**Excrement into Energy: Turning North Carolina's Swine Waste Problem into a Renewable Energy Solution**

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*Introduction*

According to the Environmental Protection Agency (EPA) and United States Department of Agriculture (USDA), livestock production is the largest cause of water quality impairment in the United States' rivers, streams, lakes, ponds, and reservoirs.[1] This impact on the country's water supply is due to the geographic concentration of animals, and rudimentary waste management and disposal systems employed by the agricultural industry.[2] The excess waste created by livestock production is a potential contaminant of both ground and surface water supplies, as it often seeps into the ground or nearby bodies of water.[3] As the second largest hog and pig producing state in the country after Iowa,[4] North Carolina faces a significant environmental challenge in attempting to mitigate the pollution caused by its massive swine industry.

In 2007, the North Carolina Legislature passed Senate Bill 3, which enacted a mandatory renewable energy and energy efficiency portfolio standard (REPS).[5] This legislation requires North Carolina electric public utility companies and electric corporations and municipalities to include a certain percentage of renewable energy sources in their electric generation portfolios.[6] Among other sources, the law requires the

[1] Michelle B. Nowlin, *Sustainable Production of Swine: Putting Lipstick on a Pig?*, 37 VT. L. REV. 1079, 1086 (2013)
[2] *Id.*
[3] *Id.*
[4] *2007 Census of Agriculture: Hog and Pig Farming*, U.S. DEPT. OF AGRIC. 1, (2007), *available at* http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Fact_Sheets/Production/hogsandpigs.pdf.
[5] S. 3, 2007 Gen. Assem., 2007-2008 Sess. (N.C. 2007).
[6] *Id.*

use of swine waste as a source from which a percentage of North Carolina's energy must come. This law, enacted as North Carolina General Statute § 62-133.8,[7] has encouraged the implementation of new technology to convert some of the copious amounts of hog waste produced in the state into renewable energy. After extensive testing, new technology has been put into use on farms in North Carolina, which may assist in turning the state's massive hog waste pollution problem into an abundant source of renewable energy.[8]

*Background*

Waste from hog farming has historically proven useful as a fertilizer.[9] However, rapid growth in hog farming, along with an increase in Concentrated Animal Feeding Operations (CAFOs) has created excessive hog waste in concentrated areas.[10] CAFOs are large agricultural operations in which animals are kept and raised in confined situations.[11] Notably, CAFOs are dedicated solely to raising animals; none of the land is used for crops, and there is no grass or other vegetation in the area where the animals are confined.[12] Because of the large number of animals confined in one area and the absence of crops to fertilize, these CAFOs create more waste than is easily manageable.[13]

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[7] Renewable Energy and Energy Efficiency Portfolio Standards, N.C. GEN. STAT. § 62-133.8 (2007) *available at* http://www.ncleg.net/EnactedLegislation/ Statutes/HTML/BySection/Chapter_62/GS_62-133.8.html [hereinafter REPS Statute].
[8] *See* Nowlin, *supra* note 1, at 18–22.
[9] Dawn A. Santoianni et al., *Power From Animal Waste: Economic, Technical, and Regulatory Landscape in the United States*, 2 J. OF EUEC 1 (2008), *available at* http://www.euec.com/getattachment/euecjournal/santoianni.pdf.aspx.
[10] *Id*.
[11] *What is a CAFO? | Region 7 | US EPA*, U.S. Envtl. Protection Agency, http://www.epa.gov/region7/water/cafo/ (last updated Sept. 10, 2012).
[12] *Id*.
[13] Santoianni, *supra* note 9, at 3–8.

In North Carolina, the use of CAFOs has become more prevalent, while the number of small-scale hog farms has decreased.[14] For example, in just two years, North Carolina saw rapid growth in the number of hogs produced, from 2.4 million in 1986 to more than 10 million in 1998.[15] At the same time that this growth in the number of hogs produced was taking place, the number of farms steadily decreased.[16] Since 1998, the number of hog farms has continued to decrease, while the number of CAFOs with more than 5,000 hogs has continued to increase.[17] In 2007, about 9.5 million hogs were raised in North Carolina each year, on only 2,300 factory farms.[18] This concentration of large numbers of hogs in a relatively small area creates waste management and disposal problems for the CAFOs, as the supply of swine waste far exceeds the demand.

Though waste management and disposal challenges vary based on the way a particular CAFO handles its swine waste, a typical method of waste management is for the animals to be kept on slatted floors, so the manure falls through the floor into a pit beneath it.[19] Manure is then flushed out of the building with water into a lagoon, where it is stored until it is disposed of or sprayed on fields as fertilizer.[20] When there is excess waste that is not needed for fertilizer in a nearby area, however, waste disposal poses a

[14] *Id*.
[15] Nowlin, *supra* note 1, at 1082.
[16] *Id*.
[17] *Overview of the U.S. Hog Industry*, U.S. DEPT. OF AGRIC. (2009), *available at* http://usda01.library.cornell.edu/usda/current/hogview/hogview-10-30-2009.pdf.
[18] Santoianni, *supra* note 9, at 5.
[19] Richard W. Gullick et al., *Source Water Protection for Concentrated Animal Feeding Operations: A Guide for Drinking Water Utilities*, ENVTL. PROT. AGENCY 21–23 (2007), *available at* http://www.waterrf.org/PublicReportLibrary/91159.pdf.
[20] *Id*.

significant problem.[21] Though North Carolina law prohibited the construction of new lagoons in 2007, lagoons built before the prohibition are still used.[22]

The excess waste generated by CAFOs has become a major pollutant that negatively affects the water quality in areas surrounding the operations. Even when hog waste is used as a fertilizer, it can pollute nearby bodies of water is if too much waste is applied to one area, or if it is sprayed on ground that is frozen and cannot, absorb the waste.[23] Livestock productions contribute to impairment of approximately 37% of the nation's surveyed rivers and streams."[24] This fecal contamination is often seen through the presence of E. coli bacteria in nearby groundwater.[25] Evidence of this is illustrated by the fact that, in eastern North Carolina, studies have shown that E. coli was found more frequently in groundwater on swine farms than on crop farms without swine.[26]

Besides groundwater pollution, CAFOs contribute to air pollution in surrounding areas as well. This pollution may come in the form of odor, which is unpleasant, and contains chemicals harmful to human health. One such chemical is Ammonia, which "is an irritant that affects the skin, eyes, and throat and causes respiratory distress, including asthma."[27] Furthermore, the particulate matter that travels to surrounding areas from swine CAFOs may contain the same pathogens that contaminate groundwater, including E. coli. The dangers inherent in swine CAFOs have been a cause of concern to North Carolina residents, and have led to increased government regulation, and initiatives to

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[21] *Id*.
[22] *Id*.
[23] *See* Freedman Farms v. NC Dep't of Env't and Nat'l Res., Div. of Water Quality, 2008 WL 5510871 (N.C. O.A.H. Oct. 23, 2008) (Spraying equipment malfunction caused a frozen field to become saturated, and excess waste was discharged into nearby wetlands).
[24] Nowlin, *supra* note 1, at 1086.
[25] *Id*. at 1088.
[26] *Id*.
[27] *Id*. at 1090.

encourage sustainable hog farming techniques.[28] One way that North Carolina has attempted to encourage green swine farming practices is by requiring the use of swine waste as a source of renewable energy in its Renewable Energy and Efficiency Portfolio.[29]

In August 2007, Governor Easley signed Senate Bill 3 into law, making North Carolina the first state in the Southeast to enact a mandatory REPS.[30] The law, enacted as N.C. Gen. Stat. § 62-133.8, defines renewable energy resources to clarify the types of energy production it means to encourage.[31] The definition lists biomass resources, including agricultural waste and animal waste, among other sources from which renewable energy can be produced.[32] North Carolina's REPS imposes incrementally increasing requirements for the percentage of renewable energy resources that electric public utilities and electric membership corporations and municipalities must include as part of their energy portfolios.[33] For example, electric public utilities, which are required to use a greater percentage of renewable energy resources than are electric membership corporations and municipalities, were required to have 3% of their 2011 North Carolina retail sales come from renewable energy resources.[34] The requirement increases incrementally every three years until the year 2021, when the state's electric public

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[28] *See id*.
[29] REPS Statute, *supra* note 7.
[30] REPS Citizen Guide, NC SUSTAINABLE ENERGY ASSOCIATION at 2 (June 13, 2012), available at http://energync.org/assets/files/podcast_episodes/a-citizens-guide-to-the-nc-reps/a-citizens-guide-north-carolina-renewable-energy-energy-efficiency-portfolio-standard.pdf.
[31] REPS Statute, *supra* note 7.
[32] *Id*. ("'Renewable energy resource' means a solar electric, solar thermal, wind, hydropower, geothermal, or ocean current or wave energy resource; a biomass resource, including agricultural waste, animal waste, wood waste, spent pulping liquors, combustible residues, combustible liquids, combustible gases, energy crops, or landfill methane; waste heat derived from a renewable energy resource and used to produce electricity or useful, measurable thermal energy at a retail electric customer's facility; or hydrogen derived from a renewable energy resource.").
[33] *Id*.
[34] *Id*.

utilities companies will be required to provide 12.5% of their electricity from renewable sources.[35] Electric membership corporations and municipalities, on the other hand, are only required to reach 10%.[36]

Electric power providers may comply with REPS in several ways. They may do so: "using renewable resources to generate power at new or existing power plants; purchasing bundled power and renewable energy certificates known as 'RECs' from renewable energy facilities; purchasing unbundled RECs; or implementing energy efficiency measures to reduce demand."[37] As part of the requirement that utilities providers use electricity derived from renewable resources, the state specifies how much of that renewable energy must be provided using swine waste resources. By 2018, 0.2% of North Carolina's renewable energy must be derived from swine waste.[38] This requirement, along with government subsidies for the development of technology has encouraged the implementation of innovative systems to convert hog waste into energy.[39]

There are several examples of the steps North Carolina has taken to encourage the implementation of green technology on swine CAFOs to reduce the amount of pollution they create and to use the waste as a renewable energy source. Two such examples of this are the Smithfield Agreement, and the Loyd Ray Farms project. The Smithfield agreement demonstrates efforts of North Carolina's government to fund green hog farming technology in conjunction with major companies.[40] The Loyd Rays Farm project, on the other hand, is an example of another type of initiative, "with private actors seeking

[35] *Id*.
[36] *Id*.
[37] REPS Citizen Guide, NC SUSTAINABLE ENERGY ASSOCIATION at 4 (June 13, 2012), *available at* http://energync.org/assets/files/podcast_episodes/a-citizens-guide-to-the-nc-reps/a-citizens-guide-north-carolina-renewable-energy-energy-efficiency-portfolio-standard.pdf.
[38] REPS Statute, *supra* note 7.
[39] *See* Nowlin, *supra* note 1, at 1118–1128.
[40] *Id*. at 1118–1128.

to implement technologies that reduce the negative externalities from the concentration of manure while making profitable use of the waste stream."[41]

*Implementation of Green Technology on CAFOs*

In 2000, North Carolina entered into an agreement with Smithfield Foods to finance a project that would fund the development of new technology, to be certified "Environmentally Superior Technologies" (EST), for the management of swine waste on Company-owned farms. In order to be certified EST, a technology must be legally permitted for use by the government, "technically, operationally, and economically feasible"[42], and must meet the following criteria:

(1) "Eliminate the discharge of animal waste to surface waters and groundwater through direct discharge, seepage, or runoff;

(2) Substantially eliminate atmospheric emissions of ammonia;

(3) Substantially eliminate the emission of odor that is detectable beyond the boundaries of farm;

(4) Substantially eliminate the release of disease-transmitting vectors and airborne pathogens; and

(5) Substantially eliminate nutrient and heavy metal contamination of soil and groundwater.[43]

This agreement set a goal for the benchmarks that new technologies should meet in order to be certified EST and implemented on swine CAFOs.[44] Though several new technologies that met the environmental performance standards were developed as a

[41] Nowlin, *supra* note 1, at 1123.
[42] *Agreement for the Management of Swine Waste*, NCSU CALS (July 25, 2000), *available at* http://www.cals.ncsu.edu/waste_mgt/smithfield_projects/agreement.pdf.
[43] *Id*.
[44] *Id*.

result of the agreement, the requirement that the technology be cost-effective proved a difficult target to meet.[45] Acceptable EST for new and existing CAFOs will include "Super Soils, nitrification-denitrification, or soluble phosphorus removal, along with one of four other specified treatment technologies."[46]

One example of a North Carolina farm that successfully implemented swine waste to energy technology is Loyd Ray Farms, mentioned above. This project is the result of a partnership between Duke University's Carbon Offset Initiative, Duke Energy, Loyd Rays Farms, and Google.[47] The farm, located in Yadkin County, North Carolina, uses anaerobic digestion, a technology that met the Smithfield Agreement's benchmarks and was authorized by North Carolina law, to generate renewable energy and carbon offsets.[48] Anaerobic digesters capture methane released through anaerobic bacterial digestion of manure, which can then be burned as a biogas fuel source.[49] "Under the agreement between the farm operator, Duke University, and Duke Energy, Duke University retains the rights to the carbon offsets (which it will split with Google), and Duke Energy retains the rights to the RECs."[50] The goals of the project are to "generate electricity from swine waste, reduce greenhouse gas emissions from the farm, reduce ammonia and other odorous emissions from the farm, improve the quality of treated wastewater from the farm," and accomplish these goals in a way that was economically

[45] Nowlin, *supra* note 1, at 1118–1121.
[46] *Id.* at 1121.
[47] *Id.* at 1123–1124.
[48] *Id.*
[49] Nicole G. Di Camillo, *Methane Digesters and Biogas Recovery—Masking the Environmental Consequences of Industrial Concentrated Livestock Production,* 29 UCLA J. ENVTL. L. & POL'Y 365, 367 (2011).
[50] *Loyd Rays Farms*, AGSTAR: AN EPA PARTERNSHIP PROGRAM, http://www.epa.gov/outreach/agstar/projects/profiles/loydrayfarms.html (last visited Oct. 22, 2013).

feasible to the owner of the farm.[51] The system was constructed using processes and systems similar to those currently in use on swine farms in the state but with modifications to improve the efficiency and environmental goals of the project.[52] "The waste stream is recycled and the energy in the animal feed is re-harnessed, thereby reducing the carbon footprint of the farming operation. The water and air quality on the farm are improved and further protected, and odors, pathogens and nutrients that are emitted from the waste treatment system are reduced."[53]

*ESTs as a Solution to Hog Waste Pollution?*

Though the results of the Loyd Rays Farm project appear promising because the farm was able to produce electricity and reduce harmful emissions,[54] the use of methane digesters is not a panacea that will cure North Carolina's hog waste pollution problem over night. Anaerobic digesters are often prohibitively expensive without government subsidies, and, even with the help of these subsidies, are generally only profitable in CAFOs.[55] Furthermore, the biogas recovery process itself creates air-polluting emissions.[56] In addition, even with the use of anaerobic digestion, CAFOs are left with manure disposal problems, as digesters do not reduce the quantity or nutrient content of manure.[57]

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[51] William G. "Gus" Simmons, Jr, *Next Generation Technology Swine Waste to Energy Project*, NC SAFE WATER (Nov. 29, 2012), *available at* http://info.ncsafewater.org/Shared%20Documents/Web%20Site%20Documents/Annual%20Conference/AC_2012_Papers/ST_Mon_AM_09.15_Simmons_PAPER.pdf.
[52] *Id*. at 4.
[53] *Id*.
[54] *Loyd Rays Farms*, DUKE: SUSTAINABILITY, http://sustainability.duke.edu/carbon_offsets/loydrayfarms/index.php (last visited Oct. 22, 2013).
[55] Camillo, *supra* note 49, at 367.
[56] *Id*.
[57] *Id*.

The results regarding electricity generation and carbon offsets from the Loyd Rays Farm project are promising. During the project's first 15 months of operation, the system produced electricity almost 70% of the time[58] and generated 367.5 MWh of electricity.[59] Based on flow and methane concentration of biogas and documentation of the electricity generated by the waste management system, the project staff estimates that it is possible to reduce the emissions of "up to 5,183 MTCO2e, which are the baseline emissions from the farm prior to the installation of the system."[60] During the first 15 months of operation, the project met 40% of total greenhouse gas emission reductions possible.[61] The relative success of the project, as evidenced by the substantial production of electricity and reduction in greenhouse gas emissions, combined with reductions in ammonia emissions and odor that the were documented in the first months of the project's operation, demonstrate the possibility of significantly reducing emissions through the implementation of similar systems on other CAFOs in the state.

While the results of the Loyd Rays Farm project demonstrate the possibility of implementing anaerobic digestion on CAFO, cost is still a barrier to the widespread use of this technology.[62] In particular, the installation of these digesters often costs up to three million dollars, with extra technology required to remove impurities into the biogas to convert it to useable natural gas.[63] Furthermore, the methane digestion and biogas burning process process, though useful in its creation of renewable energy, also creates some harmful emissions of air pollutants. These emissions include nitrogen oxide, sulfur

[58] *Loyd Rays Farms*, *supra* note 54.
[59] Nowlin, *supra* note 1, at 22.
[60] *Loyd Rays Farms*, *supra* note 54.
[61] *Id*.
[62] Camillo, *supra* note 49, at 367.
[63] *Id*. at 376–377.

oxide, and carbon monoxide.[64] The release of nitrogen oxide is especially problematic because it contributes to the creation of ground-level ozone, which can cause serious respiratory health problems.[65] Finally, anaerobic digestion is not a cure-all for North Carolina's hog waste pollution problem because it does not reduce the quantity of manure that must be disposed of.[66] Therefore, inadequate disposal of hog waste produced by CAFOs remains one of the main challenges to reducing the negative impact these large-scale operations have on the environment.[67]

*Conclusion*

The prevalence of swine CAFOs in North Carolina has created a significant pollution problem due to the excessive amount of waste created by these large-scale operations. The enactment of North Carolina Renewable Energy and Energy Efficiency Portfolio standards, however, has mandated the use of some of this hog waste as a renewable energy source.[68] This requirement, along with initiatives to fund and develop new swine waste-to-energy technology, has led to the implementation of new environmentally friendly technologies on swine CAFOs.[69]

While results have been mixed due to some significant cost barriers and the continued problems of harmful emissions and waste disposal, projects such as the Loyd Ray Farms partnership demonstrate that North Carolina has made significant progress in its effort to encourage swine to waste technology. The implementation of similar environmentally friendly technologies in CAFOs across the state could help reduce the

[64] *Id*. at 374.
[65] *Id*.
[66] *Id*.
[67] *Id*. at 1087–1089.
[68] REPS Statue, *supra* note 7.
[69] Nowlin, *supra* note 1.

damage caused by such operations, while providing North Carolina with an abundant source of renewable energy.