sup>37</sup> Mr. 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 shutdown, high maintenance costs due to the corrosiveness of the biogas, and low supply prices for selling electricity to the grid.

The author interviewed Mr. Derouchey 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<sup>38</sup> and he was willing to share some financial information, which has been integrated into the enterprise budget and sensitivity analysis in Part V.

#### **A. Cost Information for Wyoming Premium Farms**

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

##### *1. Peak demand charges*

Mr. Derouchey reports that at least once per 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, Mr. Derouchey estimates that the operation is forced to pay \$1,500–\$3,000 in monthly charges to Wheatland Rural Electric.

##### *2. Annual maintenance costs*

Mr. Derouchey estimates that he pays approximately \$20,000 per year for maintenance. Those maintenance costs include 1) replacement

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37. See KESKE, *supra* note 2. Personal communication with Mr. Doug Derouchey, July 22, 2009.

38. See KESKE, *supra* note 2, at 1, 26.

generator parts from RCM International; 2) routine oil maintenance, which occurs once every 10 days; 3) and payment for repair specialists, which costs \$60 per hour for a specialized engine operator trained in tractor maintenance from Caterpillar. At one time, Wyoming Premium Farms needed to contract with AD repair specialists from Missouri for digester maintenance and repair. This need has been reduced, however, because local labor has accumulated more experience in this specialized work.

### *3. Major engine repairs*

In addition to annual maintenance fees, Mr. Derouchey stated that he “overhauled” and conducted major repairs to both engines on two separate occasions during the past five years. This involved replacement of valves and pistons. 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 shutdown.

### *4. On-farm labor for routine maintenance*

Mr. Derouchey currently employs the equivalency of one full-time laborer to maintain the AD units. Although AD unit review is required seven days per week, the estimated time of dedicated labor necessary to run the digesters is approximately 40 hours per week. The farm pays workers \$8.76 per hour 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 per week and \$18,221 per year.

## **B. Revenue and Cost Offsets for Wyoming Premium Farms**

What follows is a summary of revenue and cost offset information for Wyoming Premium Farms. Cost offsets are treated as revenues. This data is integrated into the analysis in Parts V and VI.

### *1. Lawsuit mitigation*

During the interview, Mr. Derouchey reported that the lawsuit mitigated approximately \$2,000,000 punitive damages (2003 dollars) and \$200,000/year in legal fees.

### *2. Cost offset of irrigation system*

The company offsets electricity and water costs by using electricity and waste 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 (fed to swine and beef cattle). Additional irrigation water is also pumped at a rate of 600 gallons per minute from a well. Based upon operational costs from four irrigation units, Derouchey estimates that he saves roughly \$4,500 per month for the four months of irrigation season (\$18,000 annually). The other four irrigators are not located close enough to the generator infrastructure to utilize the energy.

### 3. *Cost offset for lighting and fans*

Mr. Derouchey reports saving approximately \$2,000–\$3000 each year from using on-farm electricity for lighting and fans.

### 4. *Net Metered Electricity*

Mr. Derouchey supplies excess electricity to Tri-State at a rate of \$0.02/kWh. He did not indicate the average volume that he sells to Tri-State each month.

### 5. *Fertilizer*

The solids separators enable Mr. Derouchey to use the remaining solids as fertilizer for silage corn. The silage corn is used to offset feeding costs for the farm's 900 head cow-calf operation. Corn is also occasionally fed to the swine during the finishing process. Mr. 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.

### 6. *Carbon credits*

Mr. Derouchey reports that he sold carbon credits through 2007, although he 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 per tonne, close to the market peak of \$7 per tonne. The Chicago Climate Exchange (CCX) has closed its trading operation and now serves as a registry.<sup>39</sup> When it closed in 2010, CO<sub>2</sub> was trading on the CCX at \$0.10 per metric tonne.<sup>40</sup>

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39. CHICAGO CLIMATE EXCH., <https://www.theice.com/ccx.jhtml> (last visited Oct. 29, 2011).

40. *Id.*

## V. ECONOMIC ANALYSIS OF AN ANAEROBIC DIGESTER UNIT IN THE WESTERN UNITED STATES

Part V presents an enterprise budget of the costs and revenues from installing and operating a large AD unit in Colorado or Wyoming.<sup>41</sup> Part V 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. Part V demonstrates that once an AD unit is installed, the agricultural operation can actually turn a profit if operational costs can be controlled. It is the lawsuit that provides the cost justification for installing the unit.

To illustrate this, three economic conditions have been created and presented in Figure 3. These conditions describe the costs and revenues associated with an AD unit. They do not, however, reflect the farm operating budget as a whole. In other words, 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 2 summary of agricultural nuisance lawsuit verdicts. There would not be revenues associated with an AD unit because it is not installed. A loss of \$2,200,000 would be subtracted from the agricultural operation's profits. In many cases, a loss this great would close an agricultural operation.<sup>42</sup>

The second condition listed on Figure 3, called "Expected," illustrates the financial revenues and cost mitigation that would result from installation of an AD unit. While the producer incurs costs, the AD unit also mitigates the lawsuit damages. Hence the anticipated legal and accounting costs are considerably lower, although ongoing 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.

The "Expected" condition shows potential for a positive rate of return on a co-digestion project, which will generate an annual return equal to \$700,205.00. However, the return would typically not be high enough to install. The figures used in the enterprise budget reflect only a

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41. See KESKE, *supra* note 2, at 44–48 (This model applies to Colorado and Wyoming electricity infrastructure and prices).

42. JOHN P. HEWLETT, *APPLIED RISK MANAGEMENT IN AGRICULTURE* 353–54 (Dana Hoag ed. 2009).

FIGURE 3: Three Budgetary Conditions for an Anaerobic Digester

	Unit	Amount	Economic and Production Conditions		
			Lawsuit	Expected	Good
<b>Revenue</b>					
Sale of electrical power					
Energy and VOM	kVA	68,657,404		\$4,394,074	\$6,327,466
Payment					
Capacity Payment	kW	94,069		\$893,656	\$1,286,864
Sale or use of Carbon Credits	CO2	22197		\$2,563,754	\$7,831,102
Total Revenue			\$0	\$7,851,483	\$15,445,432
<b>Production Costs</b>					
Utilities				\$78,971	\$63,177
Feedstock Procurement				\$1,039,030	\$831,224
Biomass waste licensing fee				\$150,000	\$120,000
Waste Disposition			\$122,000	\$97,600	
Operating Cost					
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
<b>General &amp; Administrative</b>					
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 Costs			\$2,200,000	\$3,178,728	\$2,576,982
<b>Earnings Before Interest Taxes &amp; Amortization</b>					
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	-
Producers Tax Credit (\$0.019/kWH)			\$280,082	\$3,558,360	\$3,558,360
<b>Net Income</b>			<b>-\$2,200,000</b>	<b>\$700,205</b>	<b>\$8,895,899</b>

3.66 percent annual return on investment, which is a rather low rate of return given the high amount of risk that the operator must incur in capi-

tal costs.<sup>43</sup> Furthermore, in order to achieve a positive return on investment, there are several key assumptions. Carbon credits would need to be sold at \$5.50 per tonne, with reasonable control of production costs.<sup>44</sup> Revenues would also need to be generated from selling electricity to the grid for a price of \$0.07 per kWh.<sup>45</sup> At present, the economic conditions required for a positive AD project return make the project somewhat risky,<sup>46</sup> 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 in Figure 2, such as *Turner v. Premium Standard Farms, Inc.; Contigroup Co., Inc.*, would result in much greater losses where an AD unit is not installed.

Absent a nuisance lawsuit, low electricity buyback prices, such as typical net metering prices at \$0.02 per kWh, make it more difficult to justify a digester investment.<sup>47</sup> Basic math shows that return on investment takes longer with low electricity costs and the lower value of selling excess electricity produced or offsetting consumption.<sup>48</sup> In the Intermountain West, electricity costs are generally lower than the eastern United States.<sup>49</sup> 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 fac-

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43. *Id.*

44. Matthew Debord, *The Fall and Rise of the Carbon Coalition*, HUFFINGTON POST (July 27, 2011) [http://www.huffingtonpost.com/matthew-debord/the-fall-and-rise-of-the-carbon-coalition\\_b\\_910442.html](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 ET AL., DESIGNING A TECHNOLOGY-NEUTRAL, BENEFIT-PRICING POLICY FOR THE COLORADO ELECTRICITY SECTOR (Dec. 2010) available at [http://soilcrop.colostate.edu/keske/pdf/GEO\\_Technical%20Report\\_Final\\_Print\\_12-14-2010.pdf](http://soilcrop.colostate.edu/keske/pdf/GEO_Technical%20Report_Final_Print_12-14-2010.pdf); See also Catherine M.H. Keske, *Costs of Environmental and Performance Attributes of the Colorado Electricity Sector*, 24 THE ELEC. J. 75–83, (2011).

45. Price per kWh in Colorado for energy buyback is approximately \$0.02. KESKE, *supra* note 2, at 43.

46. KESKE, *supra* note 2, 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 percent in total.

47. KESKE, *supra* note 2, at 46–50; See also Elizabeth R. Leuer, Jeffrey Hyde, and Tom L. Richard, *Investing in Methane Digesters on Pennsylvania Dairy Farms: Implications of Scale Economies and Environmental Programs*, 37(2) AGRIC. AND RESOURCE ECON. REV. 188–203 (2008).

48. *Id.* at 3.

49. *Id.*



tored into future energy policy, the current price per KWh of electricity is low compared to other regions of the country.<sup>50</sup> Appendix A further elaborates on the revenue assumptions built into the enterprise budget model.<sup>51</sup>

As Mr. Deyrouchy suggested, controlling AD operational costs is critical to profitability. Cost control is also important to increasing profitability for an agricultural production, in general.<sup>52</sup> The sensitivity analysis represented in Figure 4 measures the responsiveness of income to a one percent 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 price changes affect the viability of a project.<sup>53</sup> This analysis compares the variables that contribute to profitability in order to determine how to best control costs, generate revenues, and where to expend managerial effort. In other words, a sensitivity analysis can provide producers a “roadmap” to improving profitability with an AD unit.

A sensitivity analysis incorporated 20 percent changes of all variables in the “Expected” condition in Figure 3. 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 3.
- A budget modeling a 20 percent increase in each of the variables (with minor modifications) and a return of \$8,895,899, or a 46.45 percent return on investment. This reflects the “Good” economic condition in Figure 3, and the “Good” economic condition in Figure 4.
- A budget modeling an approximate 20 percent reduction in each of the variables (unless otherwise specified) and a negative annual return on investment of -30.78 percent. This “Poor” economic condition is not illustrated in the Figure 3 budget, but it is represented in the Figure 4 sensitivity analysis.

In sum, and as Figure 4 indicates, operational income is most sensitive to changes in production costs. A one percent change in production costs resulted in a 14.54 percent change in income. Examples of production costs might include unplanned AD unit maintenance and in-

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50. KESKE, *supra* note 2.

51. Revenues and costs are summarized in KESKE, *supra* note 2, at 44–50.

52. Catherine M.H. Keske, *Using Horsepower to Cut Costs*, AG. WOMEN AND RISK, 2 (Spring 2009) available at [http://www.ext.colostate.edu/pubs/ag\\_natr/0903\\_women-ag.pdf](http://www.ext.colostate.edu/pubs/ag_natr/0903_women-ag.pdf).

53. KESKE, *supra* note 2, at 26–36 (Operational variables selected for the sensitivity analysis were identified through interviews with technology providers, agricultural operations managers, and academic and trade publications).

creases in labor. Operational income is also sensitive to energy production. A one percent change in energy production capacity (which is a function of engine efficiency and energy prices) yields an 11.14 percent 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.<sup>54</sup>

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 included in the second column of Figure 4.

An interesting result is the effect of price changes per metric tonne of carbon credits on net income (4 percent). The sensitivity analysis does not support the premise that positive net income of an AD project hinges on carbon credits. If net income were to show high sensitivity to carbon credit price changes, producers could show rapid reductions in profit, considering the rapid change in carbon credit prices from over \$7 per tonne in May 2008 to below \$0.1 per 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 rather than on the price of carbon. Moreover, 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 that have the potential to yield environmental benefits, the state may wish to subsidize the difference between “typical” prices and 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 a reduction of energy costs for alternative energy projects. Third, should the environmental, or “social costs” of

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54. It is important to note that the enterprise budget and sensitivity analysis specifically address economic feasibility of AD in the western United States. Although data are available from other projects across the country, the decision was made to use region-specific data in order to account for Intermountain West policies and practices. For example, published reports reflecting electricity use charges ranging from \$0.08–\$0.12/kWh in New York or Pennsylvania yield a different budget compared to the typical \$0.03–\$0.07/kWh prices seen in the Intermountain West. KESKE, *supra* note, at 2.

FIGURE 4: Results of Sensitivity Analysis

	Percent Change in Income per Percent 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 <sub>2</sub> cost/tonne <sup>1</sup>	4%	\$0.5	\$5.50	\$14
Water Cost <sup>2</sup>	1.21%	\$600.00	\$600.00	\$25
Energy Production (billing capacity)	11.14%	54,925,923	68,657,404	82,388,885
(methane produced)	NA	75255	94069	112883
Production Costs	14.54%	\$3,780,473	\$3,178,727	\$2,576,982
<b>Net Income</b>	<b>NA</b>	<b>\$5,896,108</b>	<b>\$700,205</b>	<b>\$8,895,899</b>
Annual Return on Investment	NA	-30.78%	3.66%	46.45%

<sup>1</sup> 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 of carbon likely were substantially lower than \$50/tonne. Median CO<sub>2</sub> prices were imputed in the “Good” economic condition.

<sup>2</sup> 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.

carbon offset prices reflect the “true” environmental costs of methane or CO<sub>2</sub>, then there might be more financial incentives for producers who emit these greenhouse gases to implement AD technology. However, present evidence illustrates that reducing operational costs and lawsuit mitigation hold the keys to economic profitability.

## VI. CONCLUSION

Although AD has the potential to generate natural gas and electricity in the western United States, unless an operation faces the threat of a nuisance lawsuit, current AD technology does not typically pay for itself. However, the use of AD technology at the sites discussed within this Article, including Wyoming Premium Farms, has led to innovative

technological research that might reduce AD unit operating costs.<sup>55</sup> Reduced operating costs in a few parameters, such as water costs or repair costs, could be enough to make AD economically feasible, which would open the door to a market.

For example, high solids content waste is a major barrier that is unique to the arid western United States.<sup>56</sup> 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.<sup>57</sup> At the moment, private funding for high solids content research may not yield economic returns for the industry, but as shown in the Wyoming Premium Farms example, sites that have already implemented AD 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 nuisance lawsuits are the primary way that AD systems are justified in the western United States. Interviews with technology providers and agricultural operation managers<sup>58</sup> also validate that AD systems for a Colorado or Wyoming single farm project are not economically viable at this time without key cost savings from lawsuit mitigation.<sup>59</sup> This is further validated by the fact that not a single AD unit has been installed in Colorado in the three years after the initial interview with Wyoming Premium Farms in 2009.

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 carbon credits provide environmental benefits that considerably exceed market value.<sup>60</sup> One example summarized the environmental literature for the nonmarket and environmental values from CO<sub>2</sub> reduction.<sup>61</sup> From a review of 28 studies,

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55. Catherine M.H. Keske, *How Lawsuits Could Ignite an Energy Market: The Case of Anaerobic Digestion*, ENVTL. L. REP. (Dec. 2011).

56. COLO. STATE UNIV. EXTENSION, *Anaerobic Digestion in Colorado*, <http://www.ext.colostate.edu/energytalk/ad-colorado.html> (last visited May 17, 2012)

57. KESKE, *supra* note, 2.

58. Sybil Sharvelle, *Final Report on Results from Waste Characterization and Biochemical Methane Potential Tests Conducted on Wastes from Aurora Organic Dairy*, Presented to ActNeutral, Inc. Oct. 2008.

59. KESKE, *supra* note, at 2.

60. Catherine M.H. Keske, *supra* note 44; *Costs of Environmental and Performance Attributes of the Colorado Electricity Sector*, 24 THE ELEC. J. 75–83 (2011).

61. See R. Tol, *The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties* 33(16) ENERGY POL'Y 2064–2074 (2005); Richard Tol, *The Economic Effects of Climate Change* 23(2) J. ECON. PERSPECTIVES 29–51 (2009); R. Tol, *Estimates of the Damage Costs of Climate Change. Part I: Benchmark Estimates* 21(1) ENVTL. AND RES. ECON. 47–73 (2002); and,

the *median* value of estimated environmental benefits was a \$14 per tonne price.<sup>62</sup> The mode, mean, and 95th percentile values were \$2 per tonne, \$93 per tonne, and \$350 per tonne, respectively. On the other hand, methane is estimated to have 21 times the atmospheric warming potential compared to CO<sub>2</sub>, and livestock waste is a large contributor of methane emissions.<sup>63</sup> Preliminary work estimates mean marginal social damage costs at \$205 per metric tonne of methane, though methane regulation and trading markets are more inchoate at this time as compared to CO<sub>2</sub> markets.<sup>64</sup>

Nitrogen oxide emissions (NO<sub>x</sub>) also have been linked to agricultural practices, among other sources.<sup>65</sup> Volatilization of Nitrogen from manure management and other urban pollutants cause complex chemical reactions that lead to health and environmental impacts across time and geographical space. NO<sub>x</sub> has also been linked with poor visibility and long term O<sub>3</sub> concentration in national parks such as Rocky Mountain and Mesa Verde, as well as wilderness and natural areas.<sup>66</sup> Marginal damage estimates from NO<sub>x</sub> in the Intermountain West are approximately \$381 per tonne.<sup>67</sup> 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.

Nonpoint source pollution from agricultural production also poses considerable water quality concerns.<sup>68</sup> The biochemical processing of animal waste allows for the effluent product to retain high nutrient content, and is suitable for field application.<sup>69</sup> 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

R. Tol, *Estimates of the Damage Costs of Climate Change, Part II. Dynamic Estimates* 21(2) ENVTL. & RES. ECON. 135–60 (2002).

62. See KESKE, *supra* note 2.

63. *Greenhouse Gas Properties*, EPA (Oct. 30, 2011), <http://www.epa.gov/outreach/scientific.html>.

64. Stephanie Waldhoff et al., *The Marginal Damage Costs of Different Greenhouse Gases: An Application of FUND* (The Econ. and Social Research Institute, Working Paper 380, March 2011), available at <http://www.esri.ie/UserFiles/publications/WP380/WP380.pdf>.

65. David Tilman et al., *Agricultural Sustainability and Intensive Production Practices*, 418 NATURE 671 (2002).

KESKE, *supra* note 2, at 26.

66. *Id.*

67. Catherine M.H. Keske, *supra* note 44; *Costs of Environmental and Performance Attributes of the Colorado Electricity Sector*, 24 THE ELEC. J. 75–83 (2011).

68. MARC RIBAUDO ET AL., NITROGEN IN AGRICULTURAL SYSTEMS: IMPLICATIONS FOR CONSERVATION POLICY ECON. RESEARCH REPORT NO. 127 USDA (Sept. 2011).

69. Sharvelle & Keske, *supra* note 15.

effluent can also be applied in a manner where the nutrients are less likely to volatilize and cause less net environmental impact.

An operation can clearly gain environmental benefits by installing an AD unit. The implementation of these units by agricultural producers is a matter of cost. AD units can be economically viable in the western United States if nuisance lawsuits are mitigated, thus justifying the up-front capital costs. Producers might even profit from these systems if they are able to offset their operating expenses. Quantifying the results of environmental externalities provides justification for installation of an AD system because environmental damage costs might also be offset. It so appears, at least in the western United States, that the threat of a nuisance lawsuit would benefit not only the environment, but also the agricultural producer.

### Appendix

**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 tonne)\*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.<sup>3</sup>/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.<sup>3</sup>

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